

Experimental Study on pH and Titratable Acidity of Common Food Items & Its Relevance to Drinking Water Quality Standards (IS 10500:2012)

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Abstract—This study investigates the pH and titratable acidity of commonly consumed food items and evaluates their relevance to drinking water quality standards as per IS 10500:2012. A total of twenty-five samples, including vegetarian and non-vegetarian curries, chutneys, pickles, and commercial soft drinks, were analyzed using standard procedures based on APHA methods. The samples were subjected to aqueous extraction followed by pH measurement and titration to determine acidity expressed as CaCO₃ equivalents. The results show that most food samples exhibit mildly to strongly acidic pH values along with significant titratable acidity. However, the observed acidity is mainly due to weak organic acids and dissolved carbon dioxide rather than strong mineral acids. The study also highlights the role of buffering capacity in food systems, which allows high acidity without a proportional decrease in pH. A comparison with IS 10500:2012 indicates that although food items fall outside the prescribed pH range for drinking water, they are safe for consumption due to metabolic neutralization and intermittent exposure. The findings demonstrate that pH represents the intensity of acidity, whereas titratable acidity represents its capacity. The study justifies the exclusion of acidity as a parameter in drinking water standards and confirms that pH alone is sufficient for effective water quality regulation.

Index Terms—pH, Titratable Acidity, IS 10500:2012, Food Acidity, Buffering

I. INTRODUCTION

Water is one of the most essential natural resources required for the survival of human beings, animals, and plants. Apart from its availability, the quality of water plays a crucial role in determining public health, environmental sustainability, and the durability of water supply infrastructure. Chemically imbalanced or contaminated water can lead to serious health issues,

corrosion of pipelines, and failure of distribution systems. Therefore, maintaining safe drinking water quality is a primary responsibility in Civil and Environmental Engineering practice (Sawyer et al., 2003; Metcalf & Eddy, 2014).

To ensure safe and acceptable drinking water, various standards have been developed at national and international levels. In India, the Bureau of Indian Standards (BIS) has prescribed IS 10500:2012, which specifies acceptable and permissible limits for physical, chemical, and microbiological parameters (BIS, 2012). Among these parameters, pH is included as a key indicator of acidity and alkalinity, with an acceptable range of 6.5 to 8.5. However, despite its importance in environmental chemistry, acidity is not included as a separate parameter in the drinking water standards. This often creates confusion, particularly among students and practitioners, regarding the role of acidity in water quality assessment.

At the same time, it is well known that humans regularly consume a variety of food items that exhibit acidic characteristics. Food systems commonly contain organic acids such as citric acid, lactic acid, acetic acid, and tartaric acid, which influence taste, preservation, and microbial stability (Belitz et al., 2009; Fellows, 2009). In Indian dietary practices, especially in regions such as Andhra Pradesh, ingredients like tamarind, tomato, lemon, curd, and fermented products contribute significantly to food acidity. Chutneys and pickles are intentionally acidic to enhance shelf life, while curries often contain organic acids derived from natural ingredients.

In addition, commercial soft drinks and fruit-based beverages contain dissolved carbon dioxide and food-grade acids such as phosphoric and citric acids, resulting in low pH values typically ranging between

2.5 and 3.5 (McGee, 2004). Despite their acidic nature, these food items and beverages are widely consumed without immediate harmful effects when taken in moderate quantities. This observation raises a fundamental question: if acidic foods are safely consumed, why is acidity not included as a parameter in drinking water standards?

Drinking water standards are designed with objectives that differ significantly from those of food quality assessment. The primary aim of drinking water regulations is to ensure long-term safety, aesthetic acceptability, and protection of infrastructure such as pipelines and storage systems (WHO, 2017). Parameters included in IS 10500:2012 are selected based on their potential impact on human health, corrosion, scaling, and operational efficiency. pH is considered a controlling parameter because it influences metal solubility, disinfection efficiency, and corrosiveness of water (Hem, 1985; Stumm and Morgan, 1996).

In contrast, acidity in environmental engineering is often associated with the presence of strong mineral acids such as sulphuric acid, hydrochloric acid, and nitric acid. These acids are fully dissociated and can cause severe corrosion, environmental damage, and health risks (Manahan, 2010). However, such mineral acidity is rarely present in potable water systems without being reflected in very low pH values.

On the other hand, acidity in food systems is primarily due to weak organic acids and dissolved carbon dioxide. These acids are partially dissociated and are readily metabolized by the human body (DeMan, 1999). Moreover, food systems contain significant buffering components such as proteins, amino acids, and phosphates, which resist drastic changes in pH (Belitz et al., 2009). This buffering behavior allows food items to exhibit high titratable acidity while maintaining moderate pH values.

The distinction between pH and titratable acidity is crucial in understanding this phenomenon. pH represents the intensity of acidity, whereas titratable acidity represents the total acid-neutralizing capacity of a system (APHA, 2017). In simple aqueous systems such as drinking water, pH provides sufficient information about acidic conditions. However, in complex systems like food, titratable acidity becomes more relevant due to the presence of multiple weak acids and buffering agents.

Standard methods for acidity determination, such as those prescribed by APHA, are primarily developed for water and wastewater analysis (APHA, 2017). When these methods are applied to food samples, the measured values represent overall titratable acidity rather than true mineral acidity. Misinterpretation of these results often leads to the incorrect assumption that food contains harmful mineral acids.

Several studies have emphasized that drinking water standards focus on parameters that affect long-term exposure and infrastructure integrity rather than metabolizable components (WHO, 2017; BIS, 2012). Organic acids present in food are temporary in nature and do not contribute to corrosion in water distribution systems. Therefore, regulating acidity in drinking water is neither necessary nor practical.

Despite the availability of extensive literature on water quality and food chemistry, there is limited work comparing food acidity characteristics with drinking water standards. This gap often leads to conceptual misunderstanding among students and practitioners. There is a need for experimental investigation to demonstrate the difference between food acidity and water acidity and to justify the rationale behind the exclusion of acidity in IS 10500:2012.

The present study aims to address this gap by experimentally analyzing the pH and titratable acidity of commonly consumed food items and interpreting the results in the context of drinking water quality standards. The study focuses on understanding the nature of acidity in food systems, the role of buffering capacity, and the relationship between pH and titratable acidity.

The objectives of the study include determining the pH of selected food samples, evaluating their titratable acidity using standard laboratory methods, analyzing the relationship between these parameters, and comparing the results with the requirements of IS 10500:2012. The study also aims to provide a clear justification for the exclusion of acidity as a parameter in drinking water standards.

The scope of the study is limited to laboratory-scale analysis of selected food items and beverages. The results are interpreted based on established principles of environmental engineering and food chemistry. The findings are expected to provide conceptual clarity and improve the understanding of acidity-related parameters in both food and water systems.

II. MATERIALS AND METHODS

2.1 Selection of Samples

A total of twenty-five (25) commonly consumed food items were selected for the present study to represent typical dietary patterns. The samples included vegetarian and non-vegetarian curries, chutneys, pickles, and commercially available soft drinks. The selection was made to cover a wide range of food types with varying acidic characteristics. All samples were freshly prepared or procured and analyzed under similar laboratory conditions to ensure consistency.

2.2 Reagents and Apparatus

All reagents used in the study were of analytical grade. Distilled water was used throughout the experimental work. Standard sodium hydroxide (NaOH) solution was prepared and standardized prior to use. Indicators such as phenolphthalein and methyl orange were used for titration.

The apparatus used included:

- Digital pH meter (calibrated using standard buffer solutions of pH 4.0, 7.0, and 9.2)
- Burette, pipette, and conical flasks
- Measuring cylinders
- Filter paper and funnel
- Magnetic stirrer (if available)

All glassware was thoroughly cleaned and rinsed with distilled water before use to avoid contamination.

2.3 Sample Preparation

Each food sample was prepared for analysis using an aqueous extraction method. Approximately 100 g of the sample was taken and mixed with 100 mL of distilled water in a clean container. The mixture was allowed to stand for 24 hours to ensure proper extraction of soluble components.

After soaking, the mixture was filtered using filter paper to obtain a clear extract. This filtrate was used for both pH measurement and titratable acidity determination.

For liquid samples such as soft drinks, the samples were analyzed directly without dilution.

2.4 Measurement of pH

The pH of each sample extract was measured using a calibrated digital pH meter. Prior to measurement, the pH meter was standardized using buffer solutions of known pH values (4.0, 7.0, and 9.2).

The electrode was rinsed with distilled water and gently wiped before each reading. The electrode was then immersed in the sample extract, and the pH value was recorded once the reading stabilized. All measurements were carried out at room temperature.

2.5 Determination of Titratable Acidity

Titratable acidity of the samples was determined using standard titration methods as per APHA guidelines. A known volume (typically 10 mL) of the sample extract was taken in a conical flask.

The sample was titrated against standardized sodium hydroxide (NaOH) solution using phenolphthalein as an indicator. The endpoint was indicated by a faint pink color that persisted for at least 30 seconds.

In some cases, methyl orange indicator was also used to distinguish between different types of acidity.

The titratable acidity was calculated and expressed in terms of mg/L as CaCO₃ using standard formulas.

2.6 Calculation of Acidity

The acidity of the sample was calculated using the following expression:

$$\text{Acidity (mg/L as CaCO}_3\text{)} = \frac{V \times N \times 50,000}{\text{Volume of sample (mL)}}$$

where:

- V = Volume of NaOH used (mL)
- N = Normality of NaOH
- 50,000 = Equivalent weight factor for CaCO₃

2.7 Data Analysis

The obtained pH and titratable acidity values were tabulated and analyzed to identify trends and variations among different food samples. The relationship between pH and acidity was examined to understand the influence of buffering capacity.

The results were compared with the permissible pH range specified in IS 10500:2012 to evaluate their relevance to drinking water standards.

III. RESULTS AND DISCUSSION

3.1 pH Characteristics of Food Samples

The measured pH values of the selected food samples are presented in Table 5.1 and graphically illustrated in Figure 5.1. The results indicate that the pH values of the samples vary significantly, ranging approximately from 2.5 to 5.8, confirming that most of the food items are acidic in nature.

Table 5.1 pH values of food samples

SAMPLE	PH
Banana Curry	4.65
Brinjal Curry	5.32
Tomato Cucumber	4.89
Beans	5.25
Drumsticks Curry	4.61
Ridge gourd	5.13
Potato curry	5.44
Ladies finger	5.7
Poori curry	6.3
Chicken curry-1	5.5
Chicken curry-2	5.8
Tomato curry	2.42
Lentils (dal)	5.6
Bottle gourd	5.5

SAMPLE	PH
Gherkins curry	3.6
PICKLE-1 Mango	3.8
PICKLE-2 Tomato	3.5
SOFTDRINKS Mountain Dew	3.1
Maaza	3.5
Sprite	3.3
Thumsup	2.7
Appy Fizz	3.46
Pulpy Orange	3.52
Limca	3.17
Fanta	3.36

From Figure 5.1, it is clearly observed that soft drinks exhibit the lowest pH values, typically in the range of 2.5 to 3.5. This is primarily due to the presence of dissolved carbon dioxide forming carbonic acid, along with added food-grade acids such as phosphoric and citric acids. These acids contribute to high hydrogen ion concentration, resulting in low pH values.

Chutneys and pickles also show relatively low pH values, as indicated in Table 5.1, due to the presence of organic acids such as acetic acid and lactic acid, which are commonly used for preservation and flavor enhancement.

In contrast, curry samples (both vegetarian and non-vegetarian) exhibit comparatively higher pH values, generally in the range of 4.5 to 5.8, as seen in Figure 5.1. This behavior is attributed to the presence of buffering constituents such as proteins, amino acids, and mineral salts, which resist drastic changes in pH.

Although all the analyzed food samples fall below the acceptable pH range of 6.5 to 8.5 specified for drinking water in IS 10500:2012, they are widely consumed without adverse health effects. This clearly indicates that pH values in food systems cannot be directly compared with drinking water standards, as the nature and behavior of acidity differ significantly.

3.2 Titratable Acidity of Food Samples

The titratable acidity values of the samples, expressed in terms of mg/L as CaCO₃, are presented in Table 5.2 and graphically represented in Figure 5.2. The results reveal that several food samples exhibit relatively high acidity values, even when their Ph values are moderate.

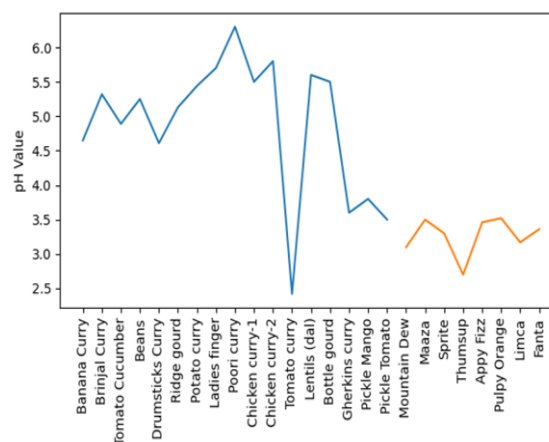


Fig. 5.2 Comparison of Ph values: curries vs softdrinks

From Figure 5.2, it is evident that pickles and chutneys show higher titratable acidity compared to other samples. This is due to the intentional addition of acidic ingredients such as tamarind, vinegar, and fermented components, which increase the total acid content.

Interestingly, some curry samples also exhibit considerable titratable acidity despite having moderately higher pH values. This indicates the presence of weak organic acids in significant quantities, which contribute to total acidity without drastically lowering pH.

On the other hand, soft drinks, although having very low pH values, show comparatively lower titratable acidity than some food samples. This suggests that while soft drinks are strong in terms of acidity intensity, they contain relatively lower total acid content compared to buffered food systems.

These observations confirm that titratable acidity depends on the total acid concentration rather than the strength of acidity, and therefore cannot be directly inferred from pH values alone.

3.3 Relationship Between pH and Titratable Acidity

The relationship between pH and titratable acidity is illustrated in Figure 5.3. The graphical representation clearly shows that there is no direct linear relationship between pH and acidity.

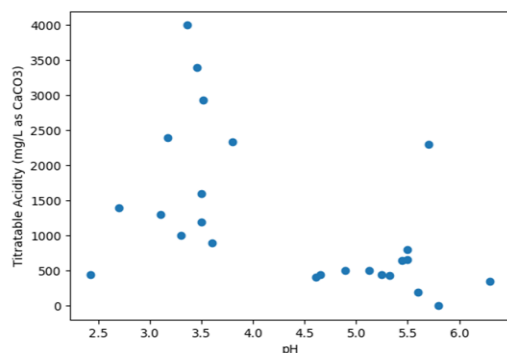


Figure 5.3. Relationship between pH and Titratable acidity

As observed in Figure 5.3, some samples with similar pH values exhibit significantly different acidity values, while others with low pH may show comparatively lower acidity. This apparent inconsistency highlights the fundamental difference between the two parameters.

pH represents the intensity of acidity, i.e., the concentration of hydrogen ions presents in the solution, whereas titratable acidity represents the total acid-neutralizing capacity of the system. Therefore, these two parameters describe different aspects of acidity.

The absence of a direct relationship between pH and acidity is primarily due to the presence of buffering systems in food samples, which stabilize pH despite variations in total acid content.

3.4 Role of Buffering Capacity

The buffering behavior of food systems plays a crucial role in explaining the observed results. Food samples contain various buffering agents such as proteins, amino acids, phosphates, and salts, which resist changes in pH.

As a result, even when the total acid content (titratable acidity) is high, the pH does not decrease proportionally. This phenomenon is clearly reflected in the results presented in Table 5.1 and Table 5.2, where several samples exhibit high acidity but moderate pH values.

In contrast, soft drinks exhibit relatively low buffering capacity. Therefore, even small amounts of acid lead to a significant decrease in pH, as observed in Figure 5.1.

This difference highlights the importance of buffering capacity in determining the behavior of acidity in complex systems like food.

3.5 Comparison with Drinking Water Standards (IS 10500:2012)

The results obtained in this study were compared with the drinking water quality standards specified in IS 10500:2012, which recommends a pH range of 6.5 to 8.5.

None of the analyzed food samples fall within this range; however, they are safe for consumption due to several important factors:

- The acidity in food is mainly due to weak organic acids, not strong mineral acids
- These acids are metabolized and neutralized in the human body
- Food consumption is intermittent, unlike continuous water intake
- Food does not interact with pipelines or distribution systems

In contrast, drinking water is consumed continuously and remains in prolonged contact with infrastructure. The presence of acidity, particularly due to mineral acids, can lead to corrosion, leaching of metals, and deterioration of pipelines.

Therefore, acidity in drinking water is indirectly controlled through pH limits. If strong acids are present, they will significantly reduce pH, making separate measurement of acidity unnecessary.

3.6 Engineering Interpretation

The experimental findings clearly demonstrate that high acidity values in food samples do not indicate the presence of harmful mineral acids. Instead, they reflect the presence of weak organic acids and buffering systems.

The study also shows that applying water quality analysis concepts directly to food systems can lead to misinterpretation. The acidity measured in food samples represents titratable acidity, which includes all acid species present, regardless of their strength. From an engineering perspective, the results justify the approach adopted in IS 10500:2012, where pH is considered sufficient for assessing acidity-related effects in drinking water, and acidity is not included as a separate parameter.

IV. CONCLUSIONS

Based on the experimental investigation of pH and titratable acidity of commonly consumed food items, the following conclusions are drawn:

- The analyzed food samples exhibited a wide range of pH values, generally between 2.5 and 5.8, indicating that most of the samples are acidic in nature.
- Significant titratable acidity was observed in many samples, particularly in chutneys and pickles, due to the presence of organic acids such as acetic, citric, and lactic acids.
- The study clearly demonstrates that pH and titratable acidity are fundamentally different parameters. While pH represents the intensity of acidity, titratable acidity represents the total acid-neutralizing capacity.
- No direct relationship was observed between pH and titratable acidity, as confirmed by the experimental data and graphical analysis. This is mainly due to the presence of buffering systems in food samples.
- The acidity observed in food samples is primarily due to weak organic acids and dissolved carbon dioxide, and not due to strong mineral acids. Therefore, high acidity values in food do not indicate harmful conditions.
- Although the pH values of food samples fall outside the permissible limits specified for drinking water in IS 10500:2012, they are safe for consumption because food acids are metabolized in the human body and exposure is intermittent.
- Drinking water quality standards are designed considering continuous consumption and infrastructure protection. The presence of acidity

in water, especially mineral acidity, can lead to corrosion and deterioration of pipelines.

- The study justifies that acidity is not required as a separate parameter in drinking water standards, as its effects are effectively controlled through pH measurement.
- The findings confirm that pH alone is a sufficient and practical parameter for regulating acidity-related effects in drinking water quality assessment.
- This study provides clear conceptual understanding and helps bridge the gap between food chemistry and environmental engineering, avoiding misinterpretation of acidity measurements.

Thus, the exclusion of acidity as a parameter in IS 10500:2012 is scientifically justified, and the use of pH as a controlling parameter is both adequate and appropriate for ensuring safe drinking water quality.

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