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Analysis of Fluoride Concentration in Toothpastes in the United Arab Emirates: Closing the Gap between Local Regulation and Practice

Ammar Abdulrahman Jairoun [1,2,*], Sabaa Saleh Al-Hemyari [1,3], Moyad Shahwan [4,5], Obaida Jairoun [6] and Sa'ed H. Zyoud [7,8]

1 Discipline of Social and Administrative Pharmacy, School of Pharmaceutical Sciences, Universiti Sains Malaysia, Pulau Pinang 1800, Malaysia; sabaa.alhemyari@mohap.gov.ae
2 Health and Safety Department, Dubai Municipality, Dubai 67, United Arab Emirates
3 Pharmacy Department, Emirates Health Services, Dubai 1853, United Arab Emirates
4 Department of Clinical Sciences, College of Pharmacy and Health Sciences, Ajman University, Ajman 346, United Arab Emirates; m.shahwan@ajman.ac.ae
5 Center of Medical and Bio-Allied Health Sciences Research, Ajman University, Ajman 346, United Arab Emirates
6 College of Dentistry, Clinical Sciences Department, Ajman University, Ajman 346, United Arab Emirates; o.jairoun@ajman.com
7 Poison Control and Drug Information Center (PCDIC), College of Medicine and Health Sciences, An-Najah National University, Nablus 44839, Palestine; saedzyoud@najah.edu
8 Clinical Research Centre, An-Najah National University Hospital, Nablus 44839, Palestine
* Correspondence: dr_ammar_91_@hotmail.com or aajairoun@student.usm.my; Tel.: +971-558099957

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Abstract: Background: While there is much scientific evidence supporting the benefits of fluoride for oral health, the concentration of fluoride in over-the-counter fluoride toothpaste should meet United Arab Emirates (UAE) regulations of a fluoride concentration not exceeding 0.15%. Objectives: The current study examines the fluoridated toothpaste products available on the UAE market and aims to quantify their total fluoride content. Methods: A total of 50 toothpaste products were collected and analyzed in this study. Ion Chromatography (IC) conductivity analysis was performed to determine the total fluoride content. Results: Among the 50 products tested, 10 exceeded the recommended concentration of total fluoride of less than 0.15%, while 12 had a total fluoride concentration that was less than was declared on their labels. Moreover, this study has revealed that 22 of the sampled products had a total fluoride concentration below 1000 ppm fluoride. An increased risk of higher total fluoride content was observed in the toothpaste products with monofluorophosphate active ingredients than in products with potassium nitrate/sodium fluoride and sodium fluoride ($p = 0.011$). Conclusions: There is a need to reassess the effectiveness of current regulations in the UAE to ensure that all fluoridated toothpastes available on the market are safe and effective for the consumer. Specifically, appropriate guidelines should be established on the basis of the risks and benefits inherent in fluoride exposure. Moreover, fluoridated toothpastes need to be subject to stricter monitoring and control regarding their safety and quality through good manufacturing practices (GMPs), education, research, and adverse event reporting.

Keywords: toothpaste; fluoridated oral care products; fluoride; cavities; anti-caries

1. Introduction

In the 1930s, it was first noted that communities with access to naturally fluoridated water experienced lower rates of tooth decay than those that did not, which thereby indicated the benefits of fluoride for dental health [1]. Consequently, fluoride began to be used in the field of dentistry during the 1940s, and it eventually became incorporated into a variety of consumer products. Caries, which is the most prevalent oral disease, results from an imbalance in the dynamic equilibrium between dental hard tissue demineralization

and remineralization, which is caused by bacterial biofilms degrading dietary sugars and fermentable carbohydrates into acid, among other causes [2–4]. The fluoride contained in fluoridated toothpaste combats caries by retarding bacterial metabolism while also reducing demineralization and enhancing the remineralization of dental enamel [5–8]. Research has proven the effectiveness of fluoridated toothpaste, which is produced through the addition of sodium fluoride monofluorophosphate, stannous fluoride, and similar fluoride compounds, in the management of dental caries. Specifically, the demineralization rate of both permanent and deciduous enamel, as well as root dentin, is directly and negatively associated with the level of fluoride in toothpaste [8–10]. Fluoride is either absorbed and used in enamel demineralization or incorporated into a calcium fluoride reservoir that can be sustained for long periods of time. If the tooth surface reaches a pH level below 6, calcium fluoride releases fluoride ions, eventually leading to the formation of hydroxyapatite (HA), which drives enamel remineralization [11,12]. Overall, fluoridated toothpaste can increase fluoride levels on the tooth surface as well as within the oral cavity for up to 10 h after application via tooth brushing [13]. Notably, there is a large body of evidence-based research demonstrating that fluoridated toothpaste is an effective method to address dental caries [5,8–10]. However, despite these anti-caries properties, it has also been proven that the excessive intake of fluoridated toothpaste can have adverse side effects, including dental fluorosis and skeletal fluorosis [14,15]. Dental fluorosis refers to a systemic overexposure to fluoride that adversely affects the development of enamel, particularly during the first six years of a person's life, as this is when the enamel of permanent teeth crowns form. Enamel affected by dental fluorosis is opaque and porous and has more protein, and the condition can manifest clinically as white to light-brown narrow horizontal lines or patches, as areas of porous enamel, or as reductions in enamel [16]. Meanwhile, research has shown that when children accidentally swallow fluoridated toothpaste it may lead to an exposure level of two or three times what is considered safe, meaning that the use of fluoridated toothpaste by children could represent a dental fluorosis risk factor [17,18]. Hence, the use of fluoridated toothpaste must be carefully evaluated in terms of the risks and benefits to oral health.

EU Regulation (EC) N° 1223/2009 on cosmetic products permits the addition of fluoride compounds to oral care products with a fluoride concentration of up to 0.15% [19]. While similar regulations concerning fluoridated oral care products have been adopted in the UAE, with the same maximum concentration of 0.15%, research has revealed the presence of adulterated or contaminated cosmetic products in the UAE [20]. Moreover, any toothpaste product with ingredients containing fluoride with concentration ranges from 0.1 to 0.15% should be labelled with "for children of six years and less: use a pea-sized amount of toothpaste or less depending on age, and parents/guardians should supervise tooth brushing to reduce the risk of swallowing too much fluoride". Against this backdrop, the current study examines the fluoridated toothpastes available on the UAE market with the aim of quantifying their total fluoride content. To the best of our knowledge, ours is the first study to perform an evaluation of fluoridated toothpastes offered on the UAE market. The results will contribute to the strengthening of current regulations by showing whether or not they are sufficiently effective while also paving the way for the development of alternative methods in identifying excessive fluoride exposure to safeguard the anti-caries effect while mitigating the risk of dental fluorosis.

2. Materials and Methods

2.1. Sampling Method

Outlets offering fluoridated oral care products were identified through a search of local business directories that contained details on all United Arab Emirates (UAE) pharmacies, parapharmacies, and health care outlets. The search revealed 2183 locations, which were entered into a sampling framework consisting of an Excel spreadsheet containing pertinent details such as business names, phone numbers, emails, and addresses. The study sample was then generated using a basic random-sample selection method based on the ID

numbers of the businesses, and stratification was applied according to location and type. In sampling the fluoridated toothpastes, the main selection criterion was that the product label listed a form of fluoride as an ingredient, e.g., sodium fluoride, stannous fluoride, or sodium monofluorophosphate. At each selected business location, one package of each available fluoridated oral care product was randomly chosen; the manufacturing origin was not taken into consideration. Each sampled product was assigned a code reference number to preclude replication and permit tracking. For each sampled product, the following details were recorded: product name, brand name, country of origin/manufacturer, item category, subcategory, batch number, barcode, dosage form, size/volume, and the recommended dose as well as the location of the outlet. If the same product (i.e., identical name, manufacturer, formulation, barcode, and size/volume) was available at more than one location, only the first product chosen was tested while the remaining samples were returned. If products had identical names yet were from different manufacturers, or were available in different formats (e.g., emulsion vs. cream), they were considered distinct products and tested separately. All products were sent to the laboratory for testing on the day of collection.

2.2. Instrumentation

The following are the materials used in the sample analysis, with the purchase location, company, and country listed [21].

Ion Chromatography (IC) consisting of 930 Compact IC Flex, conductivity detector, suppressor module, and MagIC Net software. Make: Metrohm, Switzerland.

Metrosep A Supp 7–250/4.0 mm column (P.N. 61006630) and guard column (Metrosep A Supp 16 Guard/4.0 (P.N. 61031500)) with a 20 µL sample loop. Make: Metrohm, Switzerland.

Analytical balance, max 200 g range. Make: Sartorius, Goettingen, Germany.

Centrifuge, Max 12,000 rpm. Make: Hamilton, USA.

Micropipette (100–1000 µL). Make: Transpette, Wertheim, Germany.

Sonicator. Make: Qualilife, China.

A set of 0.20 µm nylon syringe filters. Make: Biomed Scientific Ltd., Guangdong, China.

A set of 50 mL test tubes with cap. Make: Tarsons, Kolkata, India.

A set of 100 mL volumetric flasks. Make: Gulf scientific glass, Al Hidd, Bahrain.

Reagents: all reagents were of analytical purity, and included ultrapure water (deionized water, NLT resistivity 18 MΩ m, and less than 20 ppb total organic carbon at 20 °C), sodium carbonate, and sulfuric acid.

2.3. Acquisition Conditions

IC-conductivity analysis was performed with the Metrohm 930 Compact IC Flex. For quantification, the Metrosep A Supp 7–250/4.0 mm column, P.N. 61006630 and guard column (Metrosep A Supp 16 Guard/4.0 (P.N. 61031500)) were used, and conductivity detection after sequential suppression was performed with mobility-allowing (3.6 mM sodium carbonate in ultrapure water) and conductivity-suppression (100 mM sulfuric acid) solutions. Chromatographic separation was achieved with isocratic elution (20 µL of sample was injected into the chromatographic system) at a flow rate of 0.7 mL/min and column temperature of 30 °C. The peaks of the determined components were identified by their retention time compared with that of the standards, and the run time was 35 min.

2.4. Preparation of Test Portions

Powered semisolids and liquids were homogenized by stirring with spatulas or glass rods. The homogenized material was used for sample preparation.

2.5. Sample Preparations

Preparation for fluoride content (added as sodium fluoride):

A total of 1.0 g of sample was extracted in 80 mL ultrapure water under sonication, and the solution was made up to 100 mL, centrifuged for 5 min at 6000 rpm, and subsequently filtered through a 0.2 µm nylon syringe filter.

Preparation for fluoride content (added as calcium fluoride):

Samples of 0.2 g were extracted in 80 mL ultrapure water under sonication and heated at 65 °C for 30 min. The solution was made up to 100 mL, centrifuged for 5 min at 6000 rpm, and subsequently filtered through a 0.2 µm nylon syringe filter. Samples diluted 10 times were injected if fluoride was present.

2.6. Calibration Standard

2.6.1. Reference Materials

A 1000 mg/L fluoride standard was used for IC-(Cat log no-77365-100 mL). Ultrapure water was used as a diluent.

2.6.2. Linearity Procedure

Calibration standards of fluoride at concentrations of 0.04, 0.10, 0.20, 0.50, 1.0, and 2.0 mg/L were prepared in ultrapure water by serial dilution of the stock solution.

2.7. Validation Methodology for Quantitative Procedures

The method was fully validated according to the International Conference on Harmonization (ICH) guidelines by a determination of the linearity, precision, accuracy, limit of detection, and limit of quantification.

The selectivity of the method was proven with the chromatographic peak resolution of fluoride.

The linearity of the method was tested in the range of 0.04–2.0 mg/L with a correlation coefficient value greater than 0.995.

The limit of detection (LOD) was determined on analyte-free samples with a signal-to-noise ratio of at least 3:1. The limit of detection and limit of quantification of the method were tested in the range of 2 to 4 mg/kg. The limits of the method were 2 mg/kg and 4 mg/kg for limit of detection and limit of quantification, respectively.

2.7.1. Accuracy and Precision

The accuracy and precision procedure was conducted by spiking 6 individually spiked solutions with concentrations ranging from limit of quantification (LOQ) to medium and high levels of calibration concentrations. In this method validation, fluoride was spiked at 4.0 mg/kg, 20 mg/kg, and 160 mg/kg in analyte-free products such as fluoride-free toothpastes, mouthwash, and herbal toothpastes, which were prepared and analyzed for each of the six spike levels. The RSD was not more 20%, and the recovery was 80 to 120%.

2.7.2. Quality Control and Quality Assurance (QC/QA) Procedures

Quality control samples were prepared as follows (QCS-known value of 1500 mg/kg): 1.0 g of QCS sample was extracted in 80 mL ultrapure water under sonication, and the solution was made up to 100 mL, centrifuged for 5 min at 6000 rpm, and subsequently filtered through a 0.2 µm nylon syringe filter. The sample injected was 10 times diluted.

Quality control and quality assurance (QC/QA) were evaluated from the following:

Quality control sample: A known value of sample was prepared. The percent recovery was within 90–110%.

Duplicate sample preparation: Unknown samples were taken in duplicate. The variation was not more than 20%.

Spike sample preparation: An unknown sample spike was prepared with a 20.0 mg/kg concentration and was prepared in the same method as sample preparation. The recovery was found to be 80–120%.

Check Standard: The same standard preparation of 0.2 mg/L was injected as a check at the end of the sequence. The percent recovery was found to be 90–110%.

2.8. Limit of Quantification (LOQ)

The limit of quantification (LOQ) was estimated based on the signal-to-noise ratio of at least 10 times. Using this method, the limit of quantification value obtained for fluoride was 0.04%

2.9. Reporting Results

A calibration curve was used to understand the instrumental response to an analyte and predict the concentration in an unknown sample. Generally, a set of standard samples were made at various concentrations with a range than includes the unknown of interest and the instrumental response at each concentration is recorded. The analyte concentration in the test sample was calculated using Y = MX + C.

2.10. Ethical Consideration

This study received approval from the Institutional Review Board of An-Najah National University under reference number (lnt.R. March.2021/12).

2.11. Statistical Analysis

The data were analyzed using SPSS version 24 (Chicago, IL, USA). The qualitative variables were summarized as frequencies and percentages. For each fluoridated oral care product sampled, the total fluoride content (%) was measured and compared with both EU and UAE S/GSO regulations, which state that all finished fluoridated toothpastes must contain no more than 0.15% (1500 ppm) fluoride. Kruskal–Wallis and Mann–Whitney U tests were used to determine the median total fluoride content, and a p-value less than 0.05 was considered to be statistically significant.

3. Results

3.1. Sample Description

The sample baseline characteristics are shown in Table 1. A total of 50 toothpaste products were collected and analyzed in this study. Of the total, 30 (60%) of the active ingredients indicated in the formulation were sodium fluoride, 4 (8%) potassium nitrate/sodium fluoride, and 16 (32%) were sodium monofluorophosphate. The countries of origin of the sampled toothpastes were as follows: 20 (40%) were made in the European Union, 12 (24%) were made in India, 10 (20%) were made in the Middle East, and 8 (16%) were made in Russia.

Table 1. Number and Percentages of Sample Baseline Characteristics (n = 50).

Characteristics	Groups	Frequency	Percentage
Labeled active ingredient	Sodium Fluoride	30	60%
	Potassium Nitrate/sodium fluoride	4	8%
	Sodium Monofluorophosphate	16	32%
Country of origin	European Union	20	40%
	India	12	24%
	Middle East	10	20%
	Russia	8	16%

3.2. Estimation of Total Fluoride Concentration in Toothpaste Products

Estimates of the mean concentration with the confidence interval (CI) and standard deviation for the total fluoride content of toothpaste products are summarized in Table 2. Compared to the maximum allowable limit of $\leq$0.15%, the estimate for the average total

fluoride content was 0.193 with a 95% CI (0.11–0.27). Of the 50 tested toothpastes, 10 (20%) exceeded the recommended total fluoride level (≤0.15%). The relevant maximum allowable limits are displayed as vertical "cutoff" limits. The results of the total fluoride content stratified by sample characteristics of each sample are provided in Table 3.

Table 2. Descriptive Statistics of Total Fluoride in Toothpaste Products (n = 50).

	Maximum Allowable Limit	Products Exceeding Maximum Limit		Estimates of Concentration				
		N	%					
				Mean	±SD	95% CI		Median
Total Fluoride	≤0.15%	10	20%	0.193	0.284	0.11	0.27	0.107

Notes: Maximum allowable limits according to the EU regulation and UAE S. GSO, Abbreviations: LOD; limit of detection; LOD = 0.04% m/m, SD; standard deviation.

Table 3. List of Tested Toothpaste Products According to Total Fluoride Content and Sample Characteristics.

Sample Code	Claim in the Label	Active Ingredient	Country of Origin	Total Fluoride(%)
1	Supports the comforts of the gum	Sodium Fluoride	EU	0.04
2	Cleans and cools the mouth	Sodium Fluoride	EU	0.04
3	Cleans and cools the mouth	Sodium Fluoride	Russia	0.04
4	Cavity protection and teething aid	Sodium Fluoride	Russia	0.04
5	Cavity protection	Sodium Fluoride	EU	0.04
6	Cavity protection	Sodium Fluoride	EU	0.04
7	Cavity protection	Sodium Fluoride	Middle East	0.04
8	Cavity protection	Sodium Fluoride	India	0.04
9	Cavity protection	Sodium Fluoride	EU	0.04
10	Helps to strengthen the gums	Sodium Fluoride	EU	0.04
11	Cavity protection	Sodium Fluoride	EU	0.04
12	Tooth decay protection and helps prevent the appearance of dental plaque	Sodium Fluoride	EU	0.048
13	Cavity protection	Sodium Fluoride	EU	0.0497
14	Helps strengthen the tooth enamel and promote the prevention of cavities	Sodium Fluoride	EU	0.0497
15	Whitening and enamel protection	Sodium Fluoride	EU	0.04975
16	Whitening and enamel protection	Potassium Nitrate/sodium fluoride	EU	0.05

Table 3. *Cont.*

Sample Code	Claim in the Label	Active Ingredient	Country of Origin	Total Fluoride(%)
17	Protects and strengthens the milk teeth	Sodium Monofluorophosphate	EU	0.051
18	Protection against caries	Sodium Fluoride	EU	0.064
19	Cavity protection	Sodium Fluoride	EU	0.09
20	Reinforces the gums, anti-tartar action, and contains hydroxyapatite	Sodium Monofluorophosphate	EU	0.093
21	Cleans teeth, whitening, and enamel protection	Sodium Fluoride	EU	0.094
22	Protection and strengthens enamel	Sodium Fluoride	EU	0.094
23	Whitening, enamel protection, and reduces painful tooth sensitivity	Potassium Nitrate/sodium fluoride	EU	0.1
24	Whitening and enamel protection	Sodium Fluoride	EU	0.103
25	Cleans teeth and freshens the breath, antiseptic and antibacterial properties	Sodium Monofluorophosphate	EU	0.106
26	Tooth decay protection, helps prevent the appearance of dental plaque	Sodium Fluoride	EU	0.108
27	Helps strengthen the tooth enamel and promote the prevention of cavities	Sodium Fluoride	EU	0.11
28	Cavity protection	Sodium Monofluorophosphate	EU	0.116
29	Cavity protection	Sodium Monofluorophosphate	EU	0.116
30	Cavity protection	Sodium Monofluorophosphate	EU	0.116
31	Helps prevent cavities and tooth decay and helps reduce painful tooth sensitivity	Sodium Fluoride	EU	0.119
32	Cavity protection	Sodium Monofluorophosphate	EU	0.121
33	Cavity protection	Sodium Monofluorophosphate	EU	0.122
34	Cavity protection	Sodium Monofluorophosphate	EU	0.122
35	Cavity protection	Sodium Monofluorophosphate	EU	0.122

Table 3. *Cont.*

Sample Code	Claim in the Label	Active Ingredient	Country of Origin	Total Fluoride(%)
36	Cavity protection	Sodium Monofluorophosphate	EU	0.122
37	Cavity protection	Sodium Fluoride	EU	0.123
38	Cavity protection	Sodium Monofluorophosphate	EU	0.129
39	Whitening and enamel protection	Sodium Fluoride	EU	0.13
40	Tooth decay protection, helps prevent the appearance of dental plaque	Sodium Fluoride	EU	0.147
41	Helps reduce painful tooth sensitivity	Potassium Nitrate/sodium fluoride	EU	0.3152
42	Whitening and enamel protection	Potassium Nitrate/sodium fluoride	EU	0.3152
43	Whitening and enamel protection	Sodium Fluoride	EU	0.32
44	Whitening and enamel protection	Sodium Fluoride	EU	0.32
45	Whitening and enamel protection	Sodium Fluoride	EU	0.32
46	Whitening and enamel protection	Sodium Fluoride	EU	0.32
47	Helps prevent cavities and tooth decay and helps reduce painful tooth sensitivity	Sodium Monofluorophosphate	EU	1.1
48	Helps prevent cavities and tooth decay and helps reduce painful tooth sensitivity	Sodium Monofluorophosphate	EU	1.1
49	Whitening and helps reduce painful tooth sensitivity	Sodium Monofluorophosphate	EU	1.1
50	Cavity protection	Sodium Monofluorophosphate	EU	1.12

3.3. Comparison of Total Fluoride Content According to Sample Characteristics

Table 4 presents the distribution of the total fluoride content according to sample characteristics. The table also provides the estimates along with *p*-values. These *p*-values were provided from the results of the Kruskal–Wallis test. There was a statistically significant association between the labeled active ingredient and the total fluoride content. An increased risk of higher total fluoride content was observed in the toothpaste products with monofluorophosphate active ingredients compared to those products with potassium nitrate/sodium fluoride and sodium fluoride ($p = 0.011$).

Table 4. Comparison of Total Fluoride Content According to Sample Characteristics.

			Total Fluoride Content			
	Groups	**N**	**Mean**	**Median**	**±SD**	***p*-Value**
Labeled active ingredient	Sodium Fluoride	30	0.103	0.057	0.093	0.011
	Potassium Nitrate/Sodium Fluoride	4	0.195	0.208	0.140	
	Sodium Monofluorophosphate	16	0.356	0.122	0.445	
Country of origin	European Union	20	0.132	0.051	0.053	0.161
	India	12	0.113	0.121	0.007	
	Middle East	10	0.302	0.32	0.099	
	Russia	8	0.327	0.097	0.169	

p-value reported above for comparisons between variable levels ("categories-levels") using the Kruskal–Wallis test.

4. Discussion

Tooth brushing with fluoride-containing toothpaste is a key measure of public health to combat dental caries. Specifically, fluoride's dental caries-preventing properties mean that it is often added to a variety of dental products, including toothpaste and mouthwashes. These products have a topical effect on the surface of the teeth, and by using them regularly; individuals can protect themselves against dental caries. The aim of this study is to analyze the total concentrations of fluoride of the toothpastes currently available on the UAE market.

The sampled products evidenced an average total fluoride content of 0.193%, which is in excess of the level permitted under the current health and safety regulations in the UAE.

Among the 50 products tested, 10 exceeded the recommended concentration of total fluoride of less than 0.15%, while 12 had a total fluoride concentration that was less than was declared on their labels. Prior research across different countries has already evidenced some disparities between a product's actual concentration of total fluoride, and the concentration it claims to have [22–24]. Another study that analyzed children's toothpastes from a variety of countries found that about 85% had total fluoride concentrations that did not match those listed on their labels [25]. These stark disparities in toothpastes worldwide concerning their real and declared total fluoride concentrations can lead consumers to over- or under-consume fluoride, both of which have potentially harmful effects. Based on this, there is a need to routinely monitor and control dental products such as toothpaste [26].

Recent research in the form of a systematic literature review found that toothpastes do not have an anti-caries effect unless they contain at least 1000 ppm of fluoride. This underlines the importance of establishing robust standards on the amount of soluble fluoride contained in the formulations of toothpaste [15,27–29].

Nevertheless, this study has revealed that 22 of the sampled products had a total fluoride concentration below 1000 ppm fluoride, meaning that the amount of biologically active fluoride did not match the claims and indications given on the label.

One of the reasons for the observed mismatch between real and declared total fluoride concentrations could be the abrasive substances that are often included in toothpastes [30]. It should be noted that the toothpastes in the current study with a concentration of less than 1000 ppm total fluoride used abrasives based on calcium or aluminum. In the presence of sodium fluoride (NaF), the ions of these abrasive substances are known to reduce the fluoride content [31]. Specifically, in the presence of sodium monofluorophosphate, fluoride conjugates with phosphate through covalent bonds. As these bonds are unstable, they release F ions, which in turn react with the calcium ions [32], triggering the production of insoluble calcium fluoride (CaF2), which has neither remineralization [33] nor anti-caries effects [33].

In line with the findings of this study, Filho et al. [34] and Cury et al. [35] demonstrated that abrasive agents in toothpaste (typically calcium carbonate) and fluoride, generally

in the form of monofluorophosphate (MFP), are incompatible, reducing the total soluble fluoride concentration.

Further causes for the observed discrepancy between declared and actual total fluoride concentrations are manufacturing errors in toothpaste production, replacing high-cost ingredients with less costly alternatives, and higher storage temperature, which is known to lead to the instability of the fluoride [36].

Furthermore, it also emerged in this study that toothpastes with sodium monofluorophosphate (MFP) showed higher concentrations of total fluoride than products that were based on sodium fluoride. This is likely due to the fact that the sampled MFP toothpastes used a silica-based abrasive, meaning that the fluoride was in the free ionized form and thus almost entirely available. This finding highlights the urgent need to investigate the issues raised by the compatibility between abrasives containing both calcium and MFP [25]. Condeh et al. similarly demonstrated that dental products using silica-based abrasives and MFP, or also NaF, contain more total soluble fluoride; our study confirms these findings [37].

Interestingly, toothpastes claiming to mitigate the pain caused by sensitive teeth tended to show higher concentrations of total fluoride. This could be linked to the dose–response relationship between increasing fluoride content and enhanced anti-caries effects [38–40].

Our study raises concerning questions about the real-life anti-caries effects of the toothpastes sampled here in that the total fluoride concentration of most products did not match the labels' claims. Fluoride-based dental products have two crucial components, namely the availability fluoride and its stability; however, it has been shown that the abrasives contained in these products contribute to the inactivation of fluoride ions, leading to a product with low soluble fluoride that offers a substantially degraded anti-caries effect.

This study raises important implications for the manufacturers of fluoride-based toothpaste. In particular, they must address discrepancies observed here between the total fluoride concentration claimed on the label and the actual concentration in the product. Thus, the current UAE regulations in this regard need to be re-examined in terms of their effectiveness to mitigate the lack of quality control and compliance among manufacturers. The relevant authorities should hereby also ensure that such products are in compliance with the labelling and packaging legislation of the UAE market.

5. Conclusions

By enforcing stricter quality and safety control of fluoridated toothpastes in the UAE through regulations, good manufacturing practices (GMP), education, research, and adverse event reporting, it will be possible to promote better oral health among the population through increased caries protection. In addition, dental practitioners monitoring the use of fluoridated toothpastes in their patients should enquire about any further sources of fluoride, thereby ensuring the prevention of caries while reducing the risk of dental fluorosis in children under 8 years of age whose permanent teeth are developing.

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Conflicts of Interest: The authors declare no conflict of interest.

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