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Comparison of Vitamin C Content in Fresh and Canned Mandarin Oranges (*Citrus reticulata* Blanco) at a Supermarket in Pontianak

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Abstract: Vitamin C is one of the micronutrients needed and cannot be synthesized by the human body so it needs intake from the outside such as fruits. Mandarin oranges are one of the sources of vitamin C that is widely circulated in Pontianak City. This fruit is available in both fresh and canned form. However, the heating process during the processing of canned fruit can damage the vitamin C content in it. This study aimed to compare vitamin C levels in fresh and canned mandarin fruits. The methods used were in the form of qualitative colorimetric tests using $FeCl_3$, $KMnO_4$, and I_2, as well as quantitative tests using uv-vis spectrophotometry. The results showed that the two positive samples contained vitamin C with a level of 78.57 mg/100 g in the fresh sample and 31.96 mg/100 g in the canned sample. Thus, it can be concluded that the vitamin C level in fresh mandarin oranges is higher than in canned mandarin oranges. These findings highlight the importance of choosing fresh fruits over processed alternatives to maximize vitamin C intake for optimal health benefits.

Keywords: Ascorbic Acid; Fresh Fruit; Canned Fruit; UV-Visible Spectrophotometry

1. INTRODUCTION

Vitamins represent critical micronutrients that the human body requires in small quantities for numerous biochemical functions yet cannot synthesize independently. These essential compounds must be obtained through dietary sources, particularly plant-based foods like fruits and vegetables [1]. Vitamin C stands out as especially vital, functioning as a powerful antioxidant with significant reduction capabilities that provide numerous health benefits [2]. Health authorities, including those establishing the Recommended Dietary Allowance (RDA), advise that adult men consume approximately 90 mg of vitamin C daily, while adult women should aim for 75 mg per day to maintain optimal health [3]. Citrus fruits, particularly mandarin oranges, serve as excellent natural sources to fulfill these nutritional requirements due to their naturally high vitamin C concentration.

Mandarin oranges (*Citrus reticulata* Blanco) have gained widespread popularity in Indonesian markets, especially in Pontianak City, where consumers appreciate their distinctive

sweet-sour flavor profile [4]. The demand for citrus fruits has positioned Indonesia as ASEAN's foremost orange importer, with national consumption demonstrating consistent growth since 2015. The country's agricultural sector produced an impressive 2.72 million tons of oranges in 2022 across more than 57,000 hectares of cultivated land, with imports constituting just 4% of the domestic supply. These statistics reflect the significant consumer preference for citrus fruits, encompassing both fresh produce and processed products such as canned mandarin oranges [5], [6].

As orange consumption continues to rise, canned mandarin oranges have emerged as a convenient alternative for consumers seeking practical ways to incorporate vitamin C into their diets. The commercial canning process involves multiple stages including thorough washing, controlled heating, and precise sterilization to preserve the fruit's quality and extend shelf life [7], [8]. Despite these advantages in convenience, accessibility, and longevity, legitimate concerns exist regarding potential vitamin C degradation during processing. This raises important questions about whether canned products can effectively match the nutritional benefits of their fresh counterparts in meeting consumers' daily vitamin C requirements [9].

This research initiative employs UV-Vis spectrophotometry to conduct a comprehensive comparative analysis of vitamin C content between fresh and canned mandarin oranges. This analytical method was selected due to vitamin C's (ascorbic acid's) characteristic chromophore groups that demonstrate specific light sensitivity patterns, allowing for precise measurement [10]. The findings from this investigation aim to provide valuable, evidence-based insights for consumers, food manufacturers, nutritionists, and regulatory bodies to make informed decisions regarding the selection of citrus products that most effectively satisfy daily vitamin C nutritional needs. Unlike previous studies that primarily focus on raw citrus fruits, this research specifically evaluates both fresh and commercially processed citrus products, reflecting real-world consumption patterns. This approach offers novel insights into how processing methods impact vitamin C content—information that is increasingly important as processed foods continue to constitute a major component of modern diets. This information becomes increasingly relevant as processed foods continue to constitute a significant portion of modern dietary patterns.

2. MATERIALS AND METHODS

2.1. Chemicals and reagents

Materials utilized in this research study included laboratory-grade distilled water, certified vitamin C reference standard, commercially canned mandarin orange specimens, freshly harvested mandarin orange samples, iodine reagent, ferric chloride solution (1% concentration), and potassium permanganate solution (1% concentration).

2.2. Sample collection

The fresh and canned mandarin orange samples were procured from a selected supermarket in Pontianak City. The research employed random sampling methodology, wherein samples were selected arbitrarily from a larger population, ensuring each element or individual within the population maintained equal selection probability. Inclusion criteria for this research specified that both canned and fresh mandarin oranges must originate from reputable supermarkets and comply with proper product storage standards. Exclusion criteria encompassed expired canned mandarin

oranges, damaged or open can packaging, and fresh oranges exhibiting deterioration signs or complete spoilage.

2.3. Sample preparation

For the canned fruit samples, the sugar syrup was separated from the fruit segments, while for fresh fruit samples, the seeds and peels were removed. Ten grams of each prepared sample were weighed and subsequently blended with 50 ml of distilled water. The resulting mixtures were filtered using filter paper, and the filtrates were collected. The filtration process ensured the removal of solid particles, yielding clear solutions suitable for analytical procedures. These filtrates were then utilized for subsequent analysis to determine the parameters under investigation.

2.4. Standardvitamin C solution preparation

The vitamin C standard reference was precisely weighed to 10 mg and transferred to a 100 ml volumetric flask. Distilled water was added as the solvent up to the calibration mark, resulting in a stock solution with a concentration of 100 ppm. The solution was then homogenized using sonication for a duration of 5 minutes to ensure complete dissolution and uniform distribution of the analyte [8,10].

2.5. Maximum wavelenght meassurement

The 100 ppm stock solution was precisely pipetted in a volume of 0.8 ml into a 10 ml volumetric flask and diluted with distilled water to the calibration mark, yielding a solution with a concentration of 8 ppm. The solution underwent sonication for 5 minutes to ensure homogeneity. Subsequently, the maximum absorbance of the solution was measured across the wavelength range of 200-400 nm UV range using distilled water as the blank reference [8,10].

2.6. Linier curve construction

The vitamin C stock solution (100 ppm) was pipetted into separate 10 ml volumetric flasks in volumes of 400, 600, 800, 1000, 1200, and 1400 µl (equivalent to concentrations of 4, 6, 8, 10, 12, and 14 ppm respectively). Distilled water was added to each flask up to the calibration mark. The standard curve solutions were homogenized using sonication for 5 minutes and subsequently measured at the previously determined wavelength using UV-Vis spectrophotometry. All measurements were performed in triplicate to ensure analytical reliability [8,10].

2.7. Linearity assessment

The concentration series solutions were analyzed using a UV-Vis spectrophotometer to obtain absorbance values. Subsequently, a calibration curve was constructed by plotting concentration (ppm) against the corresponding absorbance values. From this plot, a linear regression equation in the form of $y = bx + a$ was determined, along with its correlation coefficient. The linearity relationship was characterized by the correlation coefficient (r) and the coefficient of determination (r^2), derived from the standard curve comparing concentration (x) and absorbance (y) across the vitamin C standard solution concentration series of 4, 6, 8, 10, 12 and 14 ppm [11].

2.8. Precision assessment

The precision, expressed as percent relative standard deviation (%RSD), was calculated from the measurement data of the standard curve concentration series (4, 6, 8, 10, 12, and 14 ppm) using the established formula [11]. This precision parameter quantifies the reproducibility of the analytical method across multiple measurements of the standard solutions.

$$\%\text{RSD} = \frac{SD}{X}\ X\ 100\%$$

2.9. Limit of detection (LOD) and quantivication (LOQ) assessment

Linearity is incorporated into the linear regression equation through the line equation y = bx + a. Meanwhile, the LOD and LOQ are determined from the linear regression equation, calculated using the formula [12]:

$$\text{LOD} = \frac{3.3\ X\ SD}{b}$$

$$\text{LOQ} = \frac{10\ X\ SD}{b}$$

2.10. Vitamin C quantification

A 0.8 mL aliquot of the filtered canned fruit sample was pipetted into a 10 mL volumetric flask and diluted to the mark with distilled water. The solution was homogenized for 5 minutes, and its absorbance was measured at the maximum wavelength. This procedure was repeated three times (in triplicate) to ensure reproducibility. The resulting data were analysed using the following equation:

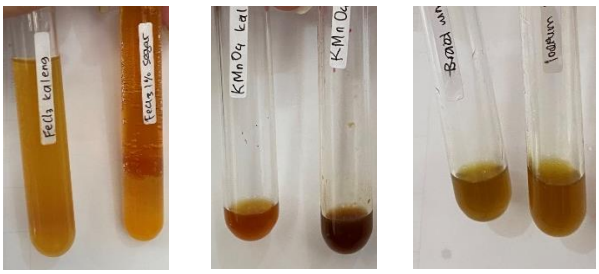
$$\text{Rate (mg)} = \text{Concentration x dilution factor x initial volume sample (L)}$$

$$\%\ \text{Rate vitamin C} = \frac{Average\ rate\ (mg)}{weight\ sample\ (mg)}\ X\ 100\%$$

3. RESULTS AND DISCUSSION

3.1. Qualitative results

This study employed qualitative testing through three distinct colorimetric assays to identify vitamin C presence in fresh and canned mandarin orange samples. Unlike quantitative methods that measure precise amounts, these tests focus on detecting the compound's existence through visible chemical reactions. The colorimetric assays utilized 1% $FeCl_3$, 1% $KMnO_4$, and 1% I_2 reagents. Both sample types showed clear positive reactions, as presented in Figure 1. The $FeCl_3$ test produced a transient yellow solution, demonstrating vitamin C's reducing capability as it converted Fe^{3+} to Fe^{2+}. When exposed to $KMnO_4$, the samples developed brown coloration from the oxidation reaction between vitamin C and MnO_4^- ions, with notably deeper pigmentation in the fresh sample. The I_2 test further confirmed vitamin C presence through decolorization, as the yellowish-brown iodine solution turned colorless upon reaction with the vitamin [12], [13], [14].



(a) (b) (c)

Figure 1. Qualitative test result on canned orange (left) and fresh mandarin orange (right). (a) 1% FeCl3, (b) 1% KMnO4, and (c) 1% I_2 reagents.

3.2. Method optimization

Before quantification, the analytical method was rigorously optimized. The maximum absorption wavelength (λ_{max}) was determined by scanning an 8 ppm vitamin C standard solution across the 200–400 nm UV range. The analysis identified 264.40 nm as the optimal wavelength (yielding absorbance of 0.550), ensuring measurement sensitivity and accuracy. This critical step prevented potential bias that could result from suboptimal wavelength selection [15]. To ensure the reliability of the quantification process, a robust calibration curve was established as part of the method validation. Calibration curves are essential in spectrophotometric analysis, as they define the linear relationship between known concentrations of a standard solution and their corresponding absorbance values. The spectrophotometric method in this research demonstrated exceptional linearity across the concentration range tested (depicted in Figure 2). Triplicate calibration curves generated correlation coefficients (r) of 0.9986, 0.9992, and 0.9993, all exceeding both SNI requirements (≥0.995) and International Conference on Harmonisation (ICH) standards (≥0.998). The third replicate (r = 0.9993) was selected for subsequent calculations due to its superior linear relationship between concentration and absorbance [11].

Sensitivity parameters further validated the method's reliability. The Limit of Detection (LOD) was established at 0.705 ppm, representing the lowest concentration that could be reliably distinguished from background noise. The Limit of Quantification (LOQ) was determined to be 2.136 ppm, establishing the minimum concentration at which vitamin C could be quantified with acceptable precision and accuracy [11]. Method precision (see Table 1), evaluated through repetitive measurements, yielded relative standard deviation (%RSD) values that satisfied both AOAC (<8%) and Horwitz (≤16%) acceptance criteria. While these values exceeded the more stringent ICH recommendation (<2%), they remained within acceptable ranges for food analysis across the 4–12 ppm concentration spectrum [16].

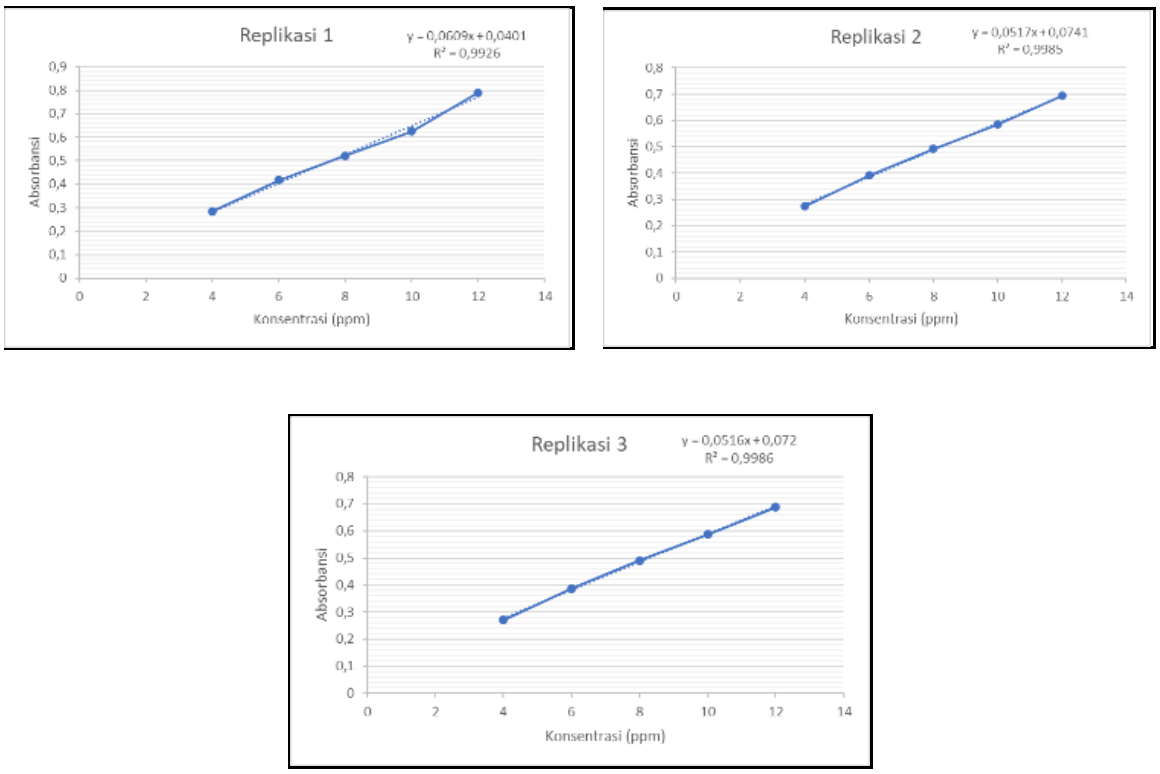


Figure 2. Linearity test based on standard curve of vitamin C concentration vs absorbance.

Table 1. The results of method precision assessment.

Concentration (ppm)	%RSD
4	2.42973
6	4.03211
8	3.46043
10	3.74914
12	7.86282

3.3. Quantitative Analysis

Quantitative analysis revealed substantial differences in vitamin C content between sample types (Table 2). Fresh mandarin oranges contained 78.57 mg/100 g of vitamin C, while canned specimens contained significantly less (31.96 mg/100 g), a reduction of approximately 59%. This marked disparity can be attributed primarily to thermal processing during canning, which degrades heat-sensitive compounds like ascorbic acid [17]. These findings align with Burdurlu, Koca, and Karadeniz. [18], who reported 60-87% vitamin C losses in citrus juices during thermal processing and storage. Their comprehensive study examined pasteurization effects on citrus juices stored at various temperatures (28°C, 37°C, and 45°C) over 180 days, finding that vitamin C degradation followed first-order kinetics with higher temperatures accelerating degradation rates. Similarly, Klimczak, Małecka, Szlachta, and Gliszczyńska-Świgło. [19] demonstrated progressive vitamin C degradation in orange juice during storage, with losses of 21-31% after 6 months at temperatures ranging from 18-38°C. Their research further correlated these losses with decreased antioxidant capacity, suggesting

broader nutritional implications beyond vitamin C content alone. The thermal sensitivity of vitamin C was further confirmed by Sapei and Hwa [20], who documented significant reductions in ascorbic acid content across various cooking methods, with losses ranging from 26-90% depending on processing intensity. Their systematic comparison of boiling, steaming, and microwaving across multiple vegetable types revealed that water-soluble nutrients like vitamin C are particularly vulnerable to leaching during aqueous thermal processing—a mechanism likely contributing to our observed losses in canned mandarin samples, which undergo water-based thermal treatment during preservation. Next, to see absorbance, concentration and mean of vitamin C content value of fresh orange and canned orange with quantification analysis (see Table 2).

Table 2. Quantification analysis of vitamin C content from fresh and canned mandarin orange.

Samples	Absorbance	Concentration (ppm)	Vitamin C content (ppm)	Mean of vitamin C content (mg/100 g)
Fresh orange	0.7129	12.4205426	77.6283915	78.56912152
	0.7127	12.4166667	77.6041668	
	0.7364	12.8759689	80.4748062	
Canned orange	0.3363	5.12209302	0.32013081	31.95655685
	0.3347	5.09108527	0.31819283	
	0.3365	5.12596899	0.32037306	

3.4. Discussion

The observed vitamin C retention pattern is consistent with Fennema's Food Chemistry, which explains that ascorbic acid degradation follows first-order kinetics under both aerobic and anaerobic conditions, with degradation rates accelerating at higher temperatures [21]. Their comprehensive analysis describes how vitamin C degradation mechanisms differ based on processing conditions: in aerobic environments, ascorbic acid undergoes oxidation to dehydroascorbic acid followed by hydrolysis to 2,3-diketogulonic acid; meanwhile, under anaerobic conditions like those in canned products, degradation proceeds via alternative pathways including delactonization. These mechanistic insights explain why different processing methods yield varying degrees of vitamin C retention. Lee and Kader [22] provide additional context by noting that postharvest factors including temperature, oxygen exposure, and metal ion catalysts significantly impact vitamin C stability in fruits and vegetables. Their landmark review emphasized that vitamin C degradation begins immediately after harvest and accelerates during processing, with temperature being the most critical factor. They detailed how each 10°C increase in temperature can double or triple degradation rates—explaining why high-temperature canning processes (typically 115-121°C) cause substantial losses compared to fresh produce. Furthermore, their research described how metal ions from processing equipment can catalyze oxidation reactions, potentially contributing to additional vitamin C losses during industrial canning operations [22].

Complementing these findings, Phillips [23]. conducted a comprehensive analysis of vitamin C content across fresh, frozen, and canned fruits and vegetables using standardized AOAC methods. Their systematic study of over 300 samples confirmed that canning generally resulted in greater

vitamin C losses (30-80%) compared to freezing (10-30%), with variations based on commodity type and specific processing parameters. For citrus fruits specifically, they noted that the acidic environment provided some protective effect against vitamin C degradation but could not fully mitigate thermal losses, consistent with our findings in mandarin oranges [23]. These studies collectively support our observations regarding the substantial vitamin C content differences between fresh and thermally processed mandarin oranges, underscoring the nutritional implications of food processing methods on this essential nutrient. The consistency between our results and the established literature validates both our analytical methodology and our conclusions regarding vitamin C retention in fresh versus canned citrus products.

4. CONCLUSION

Qualitative assessment for vitamin C in fresh and canned mandarin oranges using qualitative colorimetric tests methodologies confirmed the presence of this nutrient in both sample variants. Fresh mandarin specimens contained 78.57 mg/100 g of vitamin C, significantly exceeding the 31.96 mg/100 g measured in canned specimens—representing a 59.3% reduction. This substantial differential underscores the considerable impact of industrial processing on this critical micronutrient. These results correspond with established scientific literature regarding ascorbic acid stability during food processing operations. The considerable reduction observed in canned products can be attributed to thermal decomposition during high-temperature preservation treatments, as vitamin C demonstrates particular vulnerability to heat exposure and oxidative degradation.

In conclusion, these findings emphasize the nutritional advantage of consuming fresh mandarin oranges over canned varieties, particularly for individuals seeking to optimize their vitamin C intake. This has practical implications for consumer dietary choices, recommendations by health authorities, and formulation strategies within the food industry aiming to preserve nutrient integrity. Future research should explore innovative preservation techniques that minimize nutrient loss, as well as expand comparative studies to other fruits and vitamins affected by processing.

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