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Analyzing pH and Fluoride Levels Using Instrumental Methods in Everyday Essentials: Varied Health Implications

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Abstract

In the sphere of everyday consumer goods, carbonated juices, body cleansers, and toothpaste are integral to daily routines, each fulfilling specific needs and preferences. Carbonated juices, packed juices celebrated for their effervescence and vibrant flavours, are popular as refreshing beverages and sensory experiences they offer, characterized by a unique mouthfeel and auditory pleasure. Body cleansers, including products like shampoos and soaps, are essential for personal hygiene, meticulously formulated to cleanse the skin and hair by removing dirt, oil, and impurities. Toothpaste, a critical oral hygiene product, is designed to maintain oral health by fighting dental plaque, cavities, and gum disease. This research paper aims to provide a comprehensive analysis of pH and fluoride content in these products and potential health effects, utilising pH meters and colorimeters. The goal of this study is to explore the variation of pH of these products and assess the fluoride content in each. pH is the key determinant in determining product safety and physiological influence, especially on oral health, skin and dietary balance and Fluoride in toothpaste inhibits the demineralization of tooth enamel. Through the application of a pH meter and Colorimeter this research offers insight into the safety and health of everyday products consumed.

Keywords

- Fluoride
- Health
- pH

Introduction

The origins of **carbonated beverages** can be traced back to the late 18th century with the invention of carbonation, which led to the creation of sparkling water and eventually a variety of flavoured sodas. Carbonated beverages, often referred to as soft drinks, are a prevalent feature in contemporary consumer habits, enjoyed by individuals of all ages globally. These drinks are characterized by their signature effervescence, a result of carbon dioxide gas dissolved under pressure. The carbon dioxide in these beverages produces bubbles and a fizzy sensation that is commonly associated with refreshment and enjoyment. This effervescence, combined with various flavorings, sweeteners, and sometimes caffeine, has made carbonated beverages a favored choice among consumers seeking both taste and refreshment. From a chemical standpoint, carbonation involves dissolving CO2 in water under high pressure, resulting in the formation of carbonic acid. This weak acid contributes to the tangy taste of carbonated drinks and affects their shelf life and mouthfeel.

Packaged fruit juices constitute a vital part of the global beverage market, offering a convenient and often healthier alternative to sugary soft drinks. These juices, extracted from a wide range of fruits, provide essential vitamins, minerals, and other nutrients, making them a popular choice among health-conscious consumers. The processing of fruit juices involves several steps, including extraction, pasteurization, and sometimes the addition of extra nutrients. Advanced packaging methods, such as aseptic processing and Tetra Pak cartons, ensure the juice remains fresh and of high quality without needing preservatives. These innovations have contributed to the widespread availability and convenience of packaged fruit juices, meeting the demands of modern, busy lifestyles.

Body cleansers are essential for personal hygiene, designed to cleanse, refresh, and care for the skin. These products, which include body washes, soaps, and shower gels, effectively remove dirt, oil, sweat, and other impurities while providing hydration and nourishment. Over time, body cleansers have evolved from simple soap bars to advanced formulations that address various skin types and concerns.

Modern body cleansers typically contain a mix of surfactants, which emulsify and remove impurities, and conditioning agents that help maintain the skin's natural moisture. Ingredients such as glycerin, oils, and botanical extracts are commonly added to enhance the cleansing experience and provide additional skin benefits. The development of sulfate-free and paraben-free formulations has also responded to consumer demand for gentler, more natural products. Chemically, the effectiveness of body cleansers depends on the balance between cleansing and conditioning agents. Surfactants, such as sodium lauryl sulfate (SLS) and sodium laureth sulfate (SLES), are effective at removing oils and dirt but can be drying to the skin. Therefore, modern formulations often use milder surfactants and additional emollients to ensure gentle yet effective cleansing.

Toothpaste is a crucial part of oral hygiene routines, vital for maintaining dental health and preventing oral diseases. Used with a toothbrush, it helps clean teeth, remove plaque, and

prevent cavities, gingivitis, and bad breath. Over the years, toothpaste formulations have evolved to include a variety of ingredients that enhance its effectiveness and appeal.
Contemporary toothpaste typically consists of abrasives, fluoride, humectants, detergents, flavoring agents, and sometimes therapeutic compounds. Abrasives like calcium carbonate and hydrated silica assist in removing plaque and surface stains

The toothpaste market is diverse, offering products for various needs, including whitening, anti-cavity, tartar control, sensitivity relief, and gum health. Chemically, the effectiveness of toothpaste depends on the synergy of its active ingredients. Fluoride is particularly important in oral health, promoting remineralization and inhibiting the demineralization of tooth enamel. Abrasives must be effective enough to clean without damaging the enamel or dentin. The balance of these components ensures that toothpaste not only cleans but also protects and strengthens teeth.

The Relationship between these day-to-day essentials and analysis is distinguished as an important role in the human-kind, where Analytical chemistry comes in place, as a scientific discipline, is intricately concerned with the qualitative and quantitative examination of matter, as well as its structural elucidation. There are three pillars—qualitative analysis, quantitative analysis, and structural analysis—are foundational to the field. Here Qualitative and Quantitative analysis, which is the primary focus of this chapter, holds significant importance as it establishes the nature of the sample's components. This foundational step is crucial because it identifies the specific substances present within a sample. On the other hand, quantitative analysis is concerned with determining the precise amount of these substances, thus addressing the 'how much' aspect of the components within a sample.

Requirements

2 Sets of the sample of carbonated beverages, packages of fruit juices, Body cleanser Soap and shampoo, 3 different toothpastes, 250 ml of Sodium Fluoride, Alizarin Red-s , Zirconyl Nitrate, Standard flask, beaker, Water, Stirrer, pH meter and Colorimeter.

Methodology

To Determine the pH of the samples:
Firstly, we need to know what pH is.
In basic terminology, all aqueous solutions whether acidic, alkaline or neutral contain both hydrogen(H+) and hydroxyl(OH-) ions. The greater concentration of H+ or OH- shows whether the solution is acidic or alkaline. That is the pH.

First step is to switch ON the pH meter and second most important is to calibrate the pH meter. To calibrate a pH meter, the electrode is immersed in at least two standard buffer solutions with known pH values. Typically, buffer solutions will have a pH of 4.0, 7.0 and 10.0. This process is conducted in calibration mode, where the pH meter is adjusted to recognize these standard values, ensuring accurate pH measurements during subsequent testing. After the calibration thoroughly cleanse the electrode by rinsing it with deionized water. After cleaning, gently dry the electrode with scientific wipes to prevent any dilution of the sample to be tested. Once prepared, immerse the electrode in the solution and take its reading.

Why is it important to Calibrate?
By calibrating the pH meter using these buffer solutions, we can ensure it measures the pH of our samples accurately despite any variations in the electrode. Implementing effective calibration protocols is essential for maintaining measurement accuracy and data integrity in our laboratory settings. This procedure accounts for potential electrode discrepancies and stabilizes the instrument's performance, thereby providing reliable and reproducible results in pH measurements.

To determine the amount of Fluoride in the Toothpaste:
Weight 0.195 g of these 3 samples of toothpaste and dilute it by water in a standard flask

Sample after the dilution with H20

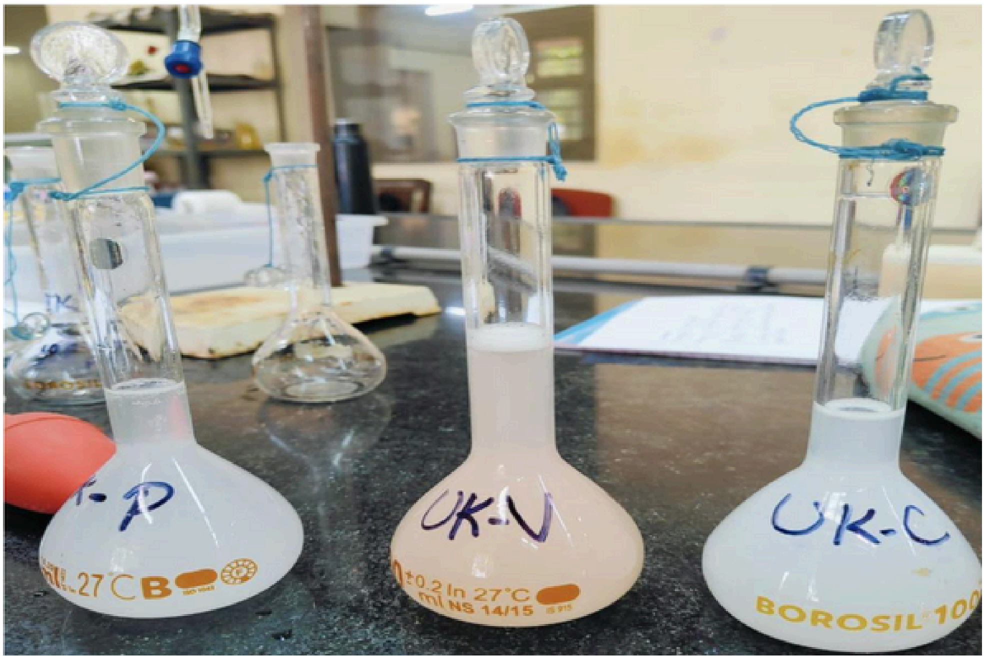


Figure 1

Prepare 250 ml of sodium Fluoride solution containing 100 ppm of fluoride ions. From these solutions, prepare a 10 ppm fluoride solution (100ml) Toothpaste sample solution. Dissolve the given sample of the toothpaste in a minimum quantity of water, transfer the solution into a 100 ml standard flask, rinse the beaker, and finally dilute to 100 ml mark (Figure 2).

Prepare the standard solutions of fluoride by preparing Concentration of fluoride of 0.5 , 1.0, 1.5 , 2.0, 2.5 and 10 ml unknown solutions of these three toothpastes by 10 ppm stock solution by addition of 5.0 of each alizarin Red-s and Zirconyl nitrate and dilute it to the 100 ml mark. After the final dilution, keep the solution in a cool dark place for 45 minutes. Measure the absorbance of the solution at 530 nm against water as blank.

Figure 2 and 3

After keeping sample and mixed solution for 45 minutes in a cool dark place

The qualitative analysis was conducted using a pH meter to ascertain the nature of essential components within Carbonated juices, fruit juices, soap & shampoo and the toothpaste. Concurrently, quantitative analysis was employed to determine the fluoride concentration in the toothpaste. This was achieved using calibration curve colorimetry, a sophisticated method that allows for precise measurement of fluoride levels by correlating the intensity of color produced in the reaction to the concentration of fluoride present. This method is used in various analytical procedures to determine fluoride concentrations based on the intensity of the color formed in the complexation reaction. The color intensity is proportional to the fluoride concentration, allowing for accurate quantification.

Results

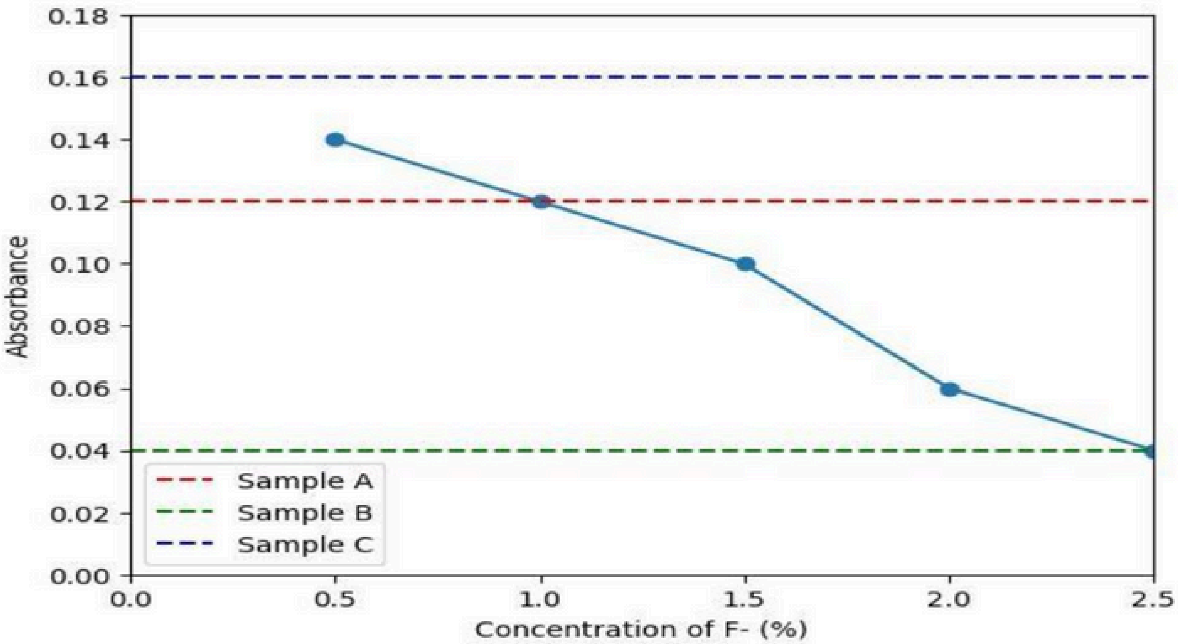
SAMPLES	pH	NATURE
Black Carbonate Juice	3.6	Acidic
White Carbonated Juice	7.8	Slightly basic
Mango Fruit Juice Packaged	6.0	Near Neutral
Peach Fruit Juice Packaged	3.35	Acidic
Green Coloured Soap	10.14	Basic
Shampoo	6.36	Near Neutral
Pink Coloured Toothpaste (A)	8.36	Basic
White Coloured Toothpaste (B)	9.33	Basic
Brown Coloured Ayurvedic Toothpaste (C)	8.19	Basic

The data shows that, among the black and white carbonated soft drinks, black is acidic and for the tetra packed fruit juice, peach fruit is acidic and mango fruit is near to the range of neutral. The cleansers on the other hand, the soap is basic while the shampoo is nearly neutral. All the three samples of toothpastes are basic, because it helps to neutralize the acidic nature of the mouth and bacteria.

Concentration of F- Content vs Absorbance

Concentration of F-	**Absorbance**
0.5	0.14
1.0	0.12
1.5	0.10
2.0	0.06
2.5	0.04
10.0 (A)	0.12
10.0 (B)	0.04
10.0 (C)	0.16

The reaction is Zirconyl nitrate and Alizarin Red S reacts to form the Zirconium-Alizarin Red S Complex . This complex has a distinct visible colour that can be used as an indicator and measured, allowing for the quantitative determination of fluoride ions in a sample.



Graph 1
Concentration vs. Absorbance

The data shows a clear inverse relationship between fluoride concentration and absorbance. As the fluoride concentration increases, the absorbance decreases, which is consistent with the expected behavior in such measurements. The results demonstrate that higher fluoride concentrations correspond to lower absorbance values, Through this analysis, Sample A showed 0.0513% fluoride content, Sample B 0.1282 %, while Sample C's fluoride percentage could not be calculated due to an absorbance of 0.16, which is higher than expected and further analysis is required to accurately quantify the fluoride concentration in Sample C. This method is used to determine fluoride concentrations based on the intensity of the colour formed in the complexation reaction. The colour intensity is proportional to the fluoride concentration, allowing for accurate quantification.

Discussion

Consuming low-pH soft drinks or packaged fruit juices, which is found in our sample black carbonated drink and peach fruit juice which are highly acidic, can lead to dental erosion. These drinks often have a pH below the critical level for enamel demineralization, causing gradual enamel wear and resulting in a thinner, weaker outer layer. This irreversible process is a major cause of dental sensitivity and cavities.

Additionally, the consumption of acidic beverages can aggravate acid reflux and GERD symptoms. The low pH can irritate the esophageal lining, leading to discomfort and potential long-term damage. There is evidence suggesting that high intake of acidic and phosphoric acid-containing drinks can negatively affect bone health by disrupting calcium metabolism, potentially decreasing bone mineral density. This is particularly concerning for those at risk of osteoporosis.

Moreover, excessive consumption of phosphoric acid from carbonated drinks has been associated with an increased risk of kidney stones. The acid load can change urinary pH, promoting stone formation in susceptible individuals.

According to the result, the soap pH is 10.14 which is basic in nature while the shampoo is near to neutral range 6.36 pH. Skincare encompasses various factors, but a critical aspect often overlooked is the pH level of body wash. pH levels are crucial for maintaining healthy skin, as using a body wash with an incorrect pH can lead to skin issues. pH measures the acidity or alkalinity of a substance. In skincare, pH impacts the skin's barrier function, product absorption, and resilience to environmental factors like pollution and sun exposure. The ideal skin pH is slightly acidic, between 4.5 and 5.5, which helps preserve the skin's natural barrier, preventing moisture loss and irritation. When the skin's pH is in this optimal range, it effectively balances water and electrolytes, resulting in healthy, hydrated skin. However, pH levels that are too high or too low can disrupt this balance, leading to dryness, irritation, and conditions such as eczema and acne. A high pH body wash can strip natural oils, causing dryness and irritation. Conversely, a low pH wash can make the skin too acidic, leading to redness, inflammation, and a compromised barrier, making it more vulnerable to environmental stressors and absorption issues. Moreover, an incorrect pH in body wash can disrupt the skin's microbiome, causing an imbalance of good and bad bacteria. This imbalance can result in skin problems like acne, rosacea, and infections. Maintaining the right pH in body wash is essential for overall skin health, as it ensures the skin's barrier remains intact and functional.

The pH of the three samples are basic to neutralize the nature and bacteria of the mouth. The Fluoride content, Sample A showed 0.0513% fluoride content, Sample B 0.1282 %, while Sample C's fluoride percentage could not be calculated due to an absorbance of 0.16. The risk of dental fluorosis increases with fluoride intakes.Toothpastes worldwide generally contain fluoride, contain monofluorophosphate with a concentration between 1,000mg/L to 1,100 mg/L(1.3mg per quarter teaspoon used for brushing). Fluoride depends on factors like the amount applied, a person's ability to swallowing and frequency of their brushing according to the National Institute of Health in America Generally, fluoride ingestion from toothpaste is estimated at 0.1 to 0.25 mg daily for infants and children aged 0 to 5, 0.2 to 0.3 mg for children aged 6 to 12, and about 0.1 mg for adults. Fluoride, no matter the type, is readily absorbed by the body. Excessive fluoride ingestion over a long period, especially during infancy and childhood when teeth are developing, can cause dental fluorosis. This chronic condition can manifest as nearly invisible white lines or spots to noticeable white or brown stains on the teeth and this condition can lead to pitting of the tooth enamel. The likelihood of developing dental fluorosis increases with greater fluoride intake.

Conclusion

Analyzing the pH of everyday essentials using a pH meter—such as carbonated drinks, packaged fruit juices, body cleansers, soap, shampoo, and toothpaste—is crucial for maintaining balance. The data gathered through the analysis can state that the black carbonated drink was acidic and peach fruit juice in tetra pack found to be acidic and mango juice is near to neutral. Excessive consumption of low pH beverages, which are acidic, can lead to dental erosion, sensitivity, cavities, and negatively impact bone health and kidney function due to phosphoric acid.

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Excessive fluoride intake, particularly during tooth development in infancy and childhood, increases the risk of dental fluorosis. Prolonged high fluoride intake can lead to dental fluorosis, manifesting as white spots, brown stains, or enamel pitting, with the risk increasing with fluoride levels as stated in the above discussion.

The sample of toothpastes to be basic to neutral the nature of mouth and fluoride content analysis using a colorimeter, Sample A showed 0.0513% fluoride content, Sample B 0.1282 %, it can be stated that these toothpastes are safe to use as these fall below the bar because of lower concentration found with minimal risk, while Sample C's fluoride percentage could not be calculated due to an absorbance of 0.16, which is higher than expected.

For further investigation, the fluoride concentration in Sample C needs to be adjusted and compared with other samples and this exploration can be taken ahead through comparative analysis varying the concentration of the toothpaste and study between different sets of commercially available drinks, cleansers and toothpastes from the market.

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About the author

Luminar Satla is a recent graduate with a degree in chemistry from K.J. Somaiya College of Science and Commerce. He possesses a strong passion for chemistry and health. His research is centred on analysing pH and fluoride levels alongside a comprehensive assessment of the chemical parameters found in everyday essentials, with a focus on their health implications. Through his work, Luminar aims to provide meaningful insights and highlight the interconnectedness of advancing scientific disciplines.

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