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Estimation of fluoride levels in indigenous Ayurvedic preparations prescribed for infants, toddlers, and preschool children in Kerala, India

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Abstract

Background: Optimal feeding of children with adequate nutrients is regarded as the most effective method for proper growth and development, which occurs rapidly during the first few years of life. In this regard, Ayurvedic nutritional supplements and herbal medicines are given in infancy and early childhood. This age group is of utmost importance in dentistry. Plants and herbal derivatives are rich sources of fluoride. Hence, monitoring of ingested fluoride levels during this stage is of utmost importance to optimize its intake and avoid toxicity. The study assessed and compared the fluoride concentration in preparations of indigenous Ayurvedic prescribed for infants, toddlers, and preschool children in Kerala, India.

Methods: In this laboratory study, three samples each of nine indigenous Ayurvedic preparations of solid, semi-solid, and liquid forms were used. Fluoride level was measured by high range fluoride colorimeter—Checker HC—Hanna Instruments, based on sodium 2-(parasulphophenylazo)-1,8-dihydroxy-3,6-naphthalene disulphonate (SPADNS) method, and recorded in parts per million (ppm).

Results: Among powder forms, the highest fluoride concentration was observed for Gopichandanadi (2.40 ± 2.02 ppm). Among semi-solid and liquid forms, the highest concentration was found in Chyavanaprasha (1.30 ± 1.73 ppm) and Indukantham syrup (9.8 ± 0.10 ppm), respectively. The highest mean fluoride concentration was obtained from liquid forms, followed by solid forms, and the lowest one was present in semi-solid forms.

Conclusion: Although the concentration of fluoride varied across the various forms of preparation, none of them exceeded the safely tolerated dose (STD) of 8-16 mg/kg.

Keywords: Fluorides, Medicine, Ayurvedic, Infant, Child

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Introduction

Ayurveda is considered the oldest system of medicine in India. The verbatim meaning of Ayurveda is 'the science of life', which is the blend of two Sanskrit words, *Ayur* (life) and *Veda* (science or knowledge) (1).

Kerala is renowned for its splendid source of flora and fauna, which has played a pivotal role in the development of the ayurvedic system of medicine (2). In a state like Kerala, where Ayurveda is widely practiced, multiple nutritional supplements and herbal medicines are prescribed for children in their infancy and early childhood for better growth and development. This age group is of utmost importance in dentistry. Herbal medicines dominate the practice of Ayurveda (3). Plants and herbal derivatives are rich sources of fluoride (4).

Fluorine, a naturally occurring element, is found universally in water, animals, plants, and soil. The age window for dentition development begins around birth and continues to almost 8 years of age. During this period of the development of dentition, fluoride exerts its systemic effects. It supports and promotes the mineralization and maturation of bones and teeth. Depending on the dosage ingested and the age of the patient, fluoride acts as a drug, nutrient, and poison (4). In dentistry, in optimum

amounts, it exerts cariostatic effects, whereas beyond the safe limits, toxicity occurs either in acute or chronic forms (4).

The global prevalence of fluorosis is reported to be 32% (5) and it is considered endemic in 25 countries including India. In India, fluorosis as a public health problem is alarming, with around two-thirds of states being fluoride endemic. Over 10 million people suffer from dental fluorosis, which is considered to be a dental public health burden (6). The World Health Organization (WHO) reported that mottling of teeth (i.e., dental fluorosis) is occasionally linked with fluoride levels in drinking water above 1.5 parts per million (ppm) (7), and crippling skeletal fluorosis may arise when fluoride levels exceed 10 ppm (7,8).

Multiple studies have been conducted to assess the prevalence of fluorosis in Kerala. Even though skeletal fluorosis has not yet been reported from the Kerala state so far, there have been collective reports of several manifestations of non-skeletal fluorosis like vague abdominal discomfort, dyspepsia, fatigue, etc (9). In Kerala, dental fluorosis is reported to be endemic in the districts of Alappuzha and Palakkad. A community-based, cross-sectional survey of 10-17-year-old children from Ambalappuzha taluk of Alappuzha district revealed that the overall prevalence of dental fluorosis was 35.6% (10).

The climate of Kerala is characterized predominantly by tropical monsoon with seasonally excessive rainfall and hot summer. The fluoride intake from multiple sources especially drinking water should be monitored with caution because the major risk factor for the development of fluorosis is the total amount of fluoride consumed from all sources during the critical period of tooth development. Thus, it is vital not only to identify the main sources of fluoride intake but also the amount ingested to produce pronounced beneficial or toxic effects on general and dental health (11,12). Hence, monitoring of ingested fluoride levels during the development stages of dentition is of utmost importance to optimize its intake and avoid toxicity in the early childhood period (13).

Fluoride intake from these indigenous Ayurvedic preparations consumed in the early childhood period acts as an indicator of total fluoride intake, which could be used in planning a prevention program against caries and fluorosis. Several studies have estimated the fluoride concentrations in infant food and milk formulas in a few countries (11,13); however, no studies have been reported so far evaluating the concentrations of fluoride in indigenous Ayurvedic preparations in India. Hence, to address this gap in the literature, the present study aimed to estimate and compare the fluoride concentration in various solid, semi-solid, and liquid forms of indigenous Ayurvedic preparations prescribed as medicaments and nutritional supplements for infants, toddlers, and preschool children in Kerala, India.

Materials and Methods

The present laboratory study was conducted on three different (solid, semisolid, and liquid) forms of indigenous Ayurvedic preparations prescribed for infants, toddlers, and preschool children in Kothamangalam, Kerala. Figure 1 shows the study location. A protocol for the intended study was submitted to the Institutional Ethics Committee, and the clearance certificate was obtained before the commencement of the study (Ref No. IEC/IGIDS/04/2022). The study was conducted from July 2022 to September 2022.

Indigenous Ayurvedic preparations used in the present study

For the present study, Ayurvedic preparations commonly prescribed for the growth and well-being of children were selected based on an active search of previous literature (1,2). As the composition of these formulations presents minor variations indigenously, recommendations and suggestions put forward by experienced practitioners in the field of Ayurveda were also taken into account before selecting the products. A total of nine different ayurvedic products in solid, semi-solid, and liquid forms were chosen based on convenience sampling, and three samples of each of the same products were tested for fluoride content. Among these three samples of each product, one was prepared locally under the direct supervision of a registered Ayurvedic practitioner. The other two samples of the same product were purchased from two different branded manufacturers.

Figure 1. Location of the present study

Various forms of Ayurvedic preparations used in the study

- Solid form (tablet and *churna*/powder): Three samples each of Ashtachoornam, Rajanyadichoornam, Navadhanyam powder, and Gopichandanadi tablet, constituting a total of 12 samples.
- Semi-solid form (*Avaleha*): Three samples of Chyavanaprasha and Narasimharasayanam, constituting six samples.
- Liquid form (*Arishta* and *Sarkara Kalpana*): Three samples of Aswagandharishtam, Saraswatharishtam, and Indukantham syrup, constituting nine samples.

The preparation of each sample followed the composition and guidelines provided in the existing literature (Table 1) (14-20).

Fluoride estimation method

Fluoride level was measured by high-range fluoride colorimeter—Checker HC—Hanna Instruments, based on the SPADNS method. The instrument was calibrated with standard fluoride solutions. In this colorimetric test, fluoride reacts with the Zirconium dye lake, dissociating a portion of it into a colorless complex anion and the dye. As the amount of fluoride rises, the color produced becomes gradually lighter compared to fluoride standard solutions (21). The fluoride estimation was expressed in parts per million (ppm). To ensure better consistency of the results, each sample was analyzed in triplicate. The fluoride level assessment and its recordings were done by the calibrated and trained principal investigator.

Statistical analysis

Data on the concentration of fluoride were collected and entered into a Microsoft Excel sheet. For the ease of analysis, the samples were coded. Descriptive and analytical statistics were computed using SPSS version 19 software (SPSS Inc., Chicago, IL, United States). Descriptive statistics with means and standard deviations were calculated. The normality of the data collected was analyzed using the Shapiro-Wilk test. It was found that the data were not normally distributed; hence, non-parametric tests were used. The Mann-Whitney U test and Kruskal-Wallis test were applied for intragroup and intergroup comparisons, respectively. The concentration of fluoride was expressed as the mean ± standard deviation. A P value of < 0.05 was considered significant.

Results

The analysis showed variations in fluoride concentrations

Table 1. Composition and dosage of the samples used in the present study

Samples used	Composition	Administration and dosage
Ashtachoornam (14)	*Carum coptycum*, *Cuminum cymium*, *Ferula asafetida*, *Nigella sativa*, *Piper longum*, *Piper nigrum*, *Zingiber officinale*, and rock salt.	1-5 g as directed by the physicians.
Rajanyadichurnam (15)	*Curcuma longa*, *Cedrus deodara*, *Pinus roxburghi*, *Piper chaba, Solanum indicum*, *Solanum xanthocarpum*, *Uraria picta* and *shatahva*, *Anethum sowa*.	1-3 g along with water, honey, or milk before or after food or as directed by the physician.
Navadhanyam powder (16)	*Eleusine coracana*, *Pennisetum typhoides*, *Andropogan sorghum Panicum miliaceum*, *Panicum ittalicum*, *Oryza sativa*, *Triticum vulgare*, *Paspalum scrobiculatum*, and *Echinochloa frumentacea*.	As directed by the physician.
Gopichandanadi tablet/ gulika (17)	*Hemidesmus indicus*, *Santalum album*, *Plectranthus vettiveroides*, *Terminalia chebula, Phyllanthus emblica*, *Terminalia bellirica*, *Cyperus rotundus*, *Elettaria cardamomum*, *Cinnamomum verum*, *Cinnamomum tamala*, *Mesuea ferrea*, *Myristica fragrans* (Mace), *Myristica fragrans* (Nutmeg), *Syzygium aromaticum*, *Cinnamomum camphora*, *Piper cubeba*, *Vitis vinifera*, *Swertia chirata*, *Cuminum cyminum*, *Nigella sativa, Foeniculum vulgare*, *Quercus infectoria*, *Curcuma longa*, *Rotheca serrata*, *Myristica malabarica*, *Alpinia galangal*, *Lepidium sativum*, *Vetiveria zizanoides*, *Crocus sativus*, *Ferula assa-foetida*, *Acorus calamus*, *Allium sativum*, *Cedrus deodara*, *Glycyrrhiza glabra*, *Solanum anguivi*, *Ox gall*, *Anacyclus pyrethrum*, *Trachyspermum ammi*, *Michelia champaca*, *Elaeocarpus serratus*, rock salt, *Elettaria cardamomum*, *Cullen corylifolium*, *Zanthoxylum alatum*, *Holarrhena pubescens*, *Coriandrum sativum*, *Embelia ribes*, *Hedychium spicatum*, *Cyclea peltate*, *Zingiber officinale*, *Piper nigrum*, *Piper longum*, *Vernonia anthelmintica*, sugar, *Citrus lemon*, and *Plectranthus amboinicus*.	As directed by the physician.
Chyavanaprasha (18)	The major components include *Dasamoolam*, *Sida cordifolia*, *Piper longum*, *Phyllanthus niruri*, *Elettaria cardamomum*, raisins, *Santalum album*, *Tinospora cordifolia*, *Adhatoda beddomei*, *Withania somnifera*, *Emblica officinalis*, *Cow ghee*, Ginger, *Sugarcandy*, *Chathurjathakam*, Honey, and *Curcuma angustifolia*.	12-28 g to be taken with milk (100-250 mL) on an empty stomach in the morning.
Narasimharasayanam (17)	*Saccharum officinarum*, *Saccharum officinarum*, *Honey*, *Butter*, *Milk*, *Eclipta prostrata*, *Asparagus racemosus*, *Acacia catechu*, *Plumbago zeylanica*, *Dalbergia sissoo*, *Pterocarpus marsupium*, *Terminalia chebula*, *Embelia ribes*, *Terminalia bellirica*, *Semecarpus anacardium*, and iron.	5-15 g.b.d., followed by rice gruel prepared in milk.
Aswagandharishtam (19)	*Withania somnifera*, *Curculigo orchioides*, *Rubia cordifolia*, *Glycyrrhiza glabra*, *Ipomoea mauritiana*, *Santalum album*, *Acorus calamus*, *Hemidesmus indicus*, *Curcuma longa*, *Alpinia calcarata*, *Elettaria cardamomum* and honey.	12-24 ml twice daily after food or as advised by the physician.
Saraswatharishtam (20)	*Bacopa monnieri*, *Ipomoea mauritiana*, *Asparagus racemosus*, honey, sugar, *Merrimia turpethum*, *Acorus calamus*, *Withania somnifera*, *Tinospora cordifolia*, *Embelia ribes*, gold (24 carat-processed).	2-4 drops preferably with milk at bedtime.
Indukantham syrup (17)	*Holoptelea integrifolia*, *Cedrus deodar*, and Dasamoolam.	5-10 ml twice daily.

Table 2. Mean fluoride concentration (expressed as mean ± standard deviation) in Ayurvedic preparations of solid forms

Ayurvedic preparation	Fluoride concentration (in ppm)	Range	Kruskal Wallis ANOVA	Mann Whitney U test
Ashtachoornam	1.33 ± 1.36	0.4-2.9	$X^2 = 4.25$	1=2, $P = 0.13$
(code 1)			$P = 0.24$	
Rajanyadichurnam	0.70 ± 0.62	0.2-1.4		1=3, $P = 0.21$
(code 2)				1=4, $P = 0.32$
Gopichandanadi	2.40 ± 2.02	0.9-4.7		2=3, $P = 0.16$
tablet (code 3)				2=4, $P = 0.24$
Navadhanya powder (code 4)	0.40 ± 0.52	0.0-1.0		3=4, $P = 0.15$

*Significant at $P < 0.05$.

in the three forms of Ayurvedic medicaments and nutritional supplements.

The mean fluoride concentrations varied across the multiple solid forms, the results are presented in Table 2. The highest mean fluoride concentration was recorded for the tablet form of Gopichandanadi (2.40 ± 2.02 ppm) when compared to the powder forms. No statistically significant difference was observed among the powder forms: Ashtachoornam, Rajanyadichurnam, and Navadhanya powder ($P = 0.44$).

Table 3 shows the mean fluoride concentration present in semi-solid form (*Avaleha*) in Narasimharasayana and Chyavanaprasha. None of the three samples of Narasimharasayana showed the presence of fluoride.

The mean fluoride concentration presented in liquid form (Arista and Sarkara Kalpana) of Ayurvedic preparations of Saraswatharishtam, Aswagandharishta, and Indukantham syrup is presented in Table 4. Among all three preparations, Indukantham syrup had the highest fluoride concentration (9.8 ± 0.10), whereas, between the two arista forms, Saraswatharishta (4.17 ± 3.79 ppm) had a higher fluoride concentration than Aswagandharishta (3.07 ± 2.57 ppm).

Figure 2 gives the overall comparison of the mean fluoride concentration of nine tested preparations in varied forms. The highest mean value was obtained for the liquid form, Indukantham syrup, amongst all the products (9.8 ± 0.10 ppm), whereas the lowest one was obtained from the semi-solid form, Narasimharasayana (0 ppm). Table 5 summarizes the overall mean fluoride concentration in various forms of indigenous Ayurvedic preparations. The highest mean fluoride concentration was obtained from liquid form (32.41 ± 43.25 ppm), followed by solid form (1.20 ± 1.35), and the lowest one was found to be present in semi-solid form (0.65 ± 1.30 ppm). This difference among the three different forms was observed to be statistically different ($P = 0.016$).

In solid and semi-solid forms, estimated fluoride concentration varied from 0.0-4.7 and 0.0-3.3 ppm, respectively, whereas in liquid forms, it was 0.0-9.9 ppm. The results showed that the estimated levels in all three forms were confined within the safely tolerated dose (STD) of 8-16 mg/kg (22).

Discussion

The regional growth of indigenous medicine in Kerala, especially Ayurveda, has significantly contributed to the development of primary child health care (2). The rarer side effects and easy availability of preparations have contributed to an increased faith and interest of the general public in opting for the Ayurvedic system (23). Ayurveda is predominated by herbal medicines, most of which are rich sources of fluoride. Fluoride is available from numerous sources, either in the form of diet, nutritional supplements, or medicaments. Fluorosis presents itself as a significant public health issue globally. Dental and skeletal fluorosis are irreversible, yet preventable. The most efficient mode is primary prevention by maintaining safe limits of fluoride intake and the recommended fluoride concentration in drinking water as suggested by the WHO (1.5 mg/L) (24). It is of great significance to assess the amount of fluoride ingested in the early childhood period, as it is considered the window period of tooth development. Analysis of fluoride from nutritional supplements and medicine is the primary step in monitoring fluoride ingestion in infants and children (3,4).

The present study attempted to assess the fluoride concentrations in indigenous Ayurvedic preparations prescribed for infants, toddlers, and preschool children in Kerala, India. So far, no studies have been reported estimating the fluoride concentrations from indigenous Ayurvedic preparations for this age group. Hence, comparisons are done with the limited literature available. The present study is the first of its kind to evaluate fluoride concentrations from multiple Ayurvedic preparations. The 27 samples used in the study were chosen through a thorough literature search and discussions with experienced Ayurvedic practitioners.

Different forms of preparation were used in the study

The common forms available in Ayurveda include solid, semi-solid, and liquid forms. In the present study, the solid (Churna/Choornam), semi-solid (Avaleha), and liquid forms (Arista and Sarkara Kalpana) of Ayurvedic

Table 3. Mean fluoride concentration (expressed as mean ± standard deviation) in Ayurvedic preparations of semi-solid forms

Ayurvedic preparation	Fluoride concentration (in ppm)	Range	Mann Whitney U test
Chayavanaprasha (code 5)	1.30±1.73	0.2-3.3	*P*= 0.04*
Narasimha rasayana (code 6)	0	0	

*Significant at $P<0.05$.

Table 4. Mean fluoride concentration expressed as (mean ± standard deviation) in Ayurvedic preparations of liquid forms

Ayurvedic preparation	Fluoride concentration (in ppm)	Range	Kruskal Wallis ANOVA	Mann Whitney U test
Saraswatharishtam (code 7)	4.17±3.79	0.0-7.4	$X^2=5.79$	7=8, $P=0.15$
Aswagandharishta (code 8)	3.07±2.57	0.0-4.7	$P=0.056$	7=9, $P=0.07$ 8=9, $P=0.39$
Indukantham syrup (code 9)	9.80±0.10	9.4-9.9		

*Significant at $P<0.05$.

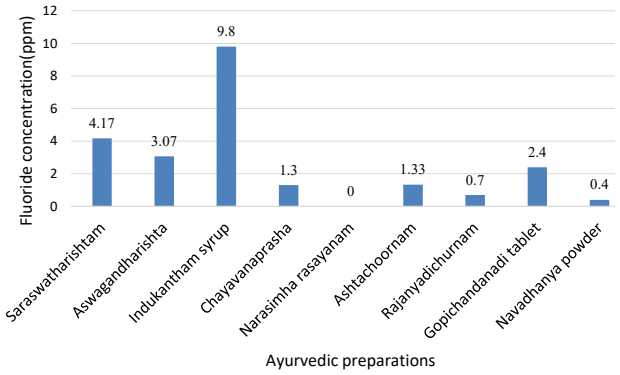

Figure 2. The mean fluoride concentration (expressed in ppm) in multiple solid, semi-solid, and liquid forms of Ayurvedic preparation

Table 5. Overall mean fluoride concentration expressed as (mean ± standard deviation) of Ayurvedic preparations in solid, semi-solid, and liquid form

Ayurvedic preparation	Total Number of samples	Fluoride concentration (ppm)	*P* value
Solid forms	12	1.20±1.35	0.016
Semi-solid forms	6	0.65±1.30	
Liquid forms	9	5.41±4.25	
Overall	27	11.48±28.35	

preparations were assessed. The general factors affecting the selection of medicinal preparation forms include taste, palatability, swallowability, appearance, color, and smell (25). Even though factors like the size and shape of the tablet as well as the palatability of liquid medicine alternatives play a pivotal role in selecting the form of medicine, it is generally believed that traditional tablets may be accepted by children (26). Oral formulations have been predominantly advised to be administered with *Madhu* (honey) and *Ghrita* (ghee) (27).

It is well documented in Ayurvedic literature that solid dosage forms give palatability, a long half-life, and easy administration, whereas liquid dosage forms offer good bioavailability and are mainly preferred for children (28). The advantage of semi-solid dosage forms is that they have a longer contact time. Internal medicaments like Avaleha in semi-solid form have been chosen to facilitate their solubility and increase their nutrient values (29). According to some researchers, liquid emerged as the most popular dosage form compared to others. This could be attributed to the least risk of choking, ease of swallowing, and better facility of dose flexibility, especially for pediatric age groups (25).

Fluoride concentrations in food and nutritional supplements for children

Few studies have been reported in the literature estimating the amount of fluoride exposure from infant formula and food supplements. The average daily intake of infants ranges from 0.16–0.26 mg/kg (7), 0.018–0.29 mg/kg (9), and 0.05–0.07 mg/kg (30). In the present study, among the various Ayurvedic preparations, Chyavanaprasha and Navdhanya powder were given as diet/nutritional supplements for children (16,18). The mean fluoride concentration in Chyavanaprasha and Navdhanya powder was estimated to be 1.30 ± 1.73 ppm and 0.40 ± 0.52 ppm, respectively. There is a paucity of research in the literature related to this aspect; hence, comparisons are not possible.

Intragroup comparison of fluoride concentration

In the present study, fluoride levels were compared among the various solid forms, semi-solid forms, and liquid forms separately. Although there were minor variations, comparable results were obtained for preparations

made under the direct supervision of practitioners and preparations commercially available.

Fluoride concentration in solid forms of Ayurvedic preparations

Among the solid forms, the highest value was obtained from Gopichandanadi tablets and the lowest one from Navadhanya powder. The intragroup variations in fluoride concentrations could be attributed to the compositional variations.

Fluoride concentration in semi-solid forms in Ayurvedic preparations

A probable explanation for the high fluoride content of Chyavanaprasha among semi-solid forms could be the relatively higher number of herbal ingredients involved in its preparation (18), thus, projecting it as a rich source of fluoride.

Fluoride concentration in liquid forms of Ayurvedic preparations

When the liquid forms were compared, Indukantham syrup (9.80 ± 0.10 ppm) showed comparatively higher fluoride concentrations than others. The samples of the same product marketed under different brand names showed variations. Despite the comparable composition and concentration of ingredients, variations in fluoride levels obtained for the same product from different manufacturers would be the result of natural (intrinsic) and/or extrinsic differences. Most of the herbs used for Ayurvedic practice in Kerala are locally grown and cultivated. Those variations that are present in the composition of natural products are called natural (intrinsic) variations. There may be considerable variations between two samples derived from the same plant species. Diverse varieties of the same plant may show changes in composition based on country of origin, growing environments, and storage. It has been reported that the concentration of fluoride is higher in plants that grow in acidic soil compared to those grown in alkaline soil. Storage is another major factor that influences the final nutrient and element content (30). Extrinsic variations are supplementary dissimilarities in the fluoride content of individual foods and drinks that can be presented by caterers, manufacturers, and in the home. Changes in proportional amounts and types of ingredients may result in an alteration of the fluoride content of the prepared product. Products processed with fluoridated water may contain more fluoride than those processed with low-fluoride water. As a result, those preparations that are made using tap water may contain variable amounts of fluoride as to those made from other sources. Other extrinsic factors of Ayurvedic preparations include the use of additives (e.g., spices, honey, pepper, or salt), which can result in variations in the fluoride content of the final preparations and the physical properties as well as the chemical composition of the cooking vessel, which may affect the fluoride content of the preparations (30).

Intergroup comparisons of fluoride concentration

The liquid forms exhibited higher concentrations than the solid forms, followed by semi-solid forms. Sakara Kalpana (syrup) contains more water and sugar content than solid forms (31). Apart from the basic differences in their composition and formulation, the higher fluoride concentrations in liquid forms could be attributed to the presence of water content used for their preparation, which itself has proven to be a potent fluoride source (32,33). Studies have reported a higher fluoride content in alcohol (34). Arista contains alcohol produced by the fermentation process (31), which could contribute to a relatively higher fluoride concentration than that present in solid forms.

Strengths and limitations of the study

The present study is the first of its kind to evaluate fluoride concentrations from multiple Ayurvedic preparations. Based on a thorough literature search and discussions with experienced Ayurvedic practitioners, 27 samples were chosen. To minimize the bias, all possible attempts were made. The principal investigator was well-trained and calibrated to avoid errors in conducting the assessment and recording the results. The samples were tested three times to guarantee their reliability and reproducibility.

A potential limitation of this study is the limited number of preparations analyzed. Only the products of three different companies were used in the present study. The same preparations from multiple brands could have been assessed for a better comparison of fluoride levels. Another possible limitation is that we could not adequately compare our results due to the scarcity of research in this field.

The fluoride metabolism comprises absorption, distribution, and excretion phases (35). The exact amount of fluoride absorbed depends on multiple factors like source, time and amount of ingestion, the vehicle used, and the systemic health of the individual (36). In Ayurveda, commonly recommended vehicles for drug ingestion are milk, honey, rice, gruel, or water, all of which have got significant impact on its absorption (14-20).

Implications of the study

Because of the dual behavioral characteristics of fluorides (anticaries and toxic effects), their levels should be monitored with extreme caution, especially when supplied to infants and children. The total ingestion of fluoride from all sources is taken into consideration when safe levels are derived. The fluoride status of the human body depends on diverse factors, including the fluoride content

of natural drinking water, the amount and duration of total ingestion, the productivity of intestinal absorption, and renal excretion. It is practically impossible to estimate fluoride from all the sources. The introduction of a regulatory approach emphasizing mandatory labeling of the fluoride content of the product marketed would improve the situation and help dental practitioners prescribe the optimum amounts of other fluoride supplements for children. All possible attempts should be made to ensure that optimal amounts of fluoride are ingested in this early period of tooth development.

Public health significance and recommendations

The samples used in this study are composed of readily available and locally grown plants and their products, many of which are known to accumulate fluoride. The related public health problems of fluorosis and dental caries are preventable diseases, provided proper monitoring of fluoride levels is done. Hence, the estimation of fluoride levels from various sources of fluoride exposure helps in the proper planning and implementation of related public health programs and policies. To get a deeper insight into the variations in fluoride levels recorded in the present study, the extrinsic and intrinsic factors involved should be taken into account. Also, estimations from other sources should be assessed to obtain an overall picture of fluoride ingestion. Hence, extensive research in this regard is recommended.

Conclusion

The present study attempted to assess the fluoride concentrations in indigenous Ayurvedic preparations prescribed for infants, toddlers, and preschool children in Kerala. Based on a thorough literature search and discussions with experienced Ayurvedic practitioners, 27 samples of nine different products were chosen and assessed. Among the powder forms, the highest mean fluoride concentration was observed for Ashtachoornam (1.33 ± 1.36 ppm). Among the semi-solid forms, the highest mean fluoride concentration was found to be present in Chyavanaprasha (1.30 ± 1.73 ppm). Among all three liquid preparations, Indukantham syrup showed the highest fluoride concentration (9.8 ± 0.10 ppm). The highest mean fluoride concentration was obtained from liquid forms, followed by solid forms, and the lowest one was found to be present in semi-solid forms. Even though the fluoride concentrations varied from form to form, in none of them, it exceeded the STD of 8-16 mg/kg. As the amount of fluoride depends on the exposure from multiple sources, the exact estimation of fluoride ingested by individuals from such sources requires extensive investigations, and further studies are recommended in this regard.

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None.

Authors' contributions

Conceptualization: Subramaniam Ramanarayanan, Suneesh Kuruvilla, Jesline Merly James.
Data curation: Ameena Mayeen Siyad.
Formal analysis: Subramaniam Ramanarayanan, Jesline Merly James.
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Software: Jesline Merly James and Subramaniam Ramanarayanan.
Supervision: Jesline Merly James.
Validation: Priya Babu.
Visualization: Subramaniam Ramanarayanan.
Writing–original draft: Jesline Merly James and Gis George.
Writing–review & editing: Priya Babu, Subramaniam Ramanarayanan, Suneesh Kuruvilla.

Competing interests

None.

Ethical issues

A protocol for the intended study was submitted to the Institutional Ethics Committee, and the clearance certificate was obtained before the start of the study (Ref No. IEC/IGIDS/04/2022).

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