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Physicochemical Analysis of Some Soft Drinks Available in Nepal

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Abstract

This work aimed to check the physicochemical parameters of some soft drinks available in Nepal. Coca-Cola, Pepsi, Fanta, Sprite, Rio juice, and Red Bull were taken from the nearby stores for the experiments. The determination of ascorbic acid, phosphoric acid, acid value, corrosiveness, amount of caffeine, dissolved oxygen, biological oxygen demand, and chemical oxygen demand was carried out by using several materials and chemical reagents as per the established protocols. All the samples were taken from their bottle or can exactly at the time of experiments. The obtained results from this work were compared to the standard values and the possible health effects of overconsumption were discussed. From the calculation, Coca-Cola was found to be highly acidic (pH 2.3), Pepsi was found to contain the highest amount of ascorbic acid (0.126 g) and dissolved oxygen (22.4 g/L), and Red Bull was found to contain the highest amount of caffeine (2.6345 g/L). Red Bull was found to have the highest percentage of weight loss on mild steel (1.12 %).

Keywords: *Soft drinks, dissolved oxygen, phosphoric acid, acid value, caffeine*

1. Introduction

A soft drink is a beverage that often includes carbonated water, a sweetener, and either artificial or natural flavourings [1]. High fructose corn syrup, fruit juice, a sugar alternative, or a combination of these may all be used as sweeteners. The majority of soft drinks contain colouring and flavouring components, emulsifiers, acidifiers, sweeteners, preservatives, and certain cold drinks also contain a trace amount of caffeine. The tart flavour is imparted by acids like citric and phosphoric acids, which also serve as preservatives [2].

Different brewing companies in Nepal manufacture soft drinks in a variety of flavours and brands. These drinks are commonly used, especially during physically demanding activities like sports and hard work. The available soft drinks are often taken during leisure and relaxation activities and are used during celebrations like weddings, festivals, and other events [3]. The high consumption rate of soft drinks is attributed to their characteristic taste and flavour as well as their thirst-quenching potential [4]. These characteristics are defined by the constituents present such as sugar, which is responsible for its sweetness, carbonated water which is water compressed with carbon dioxide to make it an ultimate thirst quencher, and flavouring agent to add flavour to the drinks [5]. In addition to taste satisfaction, soft drinks contain other constituents such as vitamins, phosphates, antioxidants, etc., which are nutritional and health benefits to the body [6]. Antioxidants are chemical compounds that inhibit the potential oxidative phenomenon in the body [7, 8, 9].

However, because of the enormous demand and consumption of soft drinks, it may be difficult to maintain quality control throughout the production process, particularly during sterilization and purification. As a result of some microbial contamination, it has been discovered that soft drinks occasionally contain traces of alcohol [10]. A few heavy metals, such as cadmium, lead, mercury, arsenic, zinc, etc. are also present [2]. Soft drinks have been found to contain some traces of heavy metals because of the food and fruits used in the production process, which may result from environmental pollution from the surface and subsurface water [11, 12].

The Food and Drug Administration (FDA) recommended value for pH of carbonated drinks is between 2.5–4.5, for acid value is below 0.6, for ascorbic acid is 90 mg per day, for caffeine is 400 mg per day, and for phosphoric acid is between 700-1000 mg per day. The acceptance levels for dissolved oxygen (DO), biological oxygen demand (BOD), and chemical oxygen demand (COD) are 7 mg/L, 30 mg/L, and 250 mg/L respectively [13]. Although many guidelines were made for non-alcoholic soft drinks, the lack of research and testing with the flow of time had been observed. The testing and evaluation of soft drinks is a necessary task because the physicochemical parameters have a direct effect on human health [14].

Thus, this study aimed to evaluate some constituents (pH, electrical conductivity, acid value, ascorbic acid, corrosiveness, phosphoric acid, caffeine, dissolved oxygen, biological oxygen demand and chemical oxygen demand) and determine them quantitatively in some of the soft drinks available in Nepal, and also analyze the effect of some characteristics on public health.

2. Materials and Methods

2.1 Sample collection

Coca-Cola, Pepsi, Fanta, Sprite, Rio juice, and Red Bull were purchased from the cold stores in Kathmandu, Nepal, and all the samples were taken from their bottle or can exactly at the time of experiments.

2.2 Ascorbic acid

In a conical flask, 200 mg of the sample was dissolved in 20 mL of 0.25 M H_2SO_4. Then, 2 g of solid KI and 50 mL of 0.01 M KIO_3 solution were added to the flask. The residual I_2 was titrated against a standard thiosulphate solution. The process was repeated two times. The amount of ascorbic acid was calculated by the following formula [15];

Amount of ascorbic acid = mole iodine × volume of iodine

(1 mole of iodine is equivalent to 1 mole of ascorbic acid)

2.3 Phosphoric acid determination

At first, 0.05 M NaOH was prepared in the laboratory. Then 50 mL of the sample was concentrated to half of its volume by heating on a Bunsen burner. Subsequently, 0.5 mL of NaOH was added to the concentrated sample, and its pH was noted. After that, pH was recorded on every 0.5 mL NaOH addition until the sharp change. The strength of phosphoric acid was calculated by the following equation [15];

Strength of phosphoric acid = (v × 0.1)/ 10

where, v = volume of NaOH

Amount of phosphoric acid = normality × equivalent mass

2.4 Corrosiveness

Almost equal-sized iron plates were taken for all different samples. All the plates were etched with sandpaper to make the surface clean and smooth. At first, the plates were cleaned with sandpaper of grit no. 100 and then by grit no. 320. Then the plates were dipped into ethanol for 30 seconds and dried in the oven at about 80°C for half an hour. Cross-section areas of every plate were determined with the help of the vernier calliper and micrometre. Every plate was weighed from a four-digit balance. The temperature of each sample was taken. The plates were dipped in 60 mL of the sample and were taken out from the sample after 10 days and let to dry. The rusting was removed from each plate and the weight was noted again. The experiment was done in triplicate.

Weight loss % = (weight loss after corrosion/ initial weight) × 100

2.5 Acid value

0.2 N KOH was prepared by dissolving 2.8 g of KOH in water and the volume was made to 250 mL. Then KOH solution was standardized with the help of 0.1 N Oxalic acid solution by using phenolphthalein as an indicator. 0.5 g of sample was taken to which 5 mL of ethanol and a few drops of phenolphthalein were added and titrated with 0.2 N KOH. Titration was carried out until the concordant reading was obtained. The acid value was calculated by using the following formula [15];

Acid value = (56 × 0.2 × V) / (1000 × W)

where, W = weight of sample taken

V = volume of 0.2 N KOH required to neutralize the fatty acid

2.6 Caffeine determination

First of all, 200 mL of sample solution was taken in a 500 mL beaker and boiled for about half an hour. The basic lead acetate was added to the hot solution mixture till complete precipitation. The solution was filtered and H_2SO_4 (2 N) was added till the whole lead acetate was removed as lead sulfate. The solution was again filtered and 0.5 g of bone charcoal was added to the filtrate. The volume was concentrated to half by heating and the solution was filtered by the Buchner funnel. The filtrate was taken and caffeine was extracted from chloroform (25 mL in 1 Lot-total 75 mL) in the separating funnel. Chloroform was distilled off and the yield was weighed after distillation [15].

2.7 Dissolved oxygen

In a conical flask, 0.5 mL $MnSO_4$ was properly mixed with 0.5 mL KI. The flask was kept still for 8 minutes for the particles to settle down. After that 0.5 mL conc. H_2SO_4 and 25 mL of the sample were added with 2-3 drops of starch as an indicator. The mixture was titrated with 0.025 N $Na_2S_2O_3$ where the blue color of the solution disappeared. Titration was carried out till the concordant reading. The value of DO was calculated by using the formula [15];

DO (mg/L) = (volume of titrant × normality of titrant × 1000) / volume of sample

2.8 Biological oxygen demand

At first, the value of dissolved oxygen of individual samples was determined. Then the samples were kept in a dark place for 5 days. After that, the values of dissolved oxygen were again measured for samples. Finally, the biochemical oxygen demand values were calculated for each sample by subtracting the DO value on the first day and the DO value after 5 days [15].

2.9 Chemical oxygen demand

In a round bottom flask, 20 mL of the sample was mixed with 10 mL of $K_2Cr_2O_7$ and a pinch of Ag_2SO_4, followed by the addition of $HgSO_4$. Then 30 mL of conc. H_2SO_4 was also added and the mixture was refluxed for about two hours using an air condenser. After that, the mixture was made up to 140 mL by adding distilled water and heated over the burner. The mixture was then titrated with FAS (ferrous ammonium sulfate) by adding 2-3 drops of ferroin as an indicator and the color change was observed. The value of COD was calculated by using the formula [15],

1000 ml of sample (COD) = 8 × (B-A) × 0.125 × 20

where, A= volume of unreacted dichromate of sample

B= volume of the original amount of dichromate

3. Results and discussion

The obtained physicochemical values from experiment were tabulated below. Each calculated value aligns with the value given in level of the bottle or can or the packed box.

Table 1. The physicochemical parameters present in some of the samples available in Nepal

Physicochemical parameters	Coca-Cola	Pepsi	Fanta	Sprite	Rio juice	Red Bull
pH values	2.30	2.36	2.66	2.74	2.80	3.47
Electrical conductivity (μ/ohm)	1.19	1.13	0.84	0.78	1.04	2.68
Acid value	0.1008	0.1322	0.0649	0.11142	0.0694	0.1389
Ascorbic acid (g/L)	0.116	0.126	0.126	0.120	0.124	0.109
Weight loss on mild steel (%)	0.16	0.14	0.35	0.26	0.26	1.12
Phosphoric acid (g/L)	0.23	0.27	-	-	-	-
Caffeine amount (g/L)	0.8755	1.0315	-	-	-	2.6345
DO (mg/L)	20.8	22.4	16.8	21.6	14.4	17.6
BOD (mg/L)	14.4	15.2	11.2	15.0	8.0	8.8
COD (mg/L)	18.72	21.28	15.68	21.00	10.4	13.20

3.1 pH values

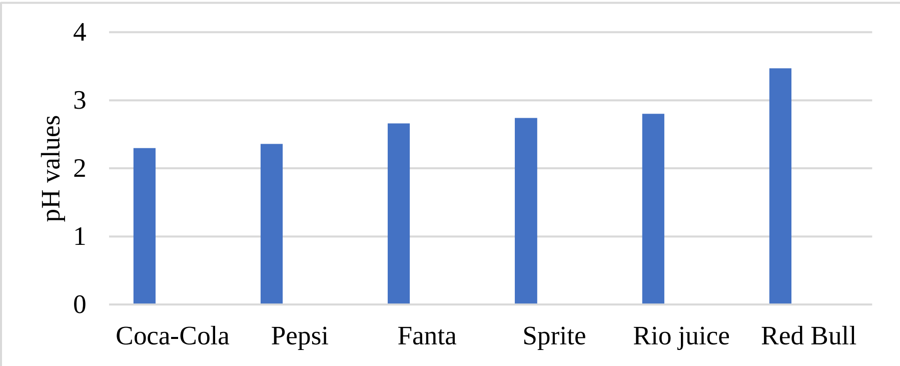

Fig 1. Comparison of pH values of different samples

The pH reading of the samples showed that Coca-Cola has the lowest pH value signifying its highly acidic nature and Red Bull has the highest pH value. The pH range of 2.5-4.5 for acid cold drinks is considered to be safe for consumption according to the WHO guidance (2015) but highly acidic cold drinks should not be consumed because they can cause many health issues like gastritis, ulcer, acidity,weight gain, fatty liver, diabetes etc. [16]. In carbonated drinks, the growth of particular microbes producing desired organoleptic changes, as in fermented foods or alcoholic beverages, is a positive attribute of the presence of microbes that will increase the pH value. It can also be a negative attribute if the microbes cause illness to consumers or spoil the food, or it can be completely neutral with no effect of microbes on the food and the consumers. The high acidity of Coca-Cola is an indication of the presence of more microbes as compared to other taken samples whereas the majority of yeasts and moulds may be suppressed by a lack of oxygen within the soft drinks packaging [17].

3.2 Electrical conductivity

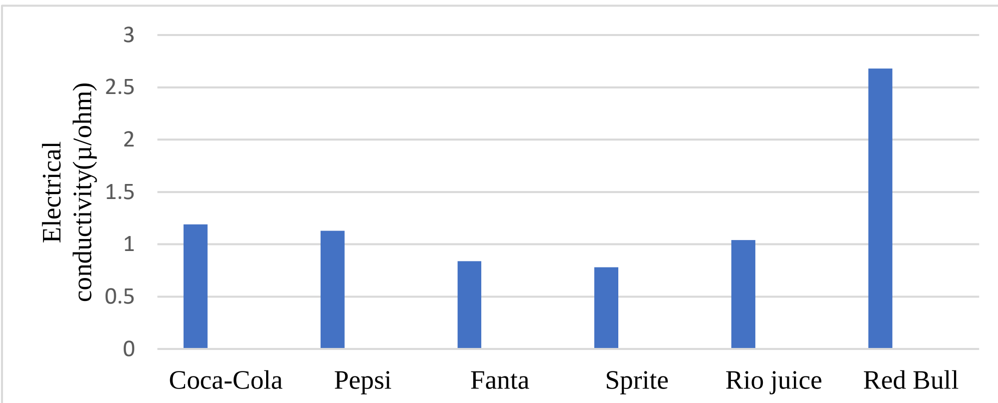

Fig 2. Comparison of electrical conductivity of different samples

Among the six samples taken for the experiment, Red Bull has the highest conductivity, and Sprite has the lowest value of electrical conductivity. The result indicated that Sprite possessed good quality in terms of electrical conductivity than other soft drinks. Electrical conductivity is the measurement of the dissolved salts in an aqueous solution, which relates to the ability of the material to conduct electrical current through it [18]. Electrical conductivity is an important parameter to check the quality of drinking water used in the preparation of soft drinks because conductivity measurements are based on the ionic composition of the water or solutions [19]. High values of electrical conductivity can mean the sample taken is too salty which is not good enough to consume [20]. Consumption of salty drinks can lead to high blood pressure, stroke, and heart disease on human health.

The lowest value of free fatty acid was found in Fanta and the highest in Red Bull. The high free fatty acid content indicated the loss of flavour quality and stability during the refining of the sample. The high value of free fatty acids in soft drinks is an indication of damage or the presence of moisture. The safe range of free fatty acids lies between 0.5-0.8%. The level of free fatty acids depends on time, temperature, and moisture content because the prepared samples are exposed to various environments such as processing, heating, storage, transportation, etc. [21].

3.3 Acid value

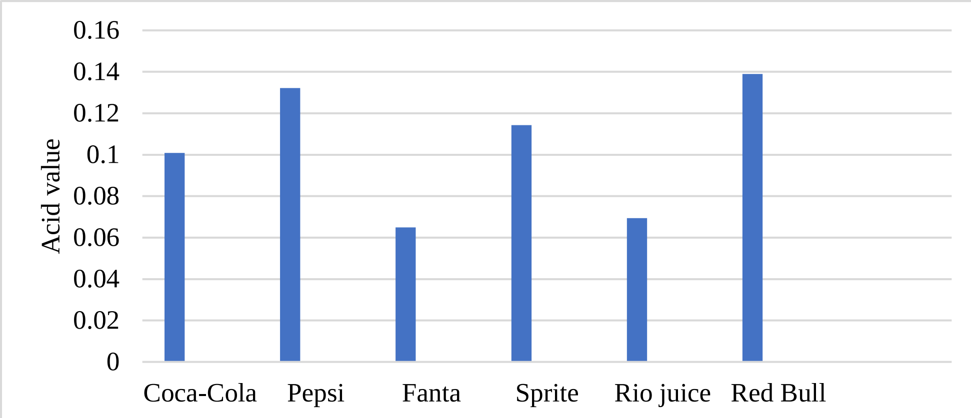

Fig 3. Comparison of acid values of different samples

3.4 Ascorbic acid

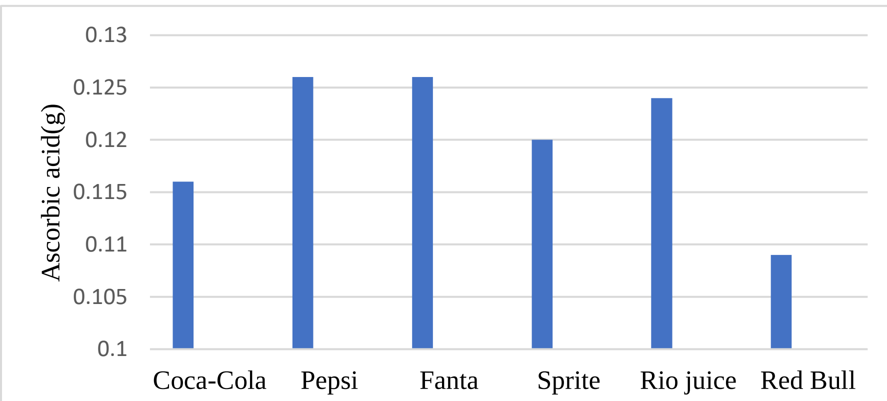

Fig 4. **Comparison of ascorbic acid of different samples**

The highest amount of ascorbic acid was found in Pepsi and Fanta, and the lowest amount of ascorbic acid was found in Red Bull. Ascorbic acid is found in various foods and sold as a dietary supplement which is used to prevent and treat scurvy. Ascorbic acid is an essential nutrient involved in the repair of tissue and the enzymatic production of certain neurotransmitters and required for the functioning of several enzymes and is important for immune system functions [22]. It is an antioxidant that has been shown to scavenge free radicals directly in the aqueous phases of cells and the circulatory system [23, 24]. The high value of ascorbic acid implies a greater antioxidant capacity [25, 26]. The consumption of antioxidants at a limited dose is essential for human beings, however, excessive consumption may cause gastrointestinal discomfort, headache, insomnia, and flushing of the skin. Consumption of more than 2.3 g of ascorbic acid per day may cause indigestion, particularly when taken on an empty stomach; other symptoms reported for large doses include kidney stones and severe diarrhoea [27].

3.5 Corrosiveness

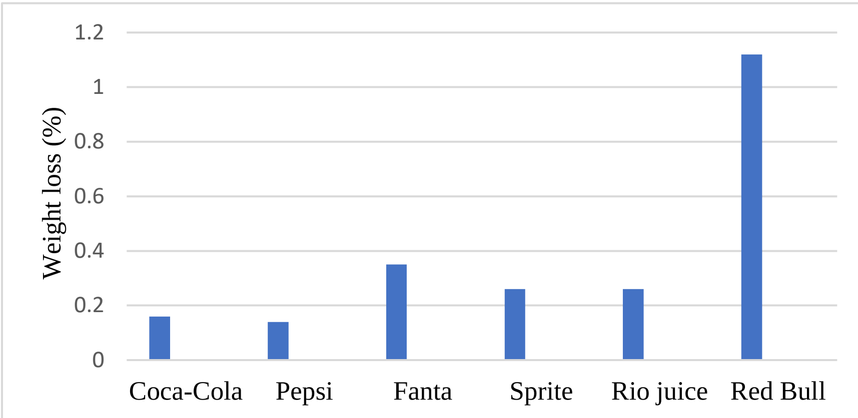

Fig 5. Comparison of weight loss in different samples

The above experiment was done by following the weight loss method which is the simplest form of corrosion monitoring. Corrosion of mild steel is caused by the presence of moisture, electrolysis, scratches, cracks on the metal surface, etc. Furthermore, corrosion can be accelerated by different factors, including low pH, high temperature, the presence of an electrolyte, the surface of the metal itself, moisture, etc. The corrosive things can destroy or at least damage the metal. The corrosive nature of soft drink not only corrode the metal but also directly affect the human digestive system, respiratory tract, eyes, skin, tooth, and other oral health problems. Therefore, the regular and high consumption of soft drinks having a high corrosive nature is not recommended. The deterioration because of corrosion can happen in minutes or slowly over days or years. Based on the obtained results, Red Bull was found to be the most corrosive with a weight loss of 1.12% to mild steel. [28, 29].

3.6 Phosphoric acid

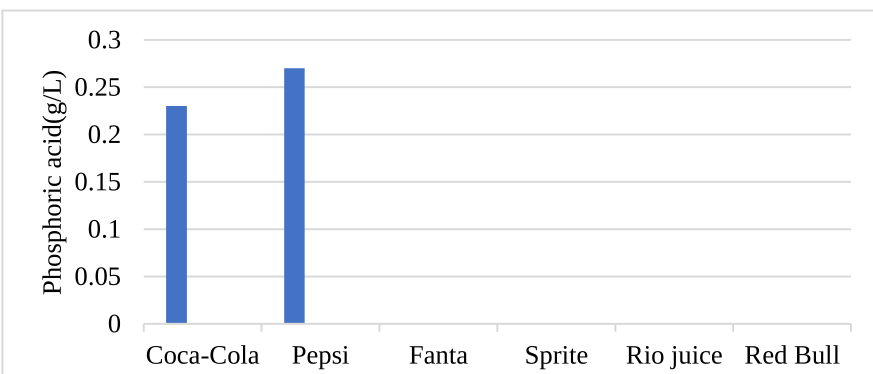

Fig 6. Comparison of phosphoric acid of different samples

Soft drinks with darker colors were found to contain phosphoric acid to some extent. In this research, we found only Coca-Cola and Pepsi contain phosphoric acid. Phosphoric acid gives a tangy flavour to soft drinks and prevents the growth of moulds and bacteria which can multiply easily in a sugary solution. The recommended daily amount (RDA) of phosphorous needed for the normal bodily function is 700 mg and we can get this easily from natural food sources. Adults with kidney diseases are recommended to have no more than 800 to 1000 mg of phosphorous in a day [30].

3.7 Caffeine

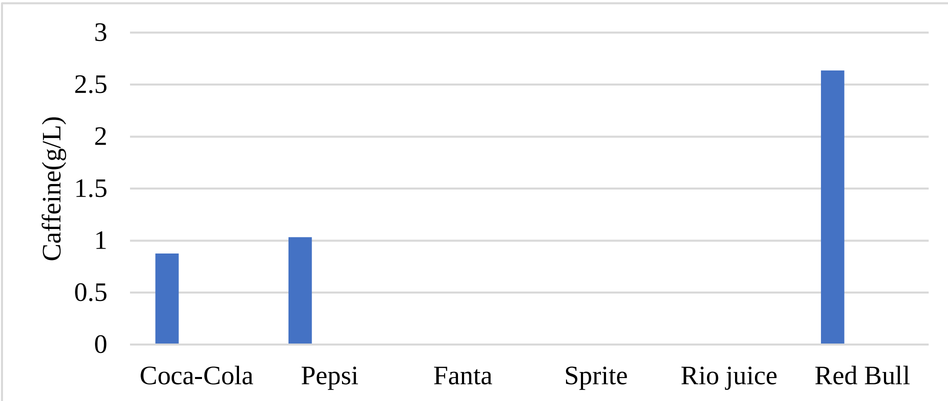

Fig 7. Comparison of caffeine extracted from different samples

Only Coca-Cola, Pepsi and Red Bull were found to contain caffeine. Different energy drinks and soft drinks have different amounts of caffeine, and they range from 50-300 mg. A limited dose (recommended by WHO) of caffeine per day is okay for consumption. Most people experience no behavioral effects with less than 300 mg of caffeine. An acute overdose of caffeine, usually over 250 mg can result in a state of central nervous system overstimulation called caffeine intoxication. After 10 hours of fasting, adolescent men and women who consumed 150–300 mg of caffeine experienced an increase in urine calcium excretion two–three hours later [31]. Excessive caffeine can have negative consequences, including irritability, gastritis, insomnia and anxiety when consumed in large quantities throughout the day [32].

3.8 Dissolved oxygen, biological oxygen demand and chemical oxygen demand

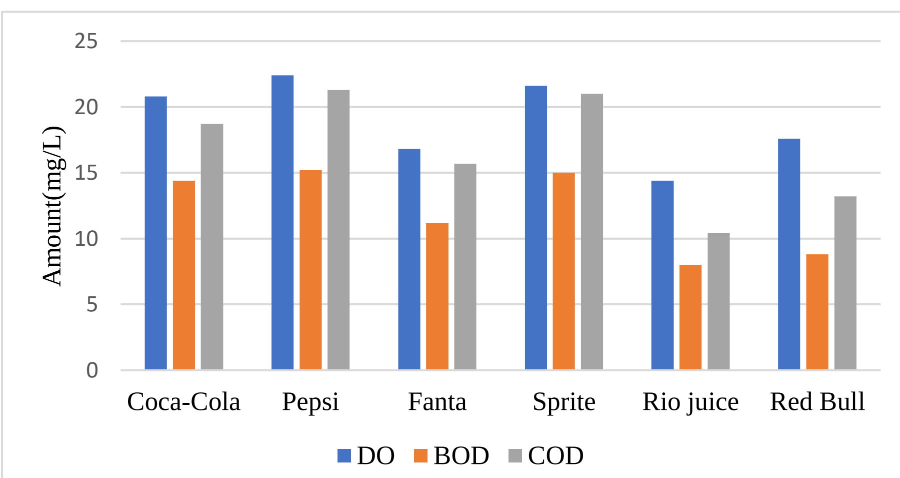

Fig 8. Comparison of DO, BOD and COD of different samples

The highest amount of dissolved oxygen, biological oxygen demand, and chemical oxygen demand was found in Pepsi and the lowest value was found in Rio juice. Many soft drinks contain natural ingredients such as pulp, fruit juices, or vitamins and these components are subject to oxidation. High levels of dissolved oxygen (O_2) in soft drinks may cause changes in the beverage's aroma and taste, changes in colour, and the loss of nutritional value. The more oxygen in the sample container, the faster the oxidation takes place but the oxidation is enhanced by elevated temperatures. The low values of DO indicate the presence of microbes in the sample and just as the high concentrations of DO can cause gas bubble diseases in invertebrates [33].

BOD represents the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic matter under aerobic conditions at a specific temperature [34]. Determining how organic matter affects the concentrations of DO in any liquid sample, the decay of organic matter in water is measured as BOD. The obtained BOD values are the measure of the amount of oxygen required to remove waste organic matter from the sample in the process of decomposition by aerobic bacteria [35]. The higher values of BOD of the samples tested indicated that there are fewer aerobic bacteria and other micro-organisms so they couldn't decompose organic matter [36].

The higher value of COD indicates the poor quality of the product. COD is a measure of water and wastewater quality [37]. COD is normally higher than BOD because more organic compounds can be chemically oxidized than biologically oxidized. Residual food waste from bottles and cans, antifreeze, and emulsified oils are the common sources of a higher amount of COD. The higher the COD value, the more serious the pollution of organic matter by water [38].

4. Conclusion

The observed readings were practically within permitted consumption limits. Of all the samples taken, they were found to be in the safe pH range. The electrical conductivity test indicated that Sprite was a good quality drink than others. Ascorbic acid was found in all the taken samples. Only Coca-Cola and Pepsi were found to contain phosphoric acid. Red Bull has the highest acid value, the greatest probability of corrosion, and the most caffeine content. The greatest DO, BOD, and COD levels were found in Pepsi among all the samples. The present study of the physicochemical properties of a few well-known soft drinks leads to the conclusion that the samples used in this study are safe to consume. The ingredient labels are slightly different, which may be caused by variations in storage temperature, moisture content, packing materials, production processes, transportation, etc.

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Conflict of interest

This research was conducted as per the laboratory condition of the Amrit Campus, Department of Chemistry. These findings do not prove or disprove the quality assurance of the studied samples in this research.

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