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Evaluation of Organoleptic Quality, Acceptability, Sugar Content, and pH Level in Dayak Onion-Ginger-Pineapple Beverage Formulations

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Abstract. Non-communicable diseases, particularly hypertension, are rising rapidly in Indonesia, highlighting the need for local food-based functional beverages to support blood pressure management. Dayak onion (*Eleutherine palmifolia*), ginger (*Zingiber officinale*), and pineapple (*Ananas comosus*) contain rich bioactive compounds, notably flavonoids and phenolics, with high antioxidant potential. This study evaluated the organoleptic quality, consumer acceptability, total soluble solids (sugar content), and pH level of composite drinks utilizing a Completely Randomized Design from December 2025 to January 2026. Four formulations of Dayak onion, ginger, and pineapple were evaluated: P1 (75:15:10), P2 (65:25:10), P3 (55:35:10), and P4 (45:45:10). Organoleptic profile and hedonic scores were assessed by 30 semi-trained panelists and analyzed using the Kruskal-Wallis test ($p<0.05$) with Mann-Whitney post-hoc tests. Total soluble solids were measured via refractometer 1°Brix = 1 g/100 g, and pH was determined using a digital pH meter. Results showed P1 had the highest red intensity, while P4 achieved superior taste acceptability and liquid clarity by effectively balancing herbal bitterness with ginger pungency. Sugar content ranged from 0.8 to 1.4 g, with pH values between 7.4 and 7.8. Formulation P4 was the most preferred overall for taste and clarity, offering a scientifically validated, accessible recipe for hypertension management while maximizing indigenous herbal resource utilization.

Keywords: Dayak onion, functional beverage, hypertension, organoleptic quality.

1. INTRODUCTION

Non-communicable diseases (NCDs), particularly hypertension, represent a escalating global public health crisis [1]. The World Health Organization estimates that NCDs account for 71% of global deaths annually, with hypertension serving as a primary modifiable risk factor for cardiovascular complications and premature mortality [2]. In Indonesia, national health survey data indicate an increasing prevalence of hypertension, reaching 30.8% among adults nationally and peaking at 40.7% in Central Kalimantan Province. In local administrative centers such as Palangka Raya City, hypertension consistently ranks among the top primary healthcare burdens [3]. Although effective, synthetic antihypertensives often cause adverse side effects and poor compliance. Consequently, functional plant-based dietary interventions are increasingly explored as complementary strategies for managing blood pressure [4], [5], [6].

Indonesia's rich biodiversity provides an extensive array of medicinal plants with therapeutic potential. Among the indigenous flora utilized in traditional Dayak medicine are Dayak onion, ginger, and pineapple. Dayak onion bulbs are abundant in bioactive phytochemicals, notably flavonoids, phenolics, and organosulfur compounds like allicin [7], [8], [9]. These constituents exhibit potent antioxidant properties, inhibit vascular inflammation, and reduce blood viscosity [10], [11]. Clinical and preclinical observations demonstrate that Dayak onion infusions significantly reduce both systolic and diastolic blood pressure [12], [13]. Similarly, ginger contains bioactive gingerols and shogaols, alongside high potassium content, which promote vasodilation via calcium channel blockade, angiotensin-converting enzyme (ACE) inhibition, and vascular smooth muscle relaxation [14], [15], [16]. Furthermore, pineapple supplies significant amounts of ascorbic acid and potassium, which attenuate vascular

oxidative stress through NADPH oxidase downregulation and endothelial nitric oxide synthase (eNOS) activation [17], [18], [19].

Despite their individual therapeutic efficacy, raw Dayak onion's herbal bitterness and ginger's sharp pungency limit consumer acceptance. Formulating a composite beverage with pineapple solves this by leveraging natural organic sweetness, acidity, and tropical aroma to mask harsh notes while adding complementary bioactives, creating an organoleptically pleasing functional drink [20], [21].

Developing an acceptable functional beverage requires optimizing physicochemical and organoleptic properties. Total soluble solids and pH must be strictly regulated to limit sugar intake, ensure dietary guideline compliance, prevent excessive calories, and maintain product palatability and stability [22]. Concurrently, product pH directly influences microbial stability, shelf-life, and sensory freshness [23]. While previous studies have examined the standalone therapeutic effects of these individual plants, limited empirical data exist regarding their composite integration into a standardized, consumer-acceptable functional beverage [24], [25].

Therefore, this study aimed to evaluate the organoleptic quality, consumer acceptability, total soluble solids, and pH levels of functional beverage formulations incorporating varying ratios of Dayak onion, ginger, and pineapple. The findings provide critical insights into optimizing indigenous herbal resources into scientifically validated, palatable functional drinks suitable for daily dietary inclusion and hypertension management.

2. METHODS

2.1 Research Design

This study employed a quantitative experimental design utilizing a Completely Randomized Design (CRD). The experimental variable consisted of four formulation ratios of Dayak onion (*Eleutherine palmifolia*), ginger (*Zingiber officinale*), and pineapple (*Ananas comosus*): P1 (75:15:10), P2 (65:25:10), P3 (55:35:10), and P4 (45:45:10) (% w/w). The study was conducted from December 2025 to January 2026 at the Food Science and Technology Laboratory and the Organoleptic Laboratory, Department of Nutrition, Health Polytechnic of the Ministry of Health, Palangka Raya, Indonesia.

2.2 Sample Preparation And Extraction

Fresh Dayak onion bulbs, ginger rhizomes, and pineapple fruits were thoroughly washed, thinly sliced, and weighed according to the treatment ratios. Each formulation was combined with 1000 mL of distilled water in a stainless-steel vessel and extracted using an infusion method in a water bath. Heating was maintained at 90 ^{o}C for 15 minutes, with periodic agitation to ensure uniform extraction. After cooling to room temperature (25 ^{o}C), the infusion was filtered through flannel cloth. The remaining pomace was gently pressed with additional water and combined to yield a final reconstituted volume of 1000 mL per formulation [26], [27].

2.3 Panellist Selection And Ethical Compliance

Sensory attributes and hedonic acceptability were evaluated by a panel of 30 semi-trained panelists selected from the Department of Nutrition. Panelists were non-smokers, free from oral diseases, and instructed to refrain from eating or drinking strong-flavored foods for 30 minutes prior to testing. Written informed consent was obtained from all participants prior to evaluation. This study protocol was reviewed and approved by the Health Research Ethics Committee of the Poltekkes Kemenkes Palangka Raya (Approval No. 90/I/KE.PE/EXM/2026).

2.4 Sensory And Hedonic Evaluation

Panelists evaluated four attributes: color, aroma, taste, and clarity. Sensory profiling used specific descriptive categories, while consumer acceptability (hedonic test) was rated on a 4-point ordinal scale (1 = Strongly Dislike, 2 = Dislike, 3 = Like, 4 = Strongly Like). Palate cleansing between samples was enforced using neutral mineral water with a 1–2 minute resting interval.

2.5 pH Measurement

Digital pH levels were recorded using a pre-calibrated digital pH meter. The electrode was calibrated against standard buffer solutions (pH 4.0 and 7.0), rinsed with deionized water, and submerged into sample aliquots until readings stabilized.

2.6 Total Soluble Solids (Sugar Content)

Total soluble solids were determined using an optical hand refractometer. The instrument was calibrated to zero using distilled water. Sample drops were applied to the glass prism, and values were recorded in degrees Brix (°Brix) [28], [29]. Brix values were converted to equivalent sugar mass concentration based on 1 °Brix = 1 g/100 g of solution, calculated as:

Equivalent Sugar Mass (g/100 g) = Measured Value (°Brix)

2.7 Data Analysis

Descriptive organoleptic profiles were tabulated and summarized as categorical distributions. Hedonic acceptability scores and pH values were expressed as Mean ± Standard Deviation. Differences in consumer acceptability across formulations were evaluated using the non-parametric Kruskal-Wallis test ($p < 0.05$). Where significant differences were identified, post-hoc pairwise comparisons were conducted using the Mann-Whitney U test. Statistical processing was performed using SPSS software (version 26.0).

3. RESULTS AND DISCUSSION

This composite functional beverage leverages the synergistic phytochemical profiles of Dayak onion, ginger, and pineapple. Dayak onion bulb serves as the primary therapeutic matrix, providing antioxidants that reduce blood viscosity and regulate blood pressure [12]. Fresh ginger acts as a secondary functional component, supplying anti-inflammatory micronutrients, stimulating vasodilation, and imparting a warming aromatic profile [14], [16].

To mitigate raw botanical bitterness and sharp pungency, pineapple was integrated at a constant 10% ratio across all formulations. Pineapple serves a dual functional purpose: its ascorbic acid aids vascular health by mitigating oxidative stress, while its natural sugars (glucose, fructose, and sucrose) serve as an unrefined sweetener matrix. This eliminated the need for added refined sugars while effectively masking harsh herbal notes.

Processed via thermal aqueous infusion, the beverage gentle extracts thermosensitive bioactives without inducing severe thermal degradation. The resulting drink features a natural red hue from Dayak onion pigments, a spicy-herbal aroma with subtle tropical notes, and a slightly turbid visual appearance. Overall, these physical and sensory attributes reflect intrinsic chemical interactions among the ingredients, establishing a solid foundation for evaluating how composite ratios influence organoleptic quality, pH, total soluble solids, and consumer acceptability.

2.1 Sensory and Hedonic Evaluation

The sensory evaluation integrated descriptive profiling and hedonic acceptability testing across four key attributes: color, aroma, taste, and liquid clarity. The structural ratio between Dayak onion bulb and ginger rhizome significantly altered the physicochemical matrix of the beverages, directly influencing panelist perceptions and consumer preferences.

2.1.1 Color and Clarity

The chromatic intensity of the beverage was dictated by the proportion of Dayak onion. Formulation P1 (75% Dayak onion) produced the most intense red coloration, with 56% of panelists categorizing it as "very red." This pigmentation is attributed to polar water-soluble anthocyanins and flavonoid derivatives present in Dayak onion bulbs. As Dayak onion content decreased from P1 to P4, the red hue diminished progressively, as ginger rhizomes contribute negligible red chromaticity. Although P1 exhibited the highest color intensity, hedonic evaluation indicated that P2 achieved the highest mean rank for consumer preference (74.67). However, non-parametric statistical testing revealed no significant difference in color acceptability across formulations ($p = 0.055$), indicating that partial reduction of Dayak onion did not compromise visual appeal.

Conversely, liquid clarity exhibited significant variation across formulations ($p = 0.005$). High Dayak onion concentrations in P1 and P2 led to increased turbidity due to suspended phenolic complexes, flavonoids, and ginger oleoresins that passed through filtration. In contrast, formulation P4 (45% Dayak onion, 45% ginger) achieved superior clarity, with 63.3% of panelists rating it as "very clear." Hedonic scoring confirmed P4 as the most preferred formulation for clarity (mean rank: 76.67). Post-hoc Mann-Whitney confirmed that P4 was significantly more acceptable in visual clarity compared to P1 and P2 ($p < 0.05$).

2.1.2 Aroma and Taste

Aroma profiling demonstrated that formulations P1, P2, and P3 maintained a balanced herbal profile characterized by volatile terpenes from ginger combined with phenolic notes from Dayak onion. Increasing the ginger proportion to a 1:1 ratio with Dayak onion in P4 resulted in a sharper, more pungent olfactory note, slightly increasing the proportion of "non-characteristic" ratings. Formulation P3 achieved the highest hedonic mean rank for aroma (67.43), though differences across all treatments were statistically non-significant ($p = 0.456$).

Taste preference was the critical factor differentiating overall product acceptability ($p = 0.006$). Formulation P1 was characterized by dominant herbal bitterness imparted by high Dayak onion saponins and phenolics. Increasing ginger levels in P2 and P3 gradually counterbalanced this bitterness with a warm, spicy perception. Formulation P4 achieved the highest acceptability rank (mean rank: 77.57), demonstrating that equalizing ginger and Dayak onion (45:45) effectively masked harsh herbal bitterness without overpowering the palate. The 10% pineapple base provided organic sugars and acids that harmonized this spicy-bitter balance. Post-hoc analysis confirmed that formulation P4 was significantly preferred over P1 and P2 ($p < 0.05$), establishing P4 as the optimal formulation for consumer sensory adoption.

2.2 Total Soluble Solids (Sugar Content)

The Total Soluble Solids (TSS) content of the Dayak onion, ginger, and pineapple functional beverage formulations exhibited noticeable variations, as measured via refractometry in degrees Brix (°Brix). Formulation P1 demonstrated the highest TSS value (1.40 °Brix), followed by P3 (1.20 °Brix), P2 (0.97 °Brix), and P4 (0.80 °Brix). Although the concentration of pineapple fruit was maintained at a constant 10% across all treatments, the resulting TSS values varied dynamically based on the proportional shifts between Dayak onion bulb and ginger rhizome. Pineapple fruit inherently serves as the primary source of simple fermentable sugars (sucrose, fructose, and glucose) contributing approximately 7–12% of natural soluble sugars in aqueous beverages [30]. Because pineapple content was kept constant, the observed total soluble solids gradient was primarily driven by varying aqueous extraction yields of water-soluble phytochemicals from Dayak onion and ginger.

Table 1. Total Soluble Solids (TSS)

Sample	Total Soluble Solids (°Brix)	Estimated sugar content in 1,000 mL (g)
P1	1.4	14.0
P2	0.97	9.7
P3	1.2	12.0
P4	0.8	8.0

Pineapple fruit inherently serves as the primary source of simple fermentable sugars (sucrose, fructose, and glucose) contributing approximately 7–12% of natural soluble sugars in aqueous beverages [30]. Because pineapple content was kept constant, the observed total soluble solids gradient was primarily driven by varying aqueous extraction yields of water-soluble phytochemicals from Dayak onion and ginger.

The elevated °Brix value observed in P1 (1.40 °Brix) correlates directly with its high Dayak onion proportion (75%). Dayak onion bulbs are abundant in low-molecular-weight polar secondary metabolites, including flavonoids, phenolics, glycosides, and tannins [7]. During thermal processing (90 °C for 15 minutes), these polar compounds readily dissolve into the aqueous matrix, increasing the refractive index read by the refractometer [31]. Conversely, as Dayak onion concentration decreased in P2 (0.97 °Brix) and P4 (0.80 °Brix), the overall concentration of extracted solids diminished accordingly.

Interestingly, formulation P3 exhibited a slight elevation in TSS (1.20 °Brix) relative to P2 (0.97 °Brix). This non-linear trend suggests a synergistic extraction threshold, where the increased ginger proportion (35%) contributed measurable amounts of soluble carbohydrates, essential oils, and phenolic derivatives (such as gingerols and shogaols) into the liquid phase [32]. Overall, the TSS values demonstrate that in the absence of added refined sugars, the refractive properties of the beverage are dictated by both natural fruit sugars and the density of extracted herbal phytochemicals [29].

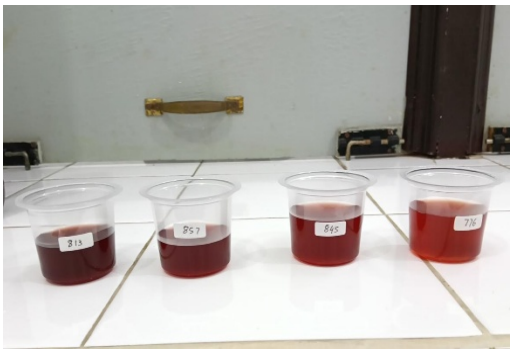


Figure 1. Dayak Onion-Ginger-Pineapple Beverage Formulations

2.3 pH Value

The pH levels of the Dayak onion, ginger, and pineapple composite beverages exhibited subtle variation across treatment formulations, remaining within a slightly alkaline to neutral range of 7.4 to 7.8. Formulation P2 demonstrated the highest pH value (7.80±0.05), followed by P3 (7.70±0.04), P4 (7.50±0.03), and P1 (7.40±0.02). The narrow variation in pH is primarily driven by the proportional shifts between Dayak onion and ginger, alongside the continuous extraction of basic and phenolic metabolites into the aqueous matrix during thermal infusion.

Although pineapple naturally contains organic acids that typically impart acidity to fruit-based drinks, its low proportion (10%) in all formulations was insufficient to lower the overall pH. Instead, the buffering capacity of the system was dominated by the aqueous soluble components of Dayak onion and ginger. Both herbs contain abundant phenolic compounds, alkaloid bases, and mineral constituents (such as potassium and magnesium ions) that act as weak bases or buffering agents, effectively neutralizing the natural acidity of pineapple juice [33], [34], [35]. Furthermore, thermal extraction at 90°C facilitates the ionization and release of these alkaline earth elements and weak organic bases into solution, maintaining hydrogen ion (H^+) equilibrium within the neutral-to-slightly-alkaline range [36], [37].

Table 2. pH Value

Sample	pH Value
P1	7.4
P2	7.8
P3	7.7
P4	7.5

From a physiological perspective, the observed pH values (7.4–7.8) align well with general safety guidelines for potable fluids (Environmental Protection Agency (EPA) safety threshold: 6.0–8.5) [38]. Unlike conventional acidic commercial fruit juices or carbonated beverages (pH < 4.0), which pose dental erosion risks and potential gastric irritation, this near-neutral beverage profile enhances gastrointestinal comfort, making it suitable for individuals with sensitive gastric mucosa or acid reflux [39], [40], [41].

However, this pH profile carries significant food preservation implications. Acidic beverages (pH < 4.6) naturally inhibit pathogenic and spoilage bacteria [42]. In contrast, neutral-to-slightly-alkaline aqueous environments (pH > 7.0) offer favorable conditions for microbial proliferation if left untreated [23]. Consequently, while the natural pH profile offers gastrointestinal advantages, commercial scaling of this functional drink will necessitate thermal pasteurization, cold-chain storage (4 °C), or natural acidification strategies to extend shelf-life stability without compromising bioactive integrity [43], [44], [45].

4. CONCLUSIONS

This study successfully developed and evaluated a functional composite beverage combining Dayak onion, ginger, and pineapple. High Dayak onion content (P1) enhanced red chromatic intensity and total soluble solids

(1.40 ºBrix) due to polar phytochemical extraction, but imparted harsh bitterness and turbidity that lowered sensory acceptability.

In contrast, Formulation P4 (45% Dayak onion, 45% ginger, 10% pineapple) provided optimal flavor masking, harmonizing herbal bitterness with ginger pungency while achieving superior clarity. Statistical analysis confirmed P4 was significantly preferred for taste ($p = 0.006$) and clarity ($p = 0.005$). Across all formulations, near-neutral pH (7.4–7.8) and low natural sugar levels (0.80 – 1.40 ºBrix) ensured excellent gastrointestinal tolerance and low-sugar dietary compliance. Overall, Formulation P4 represents a scientifically validated, palatable functional drink leveraging local botanical resources for daily health maintenance and hypertension management support.

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