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Effect of Pineapple Juice Proportion on Sensory Acceptance and Physicochemical Characteristics of a Coconut Water-Based Isotonic-Type Drink

Didik Hariyadi*, Jonni Syah R. Purba, Suaebah, Anisa Rezky Nurdin
Department of Nutrition, Poltekkes Kemenkes Pontianak, Pontianak, Indonesia

*Correspondence: didikhariyadi@yahoo.com

ABSTRACT

Coconut water is increasingly explored as a natural base for isotonic beverages, and fruit juices are added to improve flavour and vitamin content; however, few studies have examined low pineapple juice proportions in an undiluted coconut water base while quantifying sensory acceptance together with compositional quality against the Indonesian standard. This study aimed to evaluate the effect of pineapple juice (*Ananas comosus* L.) proportion on the sensory acceptance, vitamin C, sucrose, sodium, potassium, and pH of a coconut water-based isotonic-type drink. In a laboratory experiment, three formulations were prepared with coconut water to pineapple juice ratios of 900:100 mL (F1), 800:200 mL (F2), and 700:300 mL (F3), each containing 70 g sucrose and 1 g sodium benzoate per litre. Twenty-five semi-trained panelists rated the colour, aroma, and taste of all three coded samples on a 5-point hedonic scale; the data were analysed with the Friedman test followed by Wilcoxon signed-rank tests with Bonferroni correction. Vitamin C (UV–Vis spectrophotometry), sucrose (Luff–Schoorl), sodium and potassium (atomic absorption spectrophotometry), and pH (potentiometry) were determined once per formulation. Pineapple juice proportion significantly affected aroma acceptance ($\chi^2 = 9.48$, $p = 0.009$), with F3 preferred over F2, but not colour ($p = 0.283$) or taste ($p = 0.759$). F3 obtained the highest rank sums for all attributes and the highest vitamin C content (34.1 mg/100 mL vs 25.3 mg/100 mL in F1). Sucrose (6.80–7.44%) met the SNI 01-4452-1998 minimum of 5%, whereas pH (4.52–4.91) exceeded the SNI maximum of 4.0, and sodium (1671.3–1794.2 mg/kg) and potassium (589.8 mg/kg) exceeded the SNI requirements (800–1000 and 125–175 mg/kg, respectively). Increasing pineapple juice to 30% improved aroma acceptance and vitamin C content; however, none of the formulations met all SNI requirements and osmolality was not measured. Electrolyte and pH adjustment, reduction of the preservative level, and osmolality verification are required before the product can be classified as isotonic.

Keywords: Coconut water; Electrolytes; Isotonic drink; Pineapple juice; Sensory evaluation; Vitamin C

INTRODUCTION

Isotonic drinks are formulated to replace the water, carbohydrate, and electrolytes lost through sweat during physical activity. Their rehydration performance depends on carbohydrate concentration, sodium and potassium content, and an osmolality close to that of body fluids, approximately 270–330 mOsm/kg (Rowlands et al., 2021; Skarlovnik et al., 2024). Studies in physically active Indonesian populations have reported favourable effects of isotonic drinks on hydration status and heart rate recovery (Hadjarati & Massa, 2023; Ivadha, 2023). In Indonesia, the quality requirements are set by SNI 01-4452-1998, which specifies total sugar as sucrose of at least 5%, sodium of 800–1000 mg/kg, potassium of 125–175 mg/kg, and a maximum pH of 4.0 (Badan Standardisasi Nasional [BSN], 1998; Asnia et al., 2024).

Sports and isotonic drinks are no longer consumed only by athletes, and their wider use has raised concern about added sugar and synthetic additives in commercial products (Muñoz-Urtubia et al., 2023). This concern is relevant in Indonesia, where the prevalence of adult obesity increased from 15.4% in 2013 to 21.8% in 2018 (Kementerian Kesehatan Republik Indonesia [Kemenkes RI], 2018). Beverages based on minimally processed local commodities have therefore been proposed as alternatives whose composition can be controlled during formulation (Fariza et al., 2021; Pakaya et al., 2021; Ratri et al., 2024).

Coconut (*Cocos nucifera* L.) water contains sugars, amino acids, vitamins, and minerals, with potassium as the dominant cation, although its composition varies with cultivar, maturity, and growing conditions (Yong et al., 2009). Coconut water has produced performance and physiological responses comparable to a commercial sports drink during resistance exercise (O'Brien et al., 2023). However, its natural electrolyte profile does not match isotonic drink specifications, and several coconut water

formulations were found to be hypertonic or to exceed potassium limits until the formulation was adjusted (Aprilia et al., 2023; Kariyawasam et al., 2024).

Pineapple (*Ananas comosus* L.) juice contributes vitamin C, phenolic antioxidants, organic acids, and characteristic volatile esters that determine its aroma (Wei et al., 2011; Hoque et al., 2022). Pineapple juice has been used as the base of an isotonic sports drink (García et al., 2023), and blend ratios of pineapple with other juices influence physicochemical properties and sensory acceptability (Friday et al., 2021; Hamzah & Sarbon, 2022). Pineapple juice is therefore a plausible ingredient for improving the flavour and vitamin C content of coconut water-based drinks.

Previous coconut water–pineapple studies used comparatively high pineapple proportions (25–75% of the fruit base), usually diluted with water, and evaluated either sensory attributes alone (Setyaning & Endrinikapoulos, 2025) or sensory attributes together with sodium and potassium (Aprilia et al., 2023; Makriffat et al., 2026). To our knowledge, the effect of low pineapple juice proportions (10–30%) added to an undiluted coconut water base, assessed simultaneously for sensory acceptance, vitamin C, sucrose, sodium, potassium, and pH against SNI 01-4452-1998, has not been reported. This study therefore aimed to evaluate the effect of pineapple juice proportion on the sensory acceptance and physicochemical characteristics of a coconut water-based isotonic-type drink and to identify the formulation that should be prioritised for further reformulation.

METHODS

Study design and setting

This laboratory experimental study used one factor, the proportion of pineapple juice, at three levels (F1, F2, and F3). Product preparation and sensory evaluation were conducted at the Food Technology Laboratory, Department of Nutrition, Poltekkes Kemenkes Pontianak, between June and July 2025. Vitamin C and pH were analysed at the Food Design Laboratory, Universitas Tanjungpura; sodium and potassium at the Soil Fertility Laboratory, Universitas Tanjungpura; and total sugar as sucrose at the laboratory of Politeknik Negeri Pontianak. The experimental formulations were given the working label "Hydroconas" by the research team; the label identifies the laboratory formulations only and does not denote a commercial product. The study was conducted in accordance with the research ethics code of the Health Research Ethics Commission of Poltekkes Kemenkes Pontianak (062/KEPK-PK.PKP/X/D/2025), research permission was obtained from the institution, and all panelists signed written informed consent before testing.

Materials and formulation

Young green coconuts (*Cocos nucifera* L. var. *viridis*; green husk with a drying stalk and approximately 0.5 L of water per fruit) were obtained from a coconut-water vendor supplied from Sungai Kakap, Kubu Raya Regency, and ripe pineapples (*Ananas comosus* L.) with a fresh green crown, approximately 50% yellow skin, and no dirt, rot, or insect damage were purchased from a fruit seller in Rasau Jaya, Kubu Raya Regency, West Kalimantan. Coconut water was drained from the opened fruit and filtered through cheesecloth to remove fibre and debris. Pineapples were washed under running water, peeled, cut into small pieces (flesh and core), homogenised in a blender, and filtered through cheesecloth to obtain the juice. The three formulations (Table 1) were obtained by mixing coconut water and pineapple juice to a final volume of 1000 mL and dissolving 70 g of granulated sucrose and 1 g (0.1%) of sodium benzoate. No sodium or potassium salts, acidulants, or water were added, and no heat treatment was applied. Each mixture was stirred for 1 min until homogeneous, filtered again, filled into sterilised bottles, and stored in a refrigerator at 5–10 °C until sensory evaluation and analysis.

The 10–30% range of pineapple juice was selected to keep coconut water as the dominant base and main natural electrolyte source while using pineapple juice as a flavour and vitamin C enhancer; higher proportions (25–75%) had already been examined in diluted formulations (Aprilia et al., 2023; Makriffat et al., 2026), and the ratios were adapted from earlier coconut water isotonic drinks in which fruit juice or extract was added at increasing levels to an undiluted coconut water base (Lempoy et al., 2020; Pakaya et al., 2021). The sucrose level (70 g/L, approximately 6.4% w/w) was fixed to stay within the 6–8% carbohydrate range typical of isotonic drinks and above the SNI minimum of 5% sucrose (BSN, 1998), so that differences among formulations could be attributed to the pineapple juice proportion. Sodium benzoate was added at a fixed level of 0.1% as a preservative. This level corresponds to approximately 780 mg/kg expressed as benzoic acid, which exceeds the maximum of 600 mg/kg permitted for water-based flavoured drinks, including sports and electrolyte drinks (food category 14.1.4), under BPOM Regulation No. 11 of 2019 (BPOM, 2019); the preservative level must therefore be reduced in any formulation intended for distribution.

Table 1. Composition of the experimental coconut water–pineapple formulations (per batch)

Ingredient	F1	F2	F3
Coconut water (mL)	900	800	700
Pineapple juice (mL)	100	200	300
Pineapple juice in liquid base (%)	10	20	30
Sucrose (g)	70	70	70
Sodium benzoate (g)	1	1	1

Note: All formulations were prepared to a final liquid volume of 1000 mL; no water, salt, or acidulant was added.

Experimental replication

Each formulation was prepared as a single batch. Sensory evaluation and all physicochemical analyses were performed on samples from this batch, and each physicochemical parameter was determined once per formulation (single determination). Because no replicate measurements were available, physicochemical results are reported as single values and interpreted descriptively.

Sensory evaluation

Twenty-five semi-trained panelists were recruited from students of the Department of Nutrition, Poltekkes Kemenkes Pontianak, who had previously been familiarised with sensory attributes and hedonic testing, consistent with the definition of a semi-trained panel (BSN, 2006). Panelists were included if they were healthy, not hungry, not under physiological stress, and willing to participate without coercion; willingness was confirmed in a brief oral interview before written consent was obtained. A panel of 15–25 semi-trained panelists is within the range recommended by the Indonesian guideline for sensory testing (BSN, 2006) and was considered adequate for a laboratory screening of formulations; consumer-level testing was not part of this study.

Testing was conducted in the Food Technology Laboratory in individual booths separated by partitions approximately 60 cm apart. Each panelist received all three formulations simultaneously in identical plastic cups labelled with three-digit codes, together with a glass of plain water, and was not informed of the formulation identity. Panelists drank water before evaluating each subsequent sample to neutralise the palate. Colour, aroma, taste, and texture (mouthfeel) were rated on a 5-point hedonic scale (1 = dislike very much, 2 = dislike, 3 = like slightly, 4 = like, 5 = like very much).

Physicochemical analyses

Vitamin C was determined by direct UV–Vis spectrophotometry. A stock solution of L-ascorbic acid (0.05 g in 100 mL of distilled water; 500 mg/L) was diluted (1.0, 2.0, 3.0, and 4.0 mL to 25 mL) to prepare calibration standards of 20, 40, 60, and 80 mg/L; the wavelength of maximum absorbance was determined by scanning in the UV region, and sample concentrations were calculated from the calibration curve (Putri & Setiawati, 2015). Total sugar expressed as sucrose was determined by the Luff–Schoorl method according to SNI 01-2892-1992 (BSN, 1992b): 2 g of sample was clarified with lead acetate and diluted to 250 mL, inverted with 25% HCl, neutralised with 30% NaOH, reacted with Luff–Schoorl reagent under reflux for 20 min, and titrated iodometrically with 0.1 N sodium thiosulfate. Sodium and potassium were determined by atomic absorption spectrophotometry at 589.0 and 766.5 nm, respectively, after microwave-assisted digestion of 0.8 g of sample with 10 mL of HNO_3 and dilution to 100 mL with distilled water. The pH was measured potentiometrically with a pH meter calibrated with standard buffer solutions before measurement, and the electrode was rinsed with distilled water between samples (BSN, 1992a).

Statistical analysis

Because each panelist evaluated all three formulations, hedonic scores for each attribute were analysed with the Friedman test for related samples. For each panelist, the three formulations were ranked from 1 (lowest score) to 3 (highest score), with tied scores assigned the average rank; rank sums were obtained by adding the ranks of all panelists, so that a higher rank sum indicates greater acceptance. When the Friedman test was significant, pairwise comparisons were performed using the Wilcoxon signed-rank test with Bonferroni correction (adjusted $\alpha = 0.05/3 = 0.017$), and the effect size was expressed as Kendall's W ($W = \chi^2/[n(k - 1)]$). Physicochemical data were obtained as single determinations and were therefore presented descriptively against the SNI 01-4452-1998 requirements without inferential testing. Friedman tests were performed using IBM SPSS Statistics 20 (IBM Corp., Armonk, NY, USA) and pairwise Wilcoxon tests using SciPy 1.18 (Python), with a significance level of 0.05.

RESULTS AND DISCUSSION

Sensory acceptance

The Friedman test results for each sensory attribute are presented in Table 2. Pineapple juice proportion significantly affected aroma acceptance ($\chi^2 = 9.48$, $p = 0.009$; Kendall's $W = 0.19$), whereas differences in colour ($\chi^2 = 2.52$, $p = 0.283$), taste ($\chi^2 = 0.55$, $p = 0.759$), and texture ($\chi^2 = 1.03$, $p = 0.598$) were not significant. F3 obtained the highest rank sums and mean scores for all attributes, indicating that it was the most preferred formulation overall, although the preference for colour, taste, and texture was not statistically supported.

Table 2. Hedonic scores, rank sums, and Friedman test results for the sensory attributes of the formulations

Attribute	F1		F2		F3		Friedman χ^2 (p)
	Mean ± SD	Rank sum	Mean ± SD	Rank sum	Mean ± SD	Rank sum	
Colour	3.12 ± 1.01	45.0	3.28 ± 1.06	49.5	3.56 ± 0.96	55.5	2.52 (0.283)
Aroma	3.40 ± 0.87	49.0^{ab}	3.08 ± 0.91	41.5^{a}	3.84 ± 0.85	59.5^{b}	9.48 (0.009)
Taste	3.44 ± 1.04	48.0	3.60 ± 0.96	49.5	3.72 ± 1.10	52.5	0.55 (0.759)
Texture	3.92 ± 0.70	48.5	3.96 ± 0.73	49.0	4.04 ± 0.68	52.5	1.03 (0.598)
Sum of rank sums (colour, aroma, taste)	–	142.0	–	140.5	–	167.5	–

Note: Values are mean hedonic score ± SD; rank sum (n = 25 panelists, 5-point hedonic scale; the rank sums of each attribute total 150). Higher rank sums indicate greater acceptance. Different superscript letters within a row indicate significant differences in Wilcoxon signed-rank tests at a Bonferroni-adjusted α of 0.017 (aroma: F2 vs F3, p = 0.006; F1 vs F2, p = 0.140; F1 vs F3, p = 0.090).

The significant effect on aroma is consistent with the volatile profile of pineapple, whose characteristic aroma is dominated by esters such as methyl and ethyl hexanoate (Wei et al., 2011). At 30% juice, these compounds were apparently sufficient to give a distinct fruity aroma that panelists preferred. A similar pattern was reported for a coconut water–pineapple isotonic drink in which aroma was the only attribute that differed significantly among

formulations and the formulations richer in pineapple received higher aroma scores (Makriffat et al., 2026). In the post-hoc comparisons, F3 differed significantly only from F2 ($p = 0.006$), whereas F1 did not differ significantly from either F2 ($p = 0.140$) or F3 ($p = 0.090$). The lower aroma rank of F2 than F1 was therefore not significant and may reflect panel variability at intermediate proportions. The effect size was small (Kendall's $W = 0.19$), indicating modest agreement among panelists.

The absence of significant differences in colour, taste, and texture can be explained by the formulation design. All formulations contained the same amount of added sucrose, which dominates perceived sweetness, and the 10–30% range of juice produced only modest changes in colour, from pale yellow in F1 to bright yellow in F3. Setyaning and Endrinikapoulos (2025) observed significant colour differences only when pineapple juice reached 30–70% of the fruit base, whereas taste and overall preference did not differ. These results indicate that, within the range tested, pineapple juice mainly improves the aroma of the coconut water base; the sensory findings, however, are limited to a semi-trained laboratory panel and cannot be generalised to consumer acceptance.

Vitamin C, sucrose, and pH

Vitamin C increased with the proportion of pineapple juice, from 25.3 mg/100 mL in F1 to 34.1 mg/100 mL in F3, an increase of about 4.4 mg/100 mL for every additional 10% of juice (Table 3). This dose-dependent pattern confirms that pineapple juice was the main source of vitamin C, in agreement with its known composition (Hoque et al., 2022). Extrapolating this trend to 0% juice, however, gives approximately 21 mg/100 mL, which is considerably higher than the 2.2–3.7 mg/100 mL generally reported for coconut water (Yong et al., 2009). The direct spectrophotometric method may therefore have been affected by other UV-absorbing compounds, and the absolute values should be interpreted with caution until confirmed by a more specific method such as titration with 2,6-dichlorophenolindophenol or HPLC. If confirmed, a 250 mL serving of F3 would provide about 85 mg of vitamin C, which is close to the recommended dietary allowance for Indonesian adults (75–90 mg/day; Kemenkes RI, 2019). This is a compositional observation only; the present study did not assess any physiological effect of vitamin C.

Table 3. Vitamin C, total sugar (as sucrose), and pH of the formulations

Formula	Coconut water : pineapple juice (mL)	Vitamin C (mg/100 mL)	Sucrose (%)	pH
F1	900 : 100	25.3	6.80	4.91
F2	800 : 200	29.7	7.36	4.68
F3	700 : 300	34.1	7.44	4.52
SNI 01-4452-1998	–	Not regulated	≥ 5	≤ 4.0

Note: Values are single determinations per formulation (one batch); no inferential test was performed.

The sucrose content of all formulations (6.80%, 7.36%, and 7.44% for F1, F2, and F3) met the SNI minimum of 5% (BSN, 1998) and increased slightly with the pineapple juice proportion. Added sucrose alone accounts for approximately 6.4% of the beverage mass, and the remainder reflects natural sugars from coconut water and pineapple juice measured after inversion. In contrast, the pH of all formulations (4.91, 4.68, and 4.52 for F1, F2, and F3) exceeded the SNI maximum of 4.0. Although pH decreased as the pineapple juice proportion increased, reflecting the organic acids contributed by pineapple, a 30% proportion was not sufficient to bring the pH of the coconut water base below 4.0; previous coconut water isotonic formulations reached the required pH only after the addition of citric acid (Asnia et al., 2024). Acidification should therefore be included in future formulation, considering its effect on sourness and acceptance.

Sodium and potassium

All formulations exceeded the SNI requirements for both electrolytes: sodium was 1.7–1.8 times and potassium approximately 3.4 times the upper limits (Table 4). Therefore, the electrolyte content of the present formulations does not comply with the national standard, and the formulations cannot yet be regarded as meeting isotonic drink requirements. Exceeding the potassium limit is consistent with the high natural potassium content of coconut water (Yong et al., 2009) and with an earlier coconut water–pineapple formulation whose potassium also exceeded the SNI limit (Aprilia et al., 2023). Because the present formulations used undiluted coconut water as 70–90% of the liquid base, dilution or partial replacement of coconut water would be required to bring potassium within the standard, as applied in diluted formulations that met electrolyte requirements (Makriffat et al., 2026).

Table 4. Sodium and potassium contents of the formulations compared with SNI 01-4452-1998

Formula	Coconut water : pineapple juice (mL)	Sodium (mg/kg)	Potassium (mg/kg)	Na:K mass ratio
F1	900 : 100	1769.6	589.8	3.0
F2	800 : 200	1794.2	589.8	3.0
F3	700 : 300	1671.3	589.8	2.8
SNI 01-4452-1998	–	800–1000	125–175	–

Note: Values are single determinations per formulation (one batch).

The high sodium content requires particular explanation because no sodium salt other than the preservative was added. Sodium benzoate (1 g/L; 16.0% sodium by mass) contributes only about 146 mg/kg of sodium, so most of the measured sodium must originate from the raw materials or from analytical factors. Coconut water usually contains less sodium than potassium, although mineral composition varies widely with cultivar, maturity, and growing environment (Yong et al., 2009). The sodium-to-potassium ratio of approximately 3:1 observed here is therefore atypical. In addition, potassium values were identical in the three formulations, although a decrease of about 20% from F1 to F3 would be expected from the lower coconut water proportion. These

observations suggest a possible contribution of the specific raw material and of analytical factors such as ionisation interference or dilution error in flame atomic absorption spectrophotometry. The electrolyte results should therefore be confirmed by re-analysis of the raw materials and finished products, preferably with an ionisation suppressant, certified reference materials, or inductively coupled plasma–optical emission spectrometry.

Osmolality was not measured, so the formulations cannot be scientifically classified as isotonic. A theoretical estimate based on the measured values of F3 indicates that sucrose (about 217 mmol/kg), sodium (about 73 mmol/kg), and potassium (about 15 mmol/kg) alone yield about 305 mOsm/kg, before accounting for their accompanying anions and for the natural glucose and fructose of the raw materials. The actual osmolality is therefore likely to be at or above the upper limit of the isotonic range (270–330 mOsm/kg; Skarlovnik et al., 2024), similar to the hypertonic values reported for unadjusted coconut water formulations (Kariyawasam et al., 2024). Direct measurement by freezing-point osmometry is required. Accordingly, the term "isotonic-type" is used in this article to describe the intended product category rather than a verified tonicity.

Limitations

This study has several limitations. Sensory evaluation involved only 25 semi-trained panelists under laboratory conditions, without consumer-level testing; panelist age and sex were not recorded, and randomisation of sample codes and serving order was not documented. Only three formulations within a narrow range of pineapple juice (10–30%) were tested, with fixed sucrose and preservative levels, and the preservative level exceeded the national maximum for this food category. Osmolality, titratable acidity, microbial quality, and storage stability were not evaluated, and the physicochemical parameters were determined once per formulation from a single batch without replicate analysis or documented quality-control samples, so they could only be interpreted descriptively. Finally, the atypical electrolyte results require confirmation. These limitations restrict the findings to the effect of pineapple juice proportion on the sensory and compositional characteristics of the tested formulations.

CONCLUSION

Increasing the proportion of pineapple juice from 10% to 30% in a coconut water-based drink significantly improved aroma acceptance and increased vitamin C content, whereas colour and taste acceptance did not differ significantly. F3 (700:300 mL) was the most accepted formulation, and all formulations met the SNI minimum for sucrose. However, none of the formulations met the SNI requirements for sodium, potassium, and pH, the sodium benzoate level exceeded the permitted maximum, and osmolality was not measured. F3 is therefore the most promising starting formulation rather than an optimal isotonic drink. Further work should adjust the electrolyte content and pH, reduce the preservative level, confirm the electrolyte and vitamin C results with replicated and validated methods, measure osmolality, and evaluate storage stability and consumer acceptance.

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