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pH profile and acidity analysis of some Nepalese tea brands: effects of tea type and temperature

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Abstract

Tea is a popular beverage enjoyed throughout the world, often as a morning wake-up drink. However, excessive consumption may negatively affect health, especially for those who suffer from acidity. In this study, we report the pH values of four locally available tea brands, Tokla, Ridhisidhi, Suman, and Muna, brewed at cold and hot conditions and flavored with lemon juice as an additive to determine how conditions and additives affect acidity. Hot-brewed tea had an alkaline pH range of 7.74 to 9.03, while cold-brewed tea had a reduced pH range of 7.12 to 7.23. The pH value of lemon-flavored tea ranged from 4.59 to 6.98, suggesting that its acidity may cause problems for those who are sensitive to acid. Milk-based teas exhibited pH values between 6.07 and 7.4, while teas with added sugar had lower pH values. With increasing sugar concentrations, tea becomes more acidic. According to these findings, plain black tea is preferable for individuals who are sensitive to acid, whereas lemon-flavored tea may be uncomfortable for them. Studying the acidity levels of Nepalese tea can therefore provide valuable information about its potential health benefits. In turn, this could lead to research on how brewing techniques and ingredients affect tea chemical composition.

Keywords
Tea, pH value, acidity, lemon tea, health benefits, flavor.

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1 Introduction

Tea is a popular beverage worldwide, and millions of people enjoy it every day because of its refreshing taste, multiple flavors, and numerous health benefits [1]. Tea, derived from the leaves of the *Camellia sinensis* plant, is not only consumed as a daily beverage but also holds significant cultural importance, varying across regions and spanning thousands of years of history [2]. Chinese emperor Shen Nong accidentally discovered tea around 2737 BCE when some tea leaves fell into boiling water [3]. Since then, tea has spread globally, becoming an integral part of various cultures [4]. Each culture has devel-

oped unique traditions and rituals for its consumption [5].

Tea consumption is an essential part of Nepalese culture and economy, with several local brands producing high-quality tea [6]. The hilly region of Nepal has a suitable climate, fertile soil, and abundant water, making it an ideal location for tea plantations (Figure 1). The tea produced in this region is of high quality and renowned for its flavor, contributing to popularity of hills growing popularity as a destination for tea tourism. The pH of tea is an important factor that can influence its taste, and potential health benefits [7]. It is not only a refreshing beverage, but also boasts numerous health benefits, supported by scientific research [8]. Some of the key health benefits associated with regular tea consumption include antioxidant properties, cardiovascular health benefits, weight management, mental health and cognitive function, immune system support, stress reduction, bone health, skin health, and diabetes management. Polyphenols, such as catechins and flavonoids, help neutralize free radicals and reduce oxidative stress and cellular damage [9, 10]. In particular, green tea may help reduce the risk of certain cancers by protecting cells from DNA damage and inhibiting tumor growth [11]. Regular tea consumption is associated with improved cardiovascular health [12, 13]. Drinking tea may help lower blood pressure, reduce cholesterol levels, and improve blood vessel function [14]. Some studies have suggested that drinking tea may lower the risk of stroke, likely owing to its beneficial effects on blood pressure and cholesterol [15]. The catechin and caffeine components of tea can help boost metabolism and increase fat oxidation, potentially aiding weight loss and management [16]. This can help to regulate appetite and reduce overeating [17]. Caffeine in tea provides a mild stimulant effect, and improves mental alertness. Tea, especially green tea, contains L-theanine, which promotes relaxation and can enhance cognitive function by working synergistically with caffeine [18]. Peppermint and ginger tea are known to aid digestion and alleviate symptoms, such as bloating and nausea [19]. Polyphenols in tea can promote the growth of beneficial gut bacteria, contributing to a healthy digestive system [20]. Catechins in tea have been shown to possess antimicrobial properties, that can help combat bacteria and viruses [21]. The anti-inflammatory properties of tea can contribute to better joint and bone health [22]. Antioxidants in tea can help protect the skin from damage caused by ultraviolet (UV) rays, thereby reducing the risk of skin cancer and premature aging. Drinking tea may also help improve skin hydration and elasticity, giving the skin a healthier appearance [23]. Some studies have suggested that green and black tea can help regulate blood sugar levels, improve insulin sensitivity, and reduce the risk of type 2 diabetes [24].

Figure 1: Tea gardens in Nepal. Source: https://highlightstourism.com/2022/12/14/tea-gardens-a-sight-seeing-in-eastern-nepal.

Drinking tea, which is generally considered beneficial owing to its antioxidants and other health-promoting compounds, can pose certain health risks. Tea, especially black and green tea, contains caffeine, which can cause sleep disturbances and increase anxiety levels in sensitive individuals. Excessive and regular consumption of caffeine can lead to heart palpitations and increased heart rate [25, 26]. The tannins present in tea leaves hinder the absorption of iron from plant-based diets. Individuals with iron deficiency, pregnant women, and children are at high risk due to tannin contents [27, 28]. Excessive tea consumption is associated with decreased bone mineral density and an increased risk of fractures, especially in postmenopausal women, owing to the fluoride content of tea leaves [29]. It contains oxalates, which can lead to kidney stones in sensitive individuals [30, 31]. Excess tea consumption may lead to health risks due to its high heavy metal content such as Pb, Al, and metal fluorides [32]. Because tea is acidic, some people may experience nausea, acid reflux, or upset stomachs when it is taken on an empty stomach. Tea has been considered as a means of connecting people in society and is a tradition, but not only as a beverage. This study aims to measure and compare the pH values of various Nepalese tea brands under different conditions, including brewing times, temperatures, and medium types.

2 Experimental

2.1 Materials and chemicals

Four local Nepalese tea brands, Tokla, Ridhisidhi, Suman, and Muna tea, were selected for this study and purchased from the local market of Biratnagar, Nepal. Distilled water was used to brew the tea samples. They were meshed to remove dirt and brewed according to standard brewing instructions. A digital pH meter was used to measure the pH of brewed tea samples. The pH variation was investigated by varying the brewing conditions, includ-

ing temperature changes and the addition of fresh lemon juice, milk, and sugar to the tea samples.

2.2 Preparation of Tea Samples

In each set of experiments, 2 g of dry tea was added to 200 ml of distilled water to prepare tea. The temperature of hot tea was maintained at 90 °C. Various types of tea samples, including teas with milk, sugar, and fresh lemon juice, were prepared using the same procedure but in varying proportions. During preparation, the tea samples were occasionally stirred to homogenize them. The pH measurements were performed in triplicate to reduce error. The entire process of sample preparation and pH measurement is shown in Figure 2.

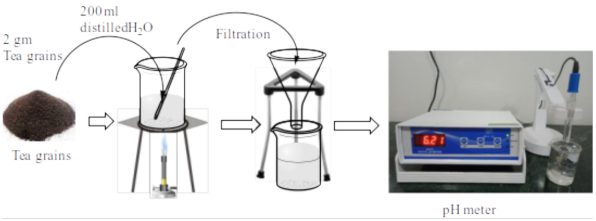

Figure 2: Tea sample preparation and pH measurement.

2.3 Statistical Analysis

The Origin 2018 version software was used to perform a one-way ANOVA test to compare the mean differences between multiple groups. The data represents the mean of pH in three replications with ± standard deviation (SD). Pair identification and the display of significant mean differences were accomplished through post-hoc analysis using Tucky's test. The pH values of $p < 0.05$ were considered significant.

3 Results and discussion

3.1 Freshly Brewed Tea

The flavor and stability of tea can be greatly influenced by pH. Black tea had a pH value of 7.73 to 9.03 under hot conditions, whereas it drops to 7.12 to 7.22 under cold conditions. The pH values of all the freshly brewed teas were within the expected range for black tea, indicating a slightly alkaline nature. Suman Tea with a pH of 9.03 under hot conditions is relatively more basic than other tea brands. Cooling decreased the pH of all tea brands. As reported in previous studies, fresh brewed black tea typically has a pH of 7–9 under hot conditions and a slightly decreased pH of 7.12 7.30 under cold conditions [31]. This decrease in pH under cold conditions may be due to the release of organic acids [32]. Table 1 presents the pH data for all tea brands under cold and hot conditions, which are graphically illustrated in Figure 3.

Table 1: pH of black tea in water without flavour

S. N.	Different Brands of Tea	pH	
		Hot Condition	Cold Condition
1	Tokla	7.73 ± 0.05	7.2 ± 0.01
2	Ridhisidhi	8.00 ± 0.1	7.18 ± 0.02
3	Suman	9.03 ± 0.05	7.22 ± 0.025
4	Muna	7.76 ± 0.03	7.12 ± 0.005

Each value represents mean pH ± standard deviation (SD)

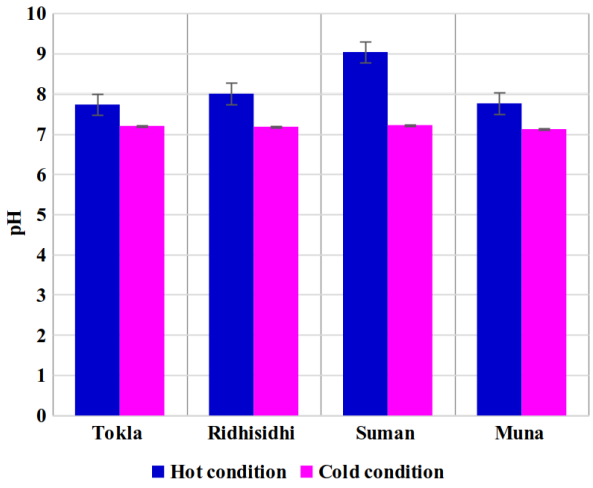

Figure 3: pH of black tea in cold and hot conditions.

3.2 Tea with Lemon flavour

Table 2 presents the pH data for all brands of black tea containing varying amounts of sugar and lemon juice. The pH value decreased as more sugar was added to the tea. Moreover, an increased concentration of sugar (2 g) resulted in a slightly acidic pH range. Likewise, adding lemon (0.1, 0.2, 0.3, and 0.4 ml), which is highly acidic (pH ~2-3) to black tea containing different levels of sugar (0.5, 1.0, 1.5, and 2.0 g) resulted in a significant drop in pH levels,

making the tea more acidic. The pH values, ranging from 4.59 to 6.97 after adding lemon to tea, are consistent with studies showing that lemon acidity (pH 2-3) lowers the overall pH of tea mixtures [33]. The pH change follows this order: Suman > Ridhisidhi > Muna ~ Tokla. This increase in acidity can enhance the antioxidant properties of tea, but might also make the tea tangier and sharper in taste. The Tokla tea brand is more acidic in this context, with a pH of 4.59. A study has shown that the addition of lemon can enhance the bioavailability of polyphenols, thereby increasing the health benefits of tea. However, increased acidity may pose discomfort issues for acid-sensitive individuals [34]. The results of the variation in the pH of sugar-supplemented tea with and without lemon are graphically presented in Figure 4.

Table 2: pH of sugar added black tea with and without lemon

S. N.	Different Brands of Tea	Sugar Content	pH		Lemon content
			Black Tea	Black Tea with Lemon	
1	Tokla	0.5 gm	7.49 ± 0.005	6.28 ± 0.005	0.1 ml
		1.0 gm	7.25 ± 0.01	5.66 ± 0.005	0.2 ml
		1.5 gm	7.07 ± 0.005	5.13 ± 0.01	0.3 ml
		2.0 gm	6.80 ± 0.01	4.59 ± 0.005	0.4 ml
2	Ridhisidhi	0.5 gm	7.73 ± 0.015	6.97 ± 0.015	0.1 ml
		1.0 gm	7.51 ± 0.015	6.39 ± 0.005	0.2 ml
		1.5 gm	7.23 ± 0.02	5.86 ± 0.015	0.3 ml
		2.0 gm	6.94 ± 0.015	4.77 ± 0.02	0.4 ml
3	Suman	0.5 gm	8.69 ± 0.005	6.67 ± 0.005	0.1 ml
		1.0 gm	8.43 ± 0.015	6.08 ± 0.01	0.2 ml
		1.5 gm	8.2 ± 0.01	5.55 ± 0.02	0.3 ml
		2.0 gm	7.87 ± 0.02	4.97 ± 0.02	0.4 ml
4	Muna	0.5 gm	7.48 ± 0.01	6.35 ± 0.005	0.1 ml
		1.0 gm	7.25 ± 0.01	5.83 ± 0.01	0.2 ml
		1.5 gm	6.94 ± 0.01	5.27 ± 0.02	0.3 ml
		2.0 gm	6.75 ± 0.01	4.75 ± 0.01	0.4 ml
Each value represents mean pH ± standard deviation (SD)					

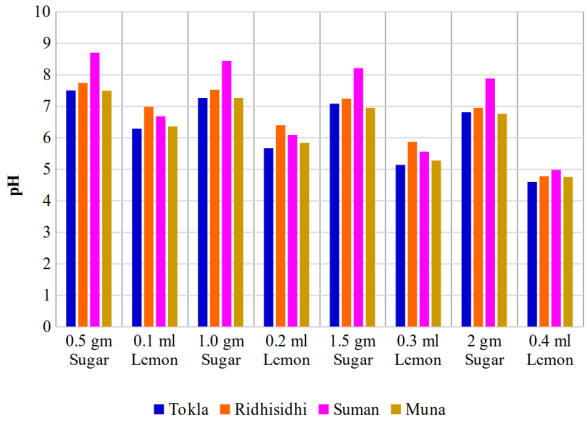

Figure 4: pH of sugar added black tea with and without lemon.

3.3 Sugar added Tea with Milk

Adding milk to tea generally decreases its pH, making it acidic, which may be due to the buffering capacity of milk that contains proteins and calcium as its main components. The pH of the tea with 100% milk ranged from 6.07 -7.40. Suman Tea had the highest pH value (7.40). This suggests that it might offer the mildest flavor when milk is added. Muna showed the largest decrease in pH (6.07) after the addition of more sugar to 100 % milk tea. When the milk concentration in tea decreases, the pH value increases slightly, moving toward an alkaline nature [35]. However, some studies have raised concerns that milk might decrease the absorption of certain antioxidants in tea, although the extent of this effect remains debated [36]. The variation in the pH profile of milk tea with added sugar is presented in Table 3, and a bar graph showing this effect is shown in Figure 5.

Table 3: pH of sugar added milk tea with varying milk-water ratios

S.N.	Different Brands of Tea	Sugar Content	pH		
			Milk tea without water	75% Milk & 25% Water	50% Milk & 50% Water
1	Tokla	0.5 gm	6.86 ± 0.05	6.91 ± 0.01	6.94 ± 0.005
		1.0 gm	6.70 ± 0.01	6.79 ± 0.005	6.86 ± 0.005
		1.5 gm	6.56 ± 0.01	6.71 ± 0.005	6.77 ± 0.005
		2.0 gm	6.44 ± 0.03	6.54 ± 0.005	6.62 ± 0.02
2	Ridhisidhi	0.5 gm	7.19 ± 0.01	7.16 ± 0.03	7.13 ± 0.06
		1.0 gm	6.99 ± 0.005	6.97 ± 0.01	6.98 ± 0.005
		1.5 gm	6.78 ± 0.01	6.84 ± 0.01	6.87 ± 0.01
		2.0 gm	6.59 ± 0.005	6.69 ± 0.005	6.78 ± 0.005
3	Suman	0.5 gm	7.40 ± 0.01	7.30 ± 0.005	7.21 ± 0.01
		1.0 gm	7.24 ± 0.01	7.17 ± 0.005	7.13 ± 0.02
		1.5 gm	7.04 ± 0.005	7.03 ± 0.01	7.03 ± 0.01
		2.0 gm	6.82 ± 0.01	6.85 ± 0.01	6.91 ± 0.01
4	Muna	0.5 gm	6.65 ± 0.01	6.75 ± 0.02	6.83 ± 0.005
		1.0 gm	6.43 ± 0.01	6.58 ± 0.01	6.73 ± 0.02
		1.5 gm	6.22 ± 0.01	6.40 ± 0.01	6.62 ± 0.01
		2.0 gm	6.07 ± 0.02	6.29 ± 0.01	6.52 ± 0.005

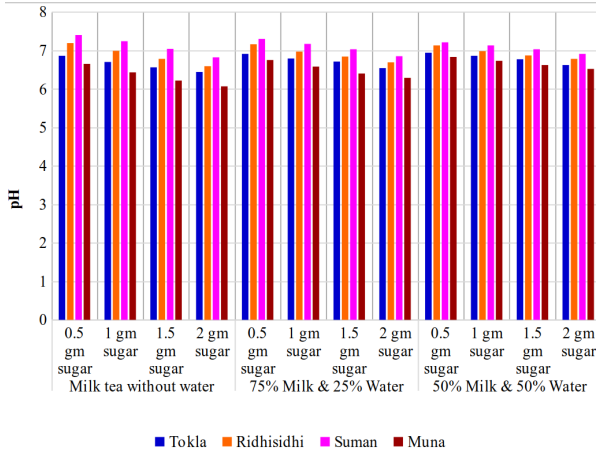

Figure 5: pH of Tea with different % of milk-water ratio and sugar content.

4 Conclusion

The pH of four local Nepalese tea brands was successfully investigated and evaluated to compare their acidity and evaluate their health impacts, particularly in acid-sensitive individuals. Most of the teas studied were basic in nature, and pH variation occurred after the addition of ingredients such as milk, sugar, and lemon flavors in different amounts. Plain black tea is mildly alkaline to neutral, which makes it relatively safe for acid-sensitive individuals. The lemon-flavored tea is significantly more acidic, which might be due to the acidic components present in lemons. The acidity level of approximately 4.59 can be sufficiently high to induce discomfort in individuals with a tendency for acid reflux or those with sensitive stomachs. Upon adding sugar to milk-based teas, the pH value decreased, even though the teas maintained a more neutral pH across different milk-water ratios. Therefore, acid-sensitive individuals must prefer to drink tea with milk or black tea without lemons to prevent aggravating symptoms, as these preparations have a less acidic pH value. Our research findings provide valuable information about the chemistry of tea and its potential effects on taste and health, especially for consumers who have specific dietary needs or are sensitive to acidity.

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