

Research Article

## Comparative Study of Vitamin C Content in Rome Beauty Apples (*Malus sylvestris* Mill) with Several Processing Methods

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### Abstract

Apples are known to contain antioxidants and vitamin C which play important roles in protecting the body from oxidative stress and degenerative diseases. However, vitamin C is sensitive to heat, light, and oxygen, which can lead to degradation during processing. This study aimed to compare the vitamin C content of Rome Beauty apple (*Malus sylvestris* Mill.) in various processed forms commonly consumed by the public, including fresh apple, apple juice, cider, dodol, and apple chips. The research was conducted using a titrimetric method with 2,6-dichlorophenol-indophenol dye to determine vitamin C content. Five samples were analyzed in duplicate. The data were statistically tested using the Kruskal–Wallis and Mann–Whitney tests to evaluate differences among samples. The vitamin C content ranged from 2.85 to 12.36 mg/100 g. The highest content was found in fresh apples (12.36 mg/100 g), followed by apple juice (6.41 mg/100 g), apple cider (5.23 mg/100 g), apple dodol (2.85 mg/100 g), and apple chips (2.85 mg/100 g). Statistical analysis showed significant differences ( $p < 0.05$ ) among the samples, particularly between fresh or juiced apples and processed forms such as dodol and chips. Processing significantly reduces the vitamin C content of Rome Beauty apples. Heat treatment, oxidation, and exposure to air during processing are the major factors contributing to vitamin C loss. Therefore, consuming fresh apples provides the greatest nutritional benefit in terms of vitamin C intake.

**Keywords:** Vitamin C, Rome Beauty apple, processing, titrimetric method

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## 1 Introduction

Free radicals are highly reactive oxygen molecules due to their unpaired electrons. The reactive activity of free radicals can be neutralized by the antioxidant system, which plays a role in supporting the body's defense mechanisms [1]. Free radicals can form naturally in the body as part of endogenous metabolic processes, for example through mitochondrial respiration, as a side effect of the metabolism of various chemical compounds, as a result of inflammation caused by physical activity, excessive exercise, reactions with iron and other metals, and excessive food consumption. Furthermore, free radicals can also originate from exogenous sources, such as exposure to environmental pollution, lack of physical activity, unhealthy diet, stress, smoking, ultraviolet radiation, ozone, the use of synthetic solvents, and various activities that result in combustion [2].

Excessive free radicals in the body can cause cell damage, but this impact can be suppressed through the presence of antioxidant compounds. These compounds play a role in protecting the body from various diseases related to free radical activity and help strengthen the immune system. Therefore, adequate and sustained consumption of antioxidants has the potential to reduce the risk of degenerative and cardiovascular diseases, such as cancer, diabetes mellitus, and atherosclerosis. Optimal antioxidant intake is important for all age groups. Antioxidants are found in many types of vegetables and fruits [1]

Optimal antioxidant intake is important for all age groups, and these compounds are widely found in vegetables and fruits, particularly in fruits such as apples, which are known for their rich phytochemical compounds. This fruit contains various phytochemical compounds that act as antioxidants, including phenolic compounds, flavonoids, cinnamic acid derivatives, coumarins, tocopherols, and polyfunctional organic acids that function as primary antioxidants. Furthermore, the beta-carotene content in apples also plays a role in inhibiting the activity of free radicals that can trigger various degenerative diseases. Several studies have shown that apples have a relatively high fiber, phytochemical, and flavonoid content. In fact, according to the United States National Cancer Institute, flavonoid content in apples is reportedly higher than those in many other fruits [3].

Apples not only contain phytochemical compounds but are also a source of vitamin C. Vitamin C content (mg/100 g) of the Rome Beauty apple variety is higher than that of the Manalagi and Anna varieties [4]. However, various processing steps, such as cutting, crushing, filtering, blanching, and heating, can reduce the vitamin C content in apples. Furthermore, research shows that the longer the fermentation process, the lower the vitamin C content in Rome Beauty, Anna, and Manalagi apple varieties [5].

Several superior apple varieties with distinctive characteristics are Malang apples (*Malus sylvestris* Mill.), including Rome Beauty, Manalagi, Anna, and Wangling, which are widely cultivated in the Malang region of East Java [6]. The abundant apple production in this area has encouraged the community, particularly in Batu City, to develop various apple-based processed products. The Rome Beauty variety is the apple variety most often used as a raw material for processed products. In addition to its relatively high tannin and vitamin C content, Rome Beauty apples are also preferred by the people of Batu City due to their attractive color and slightly sour taste. Various processed apple products that have been commercially produced include apple chips, dodol, and cider. This study focuses on processed apple products typical of Batu City based on the Rome Beauty variety which has not been studied comparatively in one study, therefore the aim of this study is to analyze the effect of various processing methods on the vitamin C content of Rome Beauty apples.

## 2 Method

The main ingredients used in this study were Rome Beauty apples (*Malus sylvestris* Mill.) and several processed apple products, including apple juice, dodol, cider, and chips, obtained from Batu City. Additionally, the researchers produced apple juice samples independently. The materials used in the vitamin C analysis included ascorbic acid, dye solution, oxalic acid, and distilled water. Vitamin C analysis was conducted using several laboratory instruments, including burettes, Erlenmeyer flasks, graduated pipettes, droppers, volumetric flasks, analytical balances, filter paper, beakers, and mortars.

The locations for purchasing the samples, were purposively selected in Batu City, East Java. The Rome Beauty apple variety, a commonly consumed variety, was selected based on sample availability, ease of access, and interviews with local residents. The researchers prepared the apple juice samples by washing the apples and their skins, cutting them, and then pulverizing them using a blender with a little water added to facilitate the pulverization process. Vitamin C content was measured using a titrimetric method with a dye or indophenol solution [7] with modifications.

The dye solution was prepared by weighing 0.0625 g of 2,6-dichlorophenol-indophenol powder. 1.5 g of Na<sub>2</sub>CO<sub>3</sub>H<sub>2</sub>O was added, heated until dissolved, filtered, and transferred to a reagent bottle. The sample was then capped and stored in the refrigerator. To analyze vitamin C content using the titrimetric method, 20 g of the sample was crushed or cut into small pieces, 10 g of oxalic acid was added, dissolved in distilled water, and made up to 250 ml. The sample was ground using a blender and placed in an Enlenmeyer flask. The sample was filtered, and 10 ml of the sample filtrate was taken. The sample was then titrated with the dye solution until it turned pink for 15 seconds.

### 3 Result and Discussion

Vitamin C is a water-soluble vitamin primarily found in vegetables and fruits, especially fresh fruit. The recommended daily intake of vitamin C for adult ranges from 30–100 mg. According to the Recommended Dietary Allowance 2004, children need 400–450 mg of vitamin C daily, and pregnant women require an additional 100 mg daily. This vitamin plays a crucial role in various physiological processes, particularly those related to cellular respiration and enzymatic activity. Some of its functions include catalyzing the oxidation of phenylalanine to tyrosine, reducing ferrous iron (Fe<sup>3+</sup>) to ferrous iron (Fe<sup>2+</sup>) in the digestive tract, thus facilitating iron utilization by the body through binding to tissue ferritin, and converting folic acid to its active form, folinic acid. Furthermore, vitamin C is thought to be involved in the biosynthesis of steroid hormones and cholesterol [8].

Vitamin C content in food can be analyzed using various methods, one of which is titrimetry. This method is based on measuring the volume of a titrant solution that reacts with the analyte. The titrant is a standard solution with a known concentration and is used in the titration process by gradually adding it to the analyte solution [9]. The principle of determining vitamin C content using the titrimetry method is the oxidation of ascorbic acid by 2,6-dichlorophenol indophenol to form dehydroascorbate. The endpoint of the titration is marked by the appearance of a pink color in the solution. In this reaction, ascorbic acid reduces the indicator dye (2,6-dichlorophenol indophenol), rendering the solution colorless. Once all the ascorbic acid has reacted, the excess unreduced dye causes the solution to turn pink under acidic conditions [7].

In this study, vitamin C content was analyzed on five types of samples: fresh Rome Beauty apples, apple juice of the same variety, apple dodol, apple cider, and apple chips. Each sample was weighed at 20 g, then oxalic acid was added and dissolved in a 100 mL volumetric flask. Ten mL of the resulting filtrate was then titrated with a dye solution until a color change occurred. A 2,6-dichlorophenol-indophenol solution will be blue under neutral or basic conditions, while under acidic conditions it will be pink. When this indicator is reduced by ascorbic acid, the solution becomes colorless. However, after all the ascorbic acid has reacted, the excess indicator will cause the solution to change color. To accurately determine vitamin C content, the dye solution is first standardized using a standard vitamin C solution [10].

The addition of oxalic acid aims to inhibit the oxidation of vitamin C by oxidative enzymes and the effects of glutathione compounds present in plant tissue. Therefore, prior to analysis, food is generally dissolved in a strong acid solution such as acetic acid, oxalic acid, metaphosphoric acid, or trichloroacetic acid [9]. Vitamin C content was determined in duplicate using a titrimetric method using a dye solution as the titrate and a sample solution as the titrant. The results of the vitamin C content in each sample are presented in Table 1.

Table 1. Vitamin C content (mg/100g)

Sample	Vitamin C (mg)	Statistical test
Apples	12.36	p=0.017
Apples juice	6.41	
Apples dodol	2.85	
Apples cider	5.23	
Apples chips	2.85	

Based on the data in Table 1, the vitamin C content in the samples ranged from 2.85 mg/100 g to 12.36 mg/100 g. The highest vitamin C content was found in fresh apples, at 12.36 mg/100 g. These results align with research which reported that the vitamin C content in fresh Rome Beauty apples reached 11.42 mg/100 g [11]. Statistical tests using the Kruskal Wallis method showed a p-value <0.05, indicating a significant difference in vitamin C content among the five study samples. Further Mann–Whitney tests showed a significant difference in vitamin C content between fresh apples and apple juice compared to dodol and chips (p <0.05).

Nutritional content and phytochemical compounds in apples tend to be higher when consumed fresh compared to processed products [12]. Processing processes such as making chips, juice, and other processed products can cause a decrease or even loss of some phytochemical compounds. For example, heating at high temperatures can result in the loss of nutrients and bioactive compounds in fruits, leading to the oxidation of antioxidant compounds. Antioxidant compounds are resistant to high-temperature cooking (>100°C) because it can reduce their antioxidant properties and damage the chemical structure of their constituent compounds. Furthermore, heating can cause the degradation of anthocyanins into ketones, which reduces their ability as antioxidants to ward off free radicals [13]. Vitamin C is an essential nutrient that is easily oxidized by heat and oxygen during food processing, packaging, and storage [7].

The vitamin C content in apple juice is higher than in apple cider, but decreases to 6.41 mg/100 g. This is due to the process of crushing the apples and their skins using a blender during the juice-making process. Mechanical processing processes such as crushing and pressing can significantly reduce bioactive activity. Research showed that processing Jonagold apples through crushing and pressing only retained approximately 10% of their initial antioxidant activity [14]

Apple dodol, apple cider, and apple chips are among the products with relatively low vitamin C content. All three products undergo several processing steps, including heating. Heating can cause the loss of heat-sensitive nutrients, particularly organic acids such as ascorbic acid [4]. Furthermore, vitamin C is easily destroyed by heat, alkaline conditions, and enzyme activity [8].

The vitamin C content in apple cider (5.23 mg/100 g) is higher than dodol and apple chips. This is thought to be due to the addition of sodium benzoate as a preservative, which inhibits spoilage and suppresses bacterial growth [15]. Increasing the concentration of sodium benzoate can inhibit the growth of microorganisms that can potentially destroy vitamin C, thus maintaining its content in the product [16].

Apple chips are a dry product that undergoes several processing stages, including peeling, cutting, and frying. The vitamin C content in apple chips is relatively low, at 2.85 mg/100 g. However, apple chips still contain vitamin C because the frying process is carried out using the vacuum frying method. Frying fruit with a highwater content generally uses vacuum frying technology, which allows the frying process to be carried out at relatively low temperatures. This method can produce fruit chips with a taste and aroma similar to fresh fruit, a crispy texture, and retain some of the nutritional content. Under vacuum conditions, the frying temperature can be lowered to around 80–90°C, thus minimizing damage to the product's color, aroma, taste, and nutrients [17].

Apple dodol is a processed product made from a mixture of glutinous rice flour, sugar, and coconut milk, cooked until it produces a thick, oily, and non-sticky texture. This product has a relatively low water content, around 10–40%, so it does not support the growth of pathogenic bacteria or yeast and has a relatively long shelf life. The brown color of apple dodol is caused by a non-enzymatic browning reaction

through the Maillard reaction and caramelization [18]. This intensive heating process causes the vitamin C content in apple dodol to be relatively low. However, the presence of sugar in the dodol formulation is thought to help maintain some of the vitamin C content. Increasing the sugar concentration in passion fruit syrup is associated with increased content of vitamin C and total acid in the product [19]. Sugar, as a natural preservative in food, can bind water and have an osmotic effect. Sugar binds some of the water in food and replaces it with sugar, thereby suppressing the growth of microorganisms that can produce oxidizing enzymes and destroy vitamin C. Furthermore, sugar also reduces the water activity of food [20].

#### 4. Conclusion

The results showed that processing methods had different effects on the stability of vitamin C in apple-based products, with significant differences in content between samples ( $p = 0.017$ ). Fresh apples had the highest vitamin C content at 12.36 mg/100 g, while the lowest content were found in apple dodol and apple chips at 2.85 mg/100 g, respectively. Processing significantly reduces the vitamin C content of Rome Beauty apples. This reduction is mainly caused by heating, oxidation, processing time, and exposure to oxygen during processing, which can accelerate vitamin C degradation. Conversely, processing methods that use lower temperatures have greater potential to preserve vitamin C content. In addition, the use of certain ingredients such as sugar or preservatives may help maintain vitamin C stability by inhibiting oxidation and microbial activity. Therefore, selecting appropriate processing methods and ingredient formulations is important to minimize vitamin C loss, although consuming fresh apples still provides the greatest nutritional benefit in terms of vitamin C intake.

#### 5. Declarations

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##### 5.2 Author contributions

The names of the authors listed in this journal contributed to this research.

##### 5.3 Ethics

This research does not require a code of ethics so it does not have a code of ethics.

##### 5.4 Conflict of Interest

The authors declare that they have no conflict of interests.

##### 5.5 Funding Statement

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