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Comparative Analysis of Natural and Artificial Beverages Based on Physicochemical Parameters

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Abstract:
With the growing consumption of both natural and artificial beverages, it is essential to evaluate their physicochemical properties and nutritional relevance, particularly for individuals with health concerns such as hypertension. This study compares various natural beverages—such as coconut water, sugarcane juice, and fruit juices—with popular artificial drinks including carbonated sodas and packaged juices. Parameters analyzed include density, sodium (Na), potassium (K), salinity, electrical conductivity, total dissolved solids (TDS), and pH. The results reveal that natural beverages typically exhibit higher potassium levels, moderate sodium content, and pH values closer to neutral, making them more suitable for maintaining electrolyte balance and supporting cardiovascular health. For example, natural coconut water contains 4415 ppm of potassium with a pH of 4.6, whereas artificial coconut water contains significantly less potassium (191.4 ppm) despite a similar pH. Artificial beverages generally show elevated sodium, lower potassium, and highly acidic pH values (ranging from 2.3 to 3.3), potentially exacerbating health issues such as hypertension and gastric irritation. The findings highlight the nutritional superiority and lower acidity of natural beverages and support their inclusion in the diet, particularly for individuals managing blood pressure. This study emphasizes the need for conscious beverage selection and greater public awareness of the potential health impacts associated with frequent consumption of artificially formulated drinks.

1. Introduction

Beverages form an integral part of the human diet, serving as sources of hydration, energy, and essential nutrients. With the growing diversity in consumer preferences and global market trends, both natural and artificial beverages have witnessed a significant rise in consumption. Natural beverages—such as coconut water, sugarcane juice, and fruit juices—are traditionally valued for their rich mineral content, lower acidity, and health-promoting attributes[1-2]. In contrast, artificial beverages, including carbonated soft drinks and synthetically flavored fruit drinks, are widely available and often consumed for their taste, convenience, and long shelf life. However, these processed drinks are frequently criticized for their high sugar content, acidity, and lower nutritional value.

Physicochemical properties such as density, sodium (Na) and potassium (K) concentrations, salinity, electrical conductivity, total dissolved solids (TDS), and pH play a crucial role in evaluating the quality, safety, and nutritional potential of beverages[3-4]. Energy value and Maker of few common, available and widely consumed soft drinks in India have been reported[5]. For example, the balance of sodium and potassium influences electrolyte homeostasis in the body, while pH levels indicate the degree of acidity, which can impact dental health and gastrointestinal function[6].

Sodium (Na^+) and potassium (K^+) are essential electrolytes that play critical roles in maintaining physiological homeostasis, including nerve transmission, muscle contraction, fluid balance, and blood pressure regulation[7-8]. An imbalance in the intake of these electrolytes, particularly excessive sodium and insufficient potassium, has been strongly associated with cardiovascular diseases (CVDs), hypertension, and renal dysfunction[9]. According to the World Health Organization (WHO), most populations consume sodium in excess of recommended levels (less than 2 g per day), often through processed foods and beverages, while potassium intake remains substantially below the suggested intake of 3.5 g per day[10].

Several epidemiological and clinical studies have demonstrated a direct correlation between high sodium intake and increased blood pressure, a major risk factor for stroke, heart attack, and heart failure[11-13]. Literature also highlights that dietary patterns rich in fruits, vegetables, and natural beverages—which are typically high in potassium and low in sodium—are associated with better cardiovascular outcomes.

Therefore, understanding the sodium and potassium content in commonly consumed beverages is crucial for informing dietary guidelines and promoting cardiovascular health, especially among populations at risk for or currently managing hypertension.

This study seeks to compare and analyze the physicochemical parameters of selected natural and artificial beverages commonly consumed in India. The primary objective is to highlight the differences in mineral composition, acidity, and overall health implications associated with each category. By providing a data-driven comparison, this research aims to guide consumers towards making informed dietary choices and contribute to ongoing discussions in the fields of food science, nutrition, and public health.

2. Methodology

The present study involves the comparative analysis of various physicochemical parameters of selected natural and artificial beverages using standard laboratory procedures and instruments such as a flame photometer and water analysis kit.

i. Sample Collection

A total of 8 natural beverages (e.g., coconut water, sugarcane juice, orange juice) and 10 artificial beverages (e.g., Mirinda, Coca-Cola, Frooti) were selected based on market availability and consumption popularity. All samples were procured in their original packaging and analyzed without any pre-treatment to preserve their natural state.

ii. Preparation of Standard Solutions

To analyze sodium (Na^+) and potassium (K^+) concentrations in the selected beverage samples, standard calibration solutions were prepared using analytical-grade sodium chloride (NaCl) and potassium chloride (KCl) salts. A stock solution of 1000 ppm was prepared by accurately weighing 2.54 g of NaCl and 1.91 g of KCl, dissolving each separately in distilled water, and making up the volume to 1 liter in volumetric flasks. From these stock solutions, working standards with concentrations of 10 ppm, 20 ppm, 30 ppm, 40 ppm, and 50 ppm were prepared by serial dilution. These standards were used to generate calibration curves for the quantitative determination of Na^+ and K^+ levels in both natural and artificial beverage samples through appropriate instrumental analysis

iii. Instrumentation and Analysis

Sodium and potassium concentrations in the beverage samples were determined using a Flame Photometer (Systronics Flame Photometer 128). Calibration was performed with prepared working standards of Na^+ and K^+. Each filtered beverage sample was aspirated into the instrument, and the emission intensities were measured. These readings were compared against the calibration curves to quantify the sodium and potassium content in parts per million (ppm). Salinity, electrical conductivity, total dissolved solids (TDS), and pH of the beverage samples were measured using a Water Analysis Kit (Systronic 371). Fresh aliquots of each sample were analyzed according to the manufacturer's instructions. The pH meter was calibrated using standard buffer solutions (pH 4, 7, and 9.2) before measurement. All parameter values were recorded directly from the kit's digital display.

Density (g/cm³) was calculated using the formula:

$$\text{Density} = \frac{\text{Weight of sample}}{\text{Volume of sample (cm}^3\text{)}}$$

iv. Data Recording and Analysis

All values were recorded in triplicate to ensure accuracy and reproducibility. Statistical analysis was performed to compare the mean values of each parameter across natural and artificial beverage groups.

3. Results and Discussion

The physicochemical analysis of natural beverages revealed substantial variation in mineral content and acidity across different juices presented in Table1. Coconut water exhibited the highest potassium concentration (4415 ppm), making it a superior natural electrolyte source, followed by grapes (3471 ppm) and pineapple (2500 ppm). Sodium levels were highest in coconut water (280 ppm) and sugarcane juice (236 ppm), suggesting their potential role in replenishing both sodium and potassium in the body. Grapes and pineapple also showed high conductivity and TDS values, indicating a rich ionic composition. The pH values ranged from 2.3 (lemon juice) to 5.2 (watermelon), with citrus-based juices like lemon and orange exhibiting higher acidity. These findings highlight the nutritional benefits of natural beverages, especially for hydration and electrolyte balance, while also emphasizing the need for caution with more acidic options.

Table 1 Physicochemical Properties of Selected Natural Beverages

Name of Brand	Density (g/cm³)	Na (ppm)	K (ppm)	Salinity (ppm)	Conductivity (µS)	TDS (ppm)	pH
Coconut water-Natural	1.0702	280	4415	4360	8270	4350	4.6
Sugarcane	1.038	236	1374	1050	2330	1230	3.5
Orange	1.0504	7.2	82.4	1990	3870	2200	3.9
Apple	1.016	19.11	399.1	720	1390	740	4.1
Pineapple	1.0706	14.21	2500	2540	4870	2560	3.5
Lemon	1.0554	5.2	11.8	2760	5260	2810	2.3
Grapes	1.0034	142	3471	2620	4680	2490	3.4
Watermelon	1.0051	36.2	188.3	2180	3650	1920	5.2

Artificial beverages displayed a significantly different nutrient and acidity profile compared to their natural counterparts shown in Table2. Most notably, potassium content remained low across almost all samples, with the exception of Frooti (105.6 ppm) and artificial coconut water (191.4 ppm). Conversely, sodium levels were relatively high, particularly in 7UP (225.1 ppm), Frooti (225.6 ppm), and Funta (202.3 ppm), indicating a higher salt load which may not be suitable for individuals with hypertension. pH levels were markedly acidic, with values as low as 2.3 in Coca-Cola and 2.4 in

Limca, which could pose risks to dental and gastric health if consumed frequently. Despite high conductivity and TDS in some samples—especially artificial coconut water—the overall mineral quality appears inferior to natural alternatives. These results underline the potential health concerns associated with frequent consumption of artificial beverages, particularly due to their high sodium-to-potassium ratio and pronounced acidity.

Table 2 Physicochemical Properties of Selected Artificial Beverages

Name of Brand	Density (g/cm³)	Na (ppm)	K (ppm)	Salinity (ppm)	Conductivity (µS)	TDS (ppm)	pH
Mirinda	1.025	82.2	8.1	510	977	519	2.5
7uP	1.0442	225.1	9.9	600	1180	620	3
Frooti	1.0795	225.6	105.6	510	1040	550	2.9
Limca	1.0557	83.5	8.4	290	551	290	2.4
Coca cola	1.0538	39	46.6	620	1230	640	2.3
Coconut water-Artificial	1.0577	23	191.4	5180	9570	5030	5
Funta	1.0524	202.3	46.2	500	991	519	2.6
Sprit	0.96	120.8	2.2	220	484	253	3
Maaza	1.0835	71.3	4.2	560	1220	650	3.3
Mountain Dew	1.0577	116.5	9.1	210	468	246	2.9

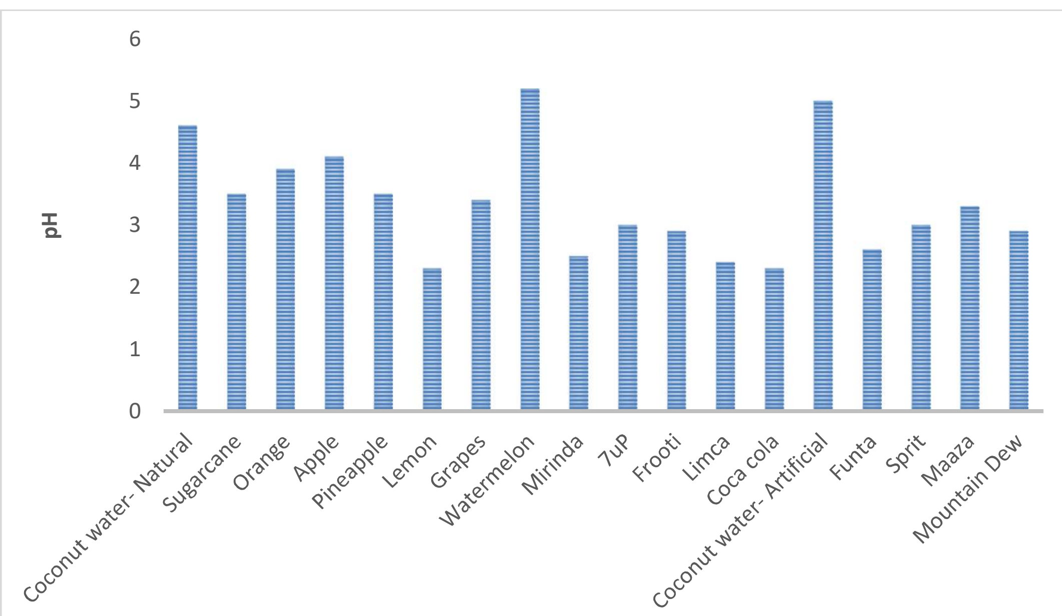

Figure 1 pH Levels Across Different Natural and Artificial Beverages

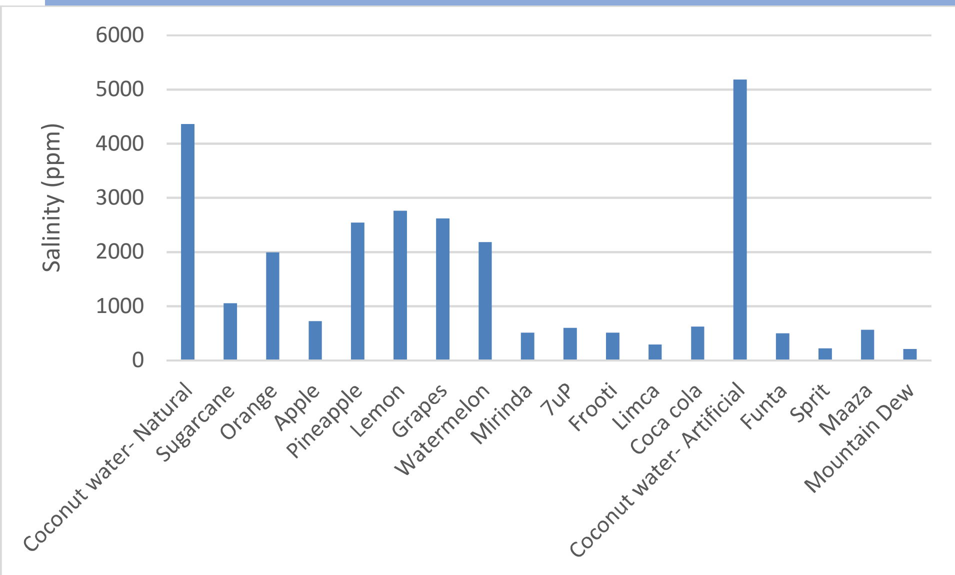

Figure 2 Salinity Levels Across Different Natural and Artificial Beverages

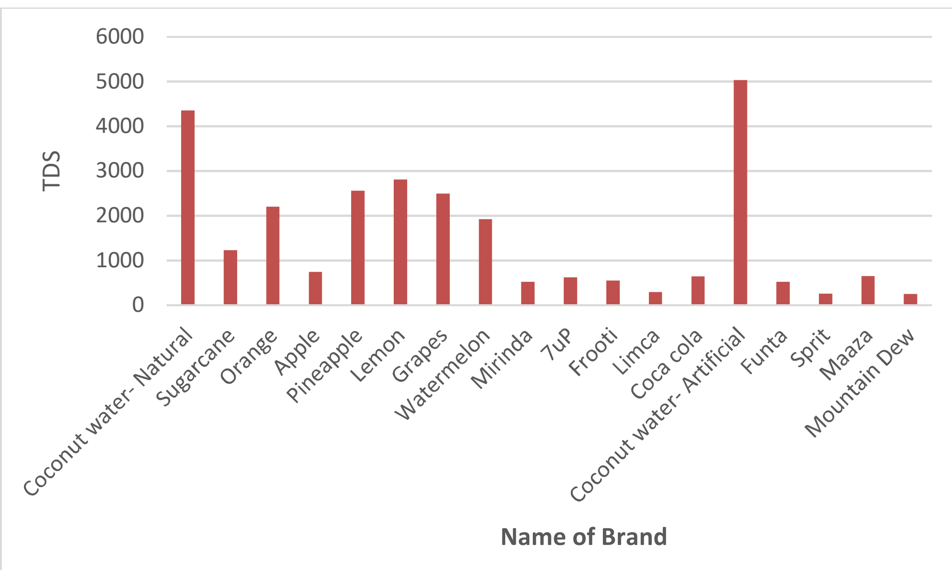

Figure 3 TDS Levels Across Different Natural and Artificial Beverages

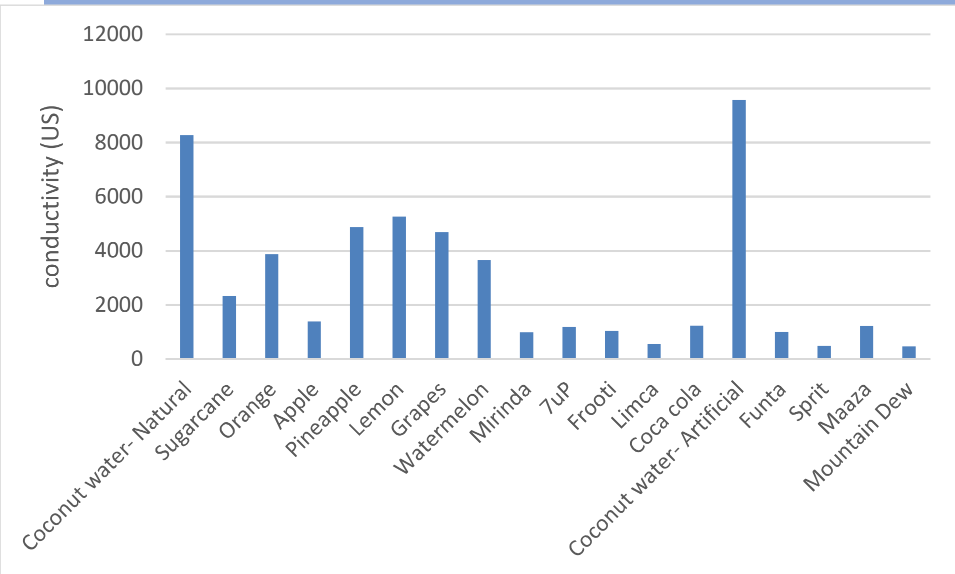

Figure 4 Conductiivity Levels Across Different Natural and Artificial Beverages

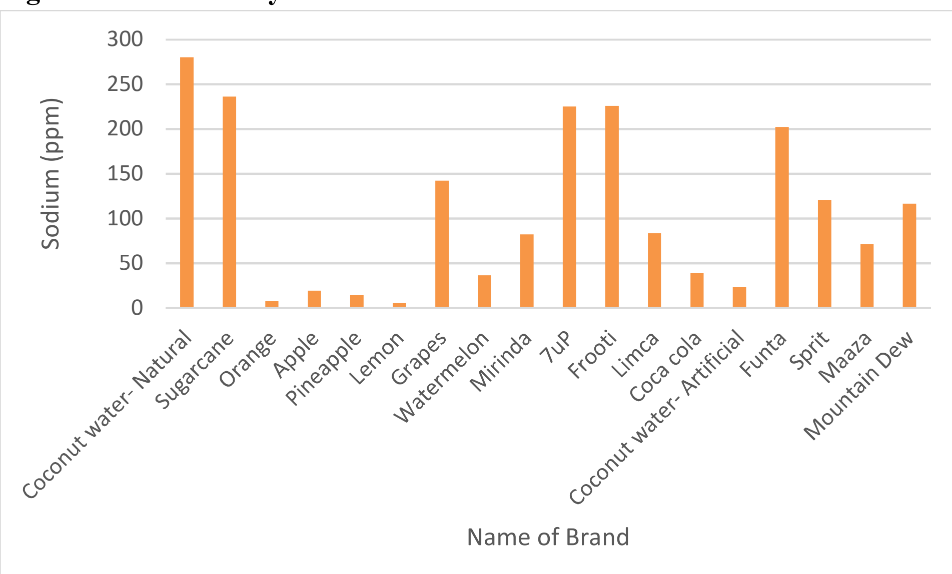

Figure 5 Sodium Levels Across Different Natural and Artificial Beverages

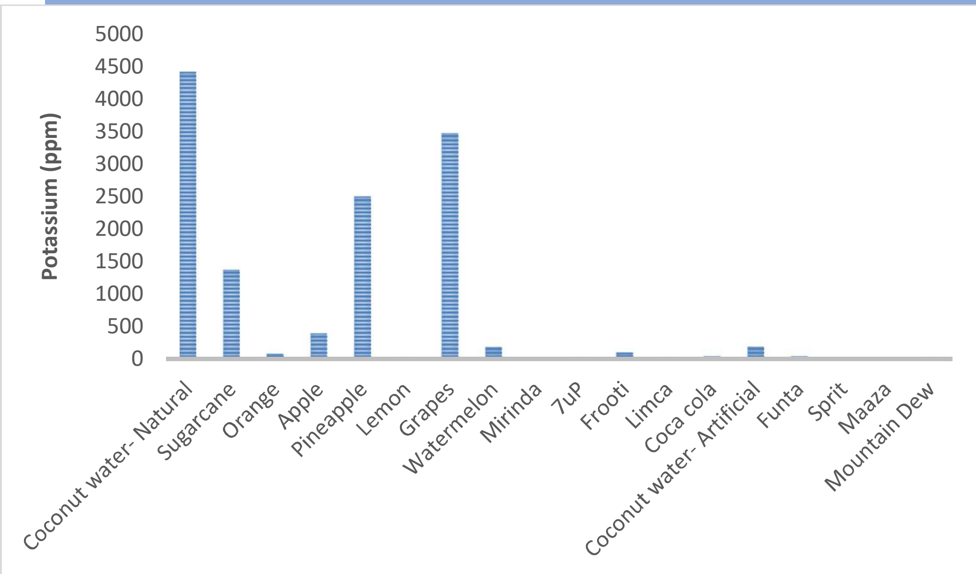

Figure 6 Potassium Levels Across Different Natural and Artificial Beverages

4. Discussion and Conclusion: Analysis of Natural and Artificial Beverages

The comparative analysis of natural and artificial beverages reveals distinct differences in physicochemical properties, influenced by their composition and processing methods.

4.1. Nutritional Composition (Na and K):

Natural beverages, particularly coconut water (4415 ppm K), exhibit significantly higher potassium levels, aligning with the inherent mineral content of fruits. This positions them as beneficial for electrolyte replenishment. Conversely, artificial beverages like 7uP (225.1 ppm Na) and Mirinda (82.2 ppm Na) show elevated sodium levels, likely due to additives for flavor or preservation. Notably, artificial coconut water (191.4 ppm K) contains far less potassium than its natural counterpart, underscoring differences in nutritional authenticity.

4.2. Salinity andTDS:

Salinity and TDS values correlate closely, reflecting dissolved salts. Natural beverages such as coconut water (4360 ppm salinity, 4350 ppm TDS) and pineapple (2540 ppm salinity, 2560 ppm TDS) demonstrate high values, attributable to natural electrolytes. Artificial coconut water, however, surpasses all with 5180 ppm salinity and 5030 ppm TDS, likely from added salts to mimic natural properties. Other artificial drinks (e.g., Sprite: 220 ppm salinity) show lower values, emphasizing targeted formulation for taste over nutrient density.

4.3. Conductivity:

Conductivity parallels TDS trends, with natural coconut water (8270 µS) and artificial coconut water (9570 µS) leading. This indicates high ion content, critical for electrolyte functionality. Most artificial beverages, such as Mountain Dew (468 µS), exhibit lower conductivity, aligning with reduced mineral content.

4.4. pH and Acidity:

Both categories are acidic, but natural beverages like watermelon (pH 5.2) approach neutrality, whereas artificial drinks (e.g., Coca Cola: pH 2.3) are more acidic. High acidity in artificial options may pose dental health risks, while natural beverages offer milder alternatives.

4.5. Density Variations:

Natural beverages show moderate density ranges (1.0034–1.0706 g/cm³), reflecting inherent sugars and solids.

Artificial beverages exhibit wider variability, with Sprite (0.96 g/cm³) potentially influenced by carbonation, and Maaza (1.0835 g/cm³) suggesting high sugar/solid content.

5. Suggestions

Based on the analysis, several recommendations can be made for individuals with high blood pressure to maintain a healthy balance of sodium and potassium through beverage choices. Natural drinks such as coconut water, grape juice, and pineapple juice should be prioritized daily due to their high potassium and low sodium content, which support blood pressure regulation. For added variety, apple and watermelon juices can also be included, as they provide moderate potassium with relatively low sodium. On the other hand, carbonated and artificial beverages—especially those containing more than 100 ppm sodium and less than 50 ppm potassium—should be strictly avoided, as they can contribute to increased blood pressure. Individuals with diabetes or kidney issues must exercise caution and consult a healthcare provider before consuming potassium-rich drinks, as excessive potassium may be harmful in certain conditions. For better hydration and electrolyte balance, natural juices can be diluted with water, and beverages with a pH below 3 should be avoided due to their high acidity, which may irritate the stomach lining.

The comparative analysis of natural and artificial beverages based on their sodium (Na), potassium (K), salinity, conductivity, total dissolved solids (TDS), and pH reveals significant differences relevant to individuals managing high blood pressure. Natural beverages such as coconut water, grapes juice, and pineapple juice demonstrate a favorable potassium-to-sodium (K:Na) ratio, making them suitable for hypertensive patients due to potassium's role in counteracting sodium's effect on blood pressure. For instance, natural coconut water contains a high level of potassium (4415 ppm) with moderate sodium (280 ppm), offering an ideal electrolyte balance. In contrast, artificial beverages, particularly carbonated soft drinks like 7UP, Frooti, and Mountain Dew, exhibit high sodium and low potassium content, which could potentially aggravate hypertension. Moreover, these artificial drinks are also more acidic (pH < 3) and may contribute to gastric discomfort. Therefore, natural beverages are strongly recommended over artificial options for better cardiovascular and overall health, especially in blood pressure management. The Table3 highlights natural beverages with high potassium and low sodium levels, ideal for individuals managing hypertension, along with their potassium-to-sodium (K:Na) ratios and pH values.

Table 3 Best Natural Beverages for Hypertensive Patients Based on Sodium and Potassium Content

Beverage	Na (ppm)	K (ppm)	K:Na Ratio	pH	Notes
Coconut Water (Natural)	280	4415	**15.8**	4.6	Excellent source of potassium. Helps in electrolyte balance.
Grapes Juice	142	3471	**24.4**	3.4	High in potassium, moderate sodium. Good balance.
Pineapple Juice	14.2	2500	**176**	3.5	Very high K:Na ratio. Great for potassium replenishment.
Apple Juice	19.1	399	**20.9**	4.1	Moderate K. Low Na. Gentle on the stomach.
Watermelon Juice	36.2	188.3	**5.2**	5.2	Mild but hydrating. Slightly lower potassium.

Artificial beverages such as 7UP, Frooti, and Funta exhibit unfavorable sodium and potassium profiles for hypertensive patients, with sodium concentrations exceeding 200 ppm and very low potassium levels, resulting in critically low K:Na ratios (e.g., 0.044 for 7UP). These drinks also possess strongly acidic pH values below 3.0, which may exacerbate gastric irritation and dental erosion. Other popular sodas like Limca, Mirinda, Coca-Cola, and Mountain Dew similarly contain high sodium levels combined with negligible potassium and high acidity, making them poor choices for those needing to control sodium intake. Collectively, these artificial beverages should be avoided or consumed sparingly to reduce the risk of negative health impacts related to hypertension and acid-related conditions.

This table 4. lists commonly consumed artificial beverages characterized by high sodium, low potassium, low potassium-to-sodium (K:Na) ratios, and acidic pH values, making them unsuitable for individuals managing blood pressure.

Table 4 Artificial Beverages to Avoid or Limit for Hypertensive Patients Due to High Sodium and Low Potassium Content

Beverage	Na (ppm)	K (ppm)	K:Na Ratio	pH	Reason
7UP	225.1	9.9	0.044	3.0	High sodium, negligible potassium.
Frooti	225.6	105.6	0.47	2.9	Very acidic, high Na.
Funta	202.3	46.2	0.23	2.6	Low potassium, high sodium.
Limca, Mirinda, Coca Cola, Mountain Dew	High Na, very low K	K:Na < 0.5	pH < 3.0	High acidity and sodium. Avoid.	

6. Conclusion:

The comparative assessment of natural and artificial beverages highlights the critical importance of electrolyte composition, particularly sodium and potassium levels, for individuals managing high blood pressure. Natural beverages such as coconut water, grape juice, and pineapple juice emerge as superior options due to their high potassium-to-sodium ratios, which aid in maintaining cardiovascular health and regulating blood pressure. In contrast, artificial and carbonated beverages not only exhibit unfavorable electrolyte profiles—with high sodium and low potassium—but also possess high acidity, posing additional health risks. Therefore, incorporating natural, potassium-rich, and less acidic beverages into the daily diet, while avoiding high-sodium artificial drinks, can be a valuable dietary strategy for hypertensive individuals. These insights reinforce the role of informed beverage choices in promoting long-term heart health and overall well-being.

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