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Roselle Flower Infusion Combined with Ginger as an Alternative Functional Beverage

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ABSTRACT

Roselle flower (Hibiscus sabdariffa L.) is known to contain high levels of vitamin C, which plays an important role in scavenging free radicals that contribute to degenerative diseases. Antioxidants are essential for preventing oxidative stress in the human body. Ginger is also widely recognized for its health benefits due to its gingerol content, which exhibits strong anti-inflammatory and antioxidant properties. This study aimed to analyze the vitamin C content and antioxidant activity of roselle flower infusion combined with ginger as an alternative functional beverage. This research employed a descriptive observational design based on laboratory analysis. The variables analyzed were vitamin C content and antioxidant activity. Vitamin C levels were determined using the iodimetric method, while antioxidant activity was assessed using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. Data on vitamin C content and antioxidant activity were statistically analyzed using One-Way ANOVA followed by Duncan's multiple range test. The relationship between vitamin C content and antioxidant activity was evaluated using Pearson correlation analysis. The results showed that there were significant differences among all formulations tested. The selected formulation demonstrated the highest vitamin C content and antioxidant activity. Pearson correlation analysis indicated a very strong positive correlation between vitamin C content and antioxidant activity (p = 0.000). These findings suggest that roselle flower infusion combined with ginger has strong potential as an alternative functional beverage with high antioxidant capacity.

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KEY MESSAGES

- *The combination of roselle flower and ginger significantly influences vitamin C content and antioxidant activity, confirming the importance of formulation in optimizing functional beverage quality.*
- *The 50:50 formulation (roselle–ginger) demonstrated the highest vitamin C content and strongest antioxidant activity, indicating it as the optimal formulation among those tested.*
- *A very strong positive correlation was found between vitamin C content and antioxidant activity, highlighting vitamin C as a key contributor to the antioxidant capacity of the beverage.*

INTRODUCTION

Indonesia is one of the developing countries that still faces limitations, particularly in addressing public health challenges. The burden of infectious diseases remains high, while the prevalence of degenerative diseases continues to increase (Werdhasari, 2014). According to statistical data from the Global Status Report on Noncommunicable Diseases published by the World Health Organization (WHO), by the end of 2008, degenerative diseases accounted for approximately 36 million deaths worldwide and are projected to continue rising, potentially reaching 70% of the global population burden. Furthermore, it is estimated that by 2030, degenerative diseases will cause approximately 52 million deaths annually, primarily due to conditions such as cancer, cardiovascular diseases, stroke, and diabetes. (Departemen Kesehatan RI, 2012). According to the Indonesian National Basic Health Research (Riset Kesehatan Dasar, Riskesdas), the prevalence of degenerative diseases in Indonesia based on physician diagnosis among individuals of all age groups in 2013 showed that the prevalence of cancer was 0.4%, heart disease 1.5%, stroke 12.1%, and diabetes mellitus 2.1% (Ministry of Health of the Republic of Indonesia, 2013). Meanwhile, data from the 2018 Riskesdas indicated changes in disease prevalence, with cancer increasing to 1.79%, heart disease remaining at 1.5%, stroke decreasing to 10.9%, and diabetes mellitus reported at 1.5%. (Departemen Kesehatan RI, 2019a).

According to the Provincial Basic Health Research (Riset Kesehatan Dasar Provinsi), the prevalence of degenerative diseases in Central Sulawesi Province based on physician diagnosis among individuals of all age groups in 2013 indicated that the prevalence of cancer was 1.4%, heart disease 3.8%, stroke 16.6%, and diabetes mellitus 3.7% (Ministry of Health of the Republic of Indonesia, 2013). Meanwhile, data from the 2018 Provincial Basic Health Research showed changes in disease prevalence, with cancer increasing to 2.23%, heart disease decreasing to 1.92%, stroke declining to 10.40%, and diabetes mellitus decreasing to 1.54%. (Departemen Kesehatan RI, 2019b).

Degenerative diseases are closely associated with the role of free radicals. Oxidative stress induced by free radicals contributes to various degenerative conditions that can damage body tissues. Antioxidants play a crucial role in the body's defense system by donating electrons to free radicals, thereby neutralizing their harmful effects. Free radicals are unstable molecules with unpaired electrons, which cause them to seek electrons from other molecules, including body cells. This process can impair the immune system and trigger the development of degenerative diseases. Therefore, the presence of antioxidants is essential to inhibit the formation and activity of free radicals. Antioxidants are compounds that act as inhibitors, preventing interactions between free radicals and their target molecules. They function by donating electrons to free radicals, stabilizing these reactive molecules and reducing cellular damage (Parwati, 2014). Adequate antioxidant intake is necessary to prevent excessive oxidative stress in the body. Indonesia is rich in natural resources that are known to contain high levels of antioxidant compounds. Improving public health status can therefore be achieved by optimizing the utilization of available natural resources (Werdhasari, 2014).

The development of alternative beverages has increased in recent years, with growing public interest in herbal drinks made from natural ingredients such as tea leaves and spices. One plant commonly used in herbal beverages is roselle (*Hibiscus sabdariffa* L.), which is rich in bioactive compounds beneficial to human health, particularly vitamin C. Roselle calyces contain approximately 260–280 mg of vitamin C per 100 g. In addition, roselle calyces are a valuable source of ascorbic acid (vitamin C), vitamins B2 and B3, beta-carotene, calcium, and iron, which are essential nutrients (Setyawati & Ali Mustofa, 2017). Roselle flowers are known to provide various health benefits and contribute to improved health status and physical stamina due to their high vitamin C and essential mineral content. Vitamin C acts as a potent antioxidant capable of preventing free radical–induced damage associated with degenerative diseases (Paruntu, 2015). Furthermore, roselle has been reported to exhibit multiple biological activities, including antihypertensive, antidiabetic, anticancer, and anti-inflammatory effects, as well as potential anti-obesity properties (Ojulari et al., 2019).

Adequate nutrient intake is essential for the community to support daily activities. Nutritional requirements include carbohydrates, fats, proteins, vitamins, and minerals. One of the essential vitamins for human health is vitamin C. According to the Regulation of the Minister of Health of the Republic of Indonesia Number 28 of 2019 concerning the Recommended Dietary Allowances for the Indonesian population, the recommended daily intake of vitamin C for children is 40–50 mg, while for adults it ranges from 50–90 mg per day. For pregnant women, the requirement increases by an additional 10 mg per day, and for lactating women, an additional 45 mg per day is required. Vitamin C can be obtained from vegetables and fruits, particularly fresh fruits. One plant known to be rich in vitamin C is roselle (*Hibiscus sabdariffa*). Vitamin C, also known as ascorbic acid, is an organic compound that cannot be synthesized by the human body and is required in small amounts; therefore, it must be obtained from dietary sources. Vitamin C is a water-soluble vitamin that is easily degraded by exposure to air, heat,

and metal. Vitamin C is known to function as a coenzyme and an effective antioxidant in preventing free radical damage in the body and is believed to play a role in reducing the risk of degenerative diseases (Setyawati & Ali Mustofa, 2017). Based on the background described above regarding the benefits of vitamin C and antioxidant compounds found in roselle and ginger, this study aims to analyze the vitamin C content and antioxidant activity of roselle (*Hibiscus sabdariffa* L.) infusion combined with ginger as an alternative functional beverage with potential health benefits.

METHODS

This study employed a quantitative approach with a descriptive observational design based on laboratory analysis. The objective was to determine the vitamin C content and antioxidant activity of roselle (*Hibiscus sabdariffa* L.) infusion combined with ginger as a functional beverage. The research was conducted at the Research Laboratory of the Chemistry Study Program, Faculty of Mathematics and Natural Sciences, Tadulako University. Materials used in the study included roselle flowers and ginger for formulation, along with distilled water and sugar. For vitamin C analysis, the formulated roselle–ginger infusion, ascorbic acid, and distilled water were used. Antioxidant activity analysis employed the formulated infusion, DPPH (2,2-diphenyl-1-picrylhydrazyl), alcohol, and 95% ethanol. Laboratory equipment used in the formulation and analytical processes included standard preparation tools and analytical instruments, such as a UV–Vis spectrophotometer, to assess vitamin C content and antioxidant activity.

RESULTS

vitamin C content

The vitamin C content of roselle (*Hibiscus sabdariffa* L.) flower infusion combined with ginger in various formulations is presented in Table 1.

Table 1. Vitamin C Content of Roselle (*Hibiscus sabdariffa* L.) Flower Combined with Ginger

Sample	Vitamin C Content	Mean	P- Value
F1	43,608	46,158	
F2	66,857	66,172	
F3	72,995	71,522	0,001
F4	56,204	54,060	
F5	43,521	46,092	

Notes: F1 : 100% roselle flowers + 0% ginger
F2 : 75% roselle flowers + 25% ginger
F3 : 50% roselle flowers + 50% ginger
F4 : 25% roselle flowers + 75% ginger
F5 : 0% roselle flowers + 100% ginger

Table 1 presents the vitamin C content of roselle (*Hibiscus sabdariffa* L.) flower infusion combined with ginger across five different formulations (F1–F5). The results show variations in vitamin C levels depending on the proportion of roselle flowers and ginger used in each formulation. The highest mean vitamin C content was observed in formulation F3 (50% roselle flowers and 50% ginger), with a mean value of 71.522, indicating that an equal combination of roselle and ginger yielded the greatest vitamin C concentration. In contrast, the lowest mean vitamin C content was found in formulation F1 (100% roselle flowers) and F5 (100% ginger), with mean values of 46.158 and 46.092, respectively. Statistical analysis revealed a significant difference in vitamin C content among the different formulations, as indicated by a p-value of 0.001 ($p < 0.05$). This finding suggests that variations in the proportion of roselle flowers and ginger significantly influence the vitamin C content of the infusion.

Antioxidant power

The results of measuring antioxidant power using the IC50 value can be seen in table 2.

Table 2. Antioxidant Power (IC_{50})

Sample	Antioxidant Activity IC_{50} (ppm)	Classification	P - Value
F1	77,363	Strong antioxidant	
F2	66,480	Strong antioxidant	
F3	37,926	Very strong antioxidant	0,000
F4	42,946	Very strong antioxidant	
F5	53,889	Strong antioxidant	

Notes: F1 : 100% roselle flowers + 0% ginger
F2 : 75% roselle flowers + 25% ginger
F3 : 50% roselle flowers + 50% ginger
F4 : 25% roselle flowers + 75% ginger
F5 : 0% roselle flowers + 100% ginger

Table 2 shows the antioxidant activity of roselle (*Hibiscus sabdariffa* L.) flower infusion combined with ginger, expressed as IC_{50} values obtained using the DPPH radical scavenging assay. Lower IC_{50} values indicate stronger antioxidant activity. Among the five formulations, F3 (50% roselle flowers and 50% ginger) exhibited the strongest antioxidant activity, with the lowest IC_{50} value of 37.926 ppm, followed by F4 (25% roselle flowers and 75% ginger) with an IC_{50} value of 42.946 ppm. Both formulations were classified as having very strong antioxidant activity. In contrast, formulations F1, F2, and F5 demonstrated higher IC_{50} values, ranging from 53.889 to 77.363 ppm, and were categorized as strong antioxidants. Statistical analysis revealed a significant difference in antioxidant activity among the formulations, as indicated by a p-value of 0.000 ($p < 0.05$). These findings suggest that variations in the proportion of roselle flowers and ginger significantly influence the antioxidant capacity of the infusion.

CONCLUSION

Vitamin C content

Vitamin C content was determined using the iodimetric method. The principle of the iodimetric method is based on the reducing property of vitamin C (ascorbic acid). Ascorbic acid is a strong reducing agent and can be directly titrated with a standard iodine solution. The iodimetric method, which involves direct titration using a 0.01 N standard iodine solution, can be applied to pure ascorbic acid or its solutions. Therefore, the vitamin C content present in roselle flowers and ginger can be quantitatively determined using this method. The iodimetric method used for determining vitamin C content in roselle–ginger infusion is considered to have good accuracy, as it produces relatively consistent titration volumes across repeated measurements (Rohman, 2007).

Based on Table 1, the results of vitamin C content indicate a statistically significant difference among the various treatments. Formulation F1 showed a mean vitamin C content of 46.158 mg/100 g. An increase was observed in formulation F2, with a mean value of 66.172 mg/100 g, while formulation F3 exhibited the highest vitamin C content, reaching 71.522 mg/100 g. In contrast, formulation F4 showed a mean value of 54.060 mg/100 g, and formulation F5 presented a mean vitamin C content of 46.092 mg/100 g. Statistical analysis revealed that the differences in vitamin C content among the formulations were significant ($p < 0.05$), indicating that variations in the proportion of roselle flowers and ginger significantly affected the vitamin C levels of the infusion. As shown in Table 1, formulation F3, consisting of an equal proportion of roselle flowers and ginger (50%:50%), resulted in the highest vitamin C content (71.522 mg/100 g). These findings are consistent with the study conducted by Falade et al. (2005), which reported that roselle extract contains a high level of vitamin C with a statistically significant difference ($p = 0.000$; $p < 0.05$), and that vitamin C is widely recognized as an antioxidant compound. In addition, Suthrasa (2016) reported that the addition of ginger powder significantly increased vitamin C content due to the naturally high vitamin C content of ginger ($p = 0.000$; $p < 0.05$). The present study supports these findings, as both roselle flowers and ginger are rich sources of vitamin C. Therefore, the equal combination of roselle flowers and ginger in formulation F3 resulted in the highest vitamin C content compared to the other formulations. Consequently, formulation F3 can be

considered a functional beverage with high vitamin C content, making it a potential alternative drink with health-promoting properties.

Among all vitamins, vitamin C is considered the most unstable and highly susceptible to degradation. Vitamin C is easily degraded by temperature, light, and exposure to air, leading to a reduction in its concentration (Cresna et al., 2014). In the processing of roselle–ginger herbal tea, two heating stages were applied, namely oven-drying and infusion. These heating processes contributed to the lower vitamin C content observed in formulations with higher proportions of roselle flowers. Under ideal conditions, increasing the amount of roselle flowers in carbonated roselle beverages generally results in higher vitamin C levels. However, the degradation of vitamin C observed in this study is primarily attributed to oxidative reactions occurring during thermal processing. This degradation process is known as oxidation. Furthermore, increasing the proportion of ginger resulted in a decrease in vitamin C content in the roselle–ginger infusion. This reduction may be attributed to the degradation of vitamin C and other bioactive compounds in ginger due to heat treatment during processing. The degradation of vitamin C in roselle–ginger infusion significantly contributed to the decrease in vitamin C levels, even with higher levels of ingredient addition (Gloria et al., 2018).

Antioxidant power

Based on Table 2, the antioxidant activity results expressed as IC_{50} values were 77.363 ppm for F1, 66.480 ppm for F2, 37.926 ppm for F3, 42.946 ppm for F4, and 53.889 ppm for F5. Prior to incubation, the solution exhibited a purple color derived from the DPPH reagent, while after incubation, the solution changed to a yellowish color. Formulations F3, F4, and F5 showed a noticeable color change from purple to yellowish, whereas no color change was observed in formulations F1 and F2. These observations are consistent with the findings reported by Molyneux (2004), which stated that the color change of the solution from purple to yellowish occurs when antioxidant compounds donate hydrogen atoms to the DPPH radical, resulting in the formation of reduced DPPH. This reduction process is characterized by a decrease in absorbance and a visible change in color from deep purple to pale yellow. The results of the ANOVA test indicated that there were statistically significant differences in antioxidant activity among all formulations ($p \leq 0.05$). Therefore, the null hypothesis (H_0) was rejected and the alternative hypothesis (H_a) was accepted, indicating significant differences in antioxidant activity among formulations F1, F2, F3, F4, and F5 of the roselle–ginger infusion.

The results of the ANOVA test showed that, overall, there were statistically significant differences in antioxidant activity among formulations F1, F2, F3, F4, and F5 ($p \leq 0.05$). Therefore, the null hypothesis (H_0) was rejected and the alternative hypothesis (H_a) was accepted, indicating significant differences in antioxidant activity among the roselle–ginger infusion formulations. The overall antioxidant activity results and significance values are presented in Table 2. Subsequently, Duncan's multiple range test was performed to further identify which formulations differed significantly. The results of Duncan's test revealed significant differences among all formulations (F1, F2, F3, F4, and F5), confirming that the null hypothesis was rejected and the alternative hypothesis was accepted. The statistical results of Duncan's test are presented in Appendix 6. In addition, the ANOVA results indicated that the antioxidant activity of the roselle–ginger infusion formulations decreased significantly. The increase in IC_{50} values from F1 to F5 was attributed to variations in the proportion of roselle flowers and ginger. A lower proportion of roselle flowers in the formulation resulted in higher IC_{50} values, indicating reduced antioxidant activity.

The IC_{50} value is inversely related to the antioxidant capacity of a compound; the lower the IC_{50} value, the stronger the antioxidant activity. IC_{50} is commonly used to describe the antioxidant activity of test samples using the DPPH free radical scavenging method. The determination of antioxidant activity in the roselle–ginger formulations was conducted using the DPPH assay, in which DPPH acts as a free radical and is inhibited by antioxidant compounds present in the roselle–ginger infusion. Studies on roselle–ginger infusion formulations are closely related to their antioxidant potential in preventing free radical formation and oxidative stress, which are known to contribute to adverse effects on human health (Molyneux & Philip, 2004).

Antioxidant activity can be classified into four categories: very strong (< 50 ppm), strong (50–100 ppm), moderate (100–150 ppm), and weak (150–200 ppm). Antioxidants with IC_{50} values greater than 200 ppm are categorized as very weak antioxidants (Molyneux, 2004). The antioxidant activity of the roselle–ginger infusion was 37 ppm, which falls into the very strong category. This activity was observed in formulation F3, consisting of an equal proportion of roselle flowers and ginger (50%:50%). According to Lestario et al. (2002), roselle flowers exhibit high antioxidant activity with statistically significant results ($p \leq 0.05$). Similarly, a study by Agus Martua Ibrahim et al. (2015) reported that ginger

possesses strong antioxidant activity with significant results ($p \leq 0.05$). The findings of the present study are consistent with these previous reports, as both roselle flowers and ginger are rich sources of antioxidant compounds. Consequently, formulation F3, containing an equal proportion of roselle flowers and ginger, exhibited the highest antioxidant activity among all formulations. Therefore, formulation F3 can be considered a functional beverage with potent antioxidant properties, as its antioxidant activity falls within the very strong category.

Differences in antioxidant activity among formulations may be attributed to several factors, including variations in the ability to donate hydrogen atoms to free radicals, differences in the chemical structure of antioxidant compounds, and the pH of the reaction mixture (Widyawati et al., 2010). Thermal processing may accelerate the oxidation of antioxidants present in natural materials, leading to a reduction in antioxidant activity to varying degrees. This reduction is strongly influenced by the type of bioactive components involved in the antioxidant process and their concentration within the material. Furthermore, antioxidant activity is affected by heating temperature and duration during oven processing, as prolonged heating and incubation time can significantly reduce total antioxidant activity in the formulations (Riyawan, 2015).

CONCLUSION

The combination of roselle (*Hibiscus sabdariffa* L.) flower infusion and ginger significantly influenced vitamin C content and antioxidant activity ($p < 0.05$). The highest vitamin C content was observed in formulation F3 (50% roselle and 50% ginger), reaching 71.522 mg/100 g, while the lowest was found in F5 (46.092 mg/100 g). Antioxidant activity also differed significantly among formulations, with F3 showing the strongest activity, indicated by the lowest IC_{50} value (37.926 ppm), and F5 exhibiting the weakest activity (77.363 ppm). These results suggest that an equal proportion of roselle flowers and ginger provides the optimal formulation, supporting its potential application as a functional beverage rich in vitamin C and antioxidants.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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