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Comparative Study of Ascorbic Acid Content in Fresh and Packaged Fruit Juices Using Iodometric Titration

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دراسة مقارنة لمحتوى حمض الأسكوربيك في عصائر الفاكهة الطازجة والمعلبة باستخدام معايرة اليود

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Abstract:

This research was conducted to estimate and compare the concentration of ascorbic acid (Vitamin C) in a variety of natural and processed fruit juices using the iodine titration method. A total of 14 samples were analyzed, categorized into two groups: seven types of fresh natural fruits (mango, strawberry, guava, pineapple, banana, orange, and lemon) and their corresponding seven types of commercially packaged or canned juices. The chemical principle employed is a classic redox reaction where ascorbic acid acts as a reducing agent that reacts quantitatively with iodine. During the titration, ascorbic acid is oxidized to dehydroascorbic acid, while iodine is reduced to iodide ions, with a starch indicator signaling the endpoint by forming a blue-black complex. The experimental results revealed significant variations in vitamin C content across the different juice types. Among the natural juices, orange juice recorded the highest concentration at 69.7 mg/100 ml, followed by guava at 58.3 mg/100 ml, while banana exhibited the lowest value at 6.33 mg/100 ml. In the processed juice category, orange juice again topped the list with 59.17 mg/100 ml, whereas mango juice showed the lowest concentration at 3.4 mg/100 ml. The study confirmed an inverse relationship between the canning process and vitamin C concentration, as a notable loss was observed in all processed samples compared to their natural counterparts. Strawberries and mangoes were the most affected, with loss percentages exceeding 50%, likely due to thermal pasteurization and oxidation during storage. Conversely, lemon and pineapple juices demonstrated higher chemical stability, attributed to their low pH levels. The findings underscore the importance of consuming fresh juices, particularly citrus and guava, to meet daily nutritional requirements, and highlight the precision of industrial quality control compared to natural biological variability.

Keywords: Ascorbic acid, Vitamin C, Iodine titration, Natural juice, Canned juice, Redox reaction, Food analysis.

الملخص
أُجري هذا البحث لتقدير ومقارنة تركيز حمض الأسكوربيك (فيتامينC) في مجموعة متنوعة من عصائر الفاكهة الطبيعية والمصنعة باستخدام طريقة معايرة اليود .تم تحليل إجمالي 14 عينة، صُنفت إلى مجموعتين: سبعة أنواع من الفواكه الطبيعية الطازجة (المانجو، الفراولة، الجوافة، الأناناس، الموز، البرتقال، والليمون) وما يقابلها من سبعة أنواع من العصائر المعلبة تجارياً .المبدأ الكيميائي المستخدم هو تفاعل أكسدة واختزال كلاسيكي حيث يعمل حمض الأسكوربيك كعامل مختزل يتفاعل كمياً مع اليود .أثناء المعايرة، يتأكسد حمض الأسكوربيك إلى حمض ديهيدروأسكوربيك، بينما يُختزل اليود إلى أيونات اليوديد، مع وجود كاشف النشا الذي يشير إلى نقطة النهاية من خلال تكوين معقد أزرق مائل إلى السواد. كشفت النتائج التجريبية عن تباينات ملحوظة في محتوى فيتامين C عبر أنواع العصائر المختلفة .ومن بين العصائر الطبيعية، سجل عصير البرتقال أعلى تركيز بنسبة 69.7 ملجم/100 مل، تلاه الجوافة بنسبة 58.3 ملجم/100 مل، بينما أظهر الموز أدنى قيمة بنسبة 6.33 ملجم/100 مل .وفي فئة العصائر المصنعة، تصدر عصير البرتقال القائمة مرة أخرى بنسبة 59.17 ملجم/100 مل، في حين سجل عصير المانجو أدنى تركيز بنسبة 3.4 ملجم/100 مل. أكدت الدراسة وجود علاقة عكسية بين عملية التعليب وتركيز فيتامينC ، حيث لوحظ فقدان ملحوظ في جميع العينات المصنعة مقارنة بنظيراتها الطبيعية .كانت الفراولة والمانجو الأكثر تضرراً، بنسب فقدان تجاوزت 50%، ويرجح أن يكون ذلك بسبب البسترة الحرارية والأكسدة أثناء التخزين .وعلى العكس من ذلك، أظهر عصير الليمون والأناناس استقراراً كيميائياً أعلى، ويُعزى ذلك إلى انخفاض مستويات الحموضة .(pH) وتؤكد النتائج على أهمية استهلاك العصائر الطازجة، وخاصة الحمضيات والجوافة، لتلبية الاحتياجات الغذائية اليومية، وتسلط الضوء على دقة مراقبة الجودة الصناعية مقارنة بالتباين البيولوجي الطبيعي.

الكلمات المفتاحية: حمض الأسكوربيك، فيتامين C، معايرة اليود، عصير طبيعي، عصير معلب، تفاعل الأكسدة والاختزال، تحليل الأغذية..

Introduction

Ascorbic acid, widely recognized as Vitamin C ($C_6H_8O_6$), is a fundamental water-soluble organic micronutrient that plays a pivotal role in numerous physiological processes (Levine et al., 1999). Unlike most mammalian species that possess the enzymatic machinery (L-gulonolactone oxidase) to synthesize this compound from glucose, humans lack this ability due to a specific genetic mutation. Consequently, it is classified as an essential dietary requirement, making the consumption of external sources or supplements mandatory to prevent nutritional deficiencies (Hernandez et al., 2006).

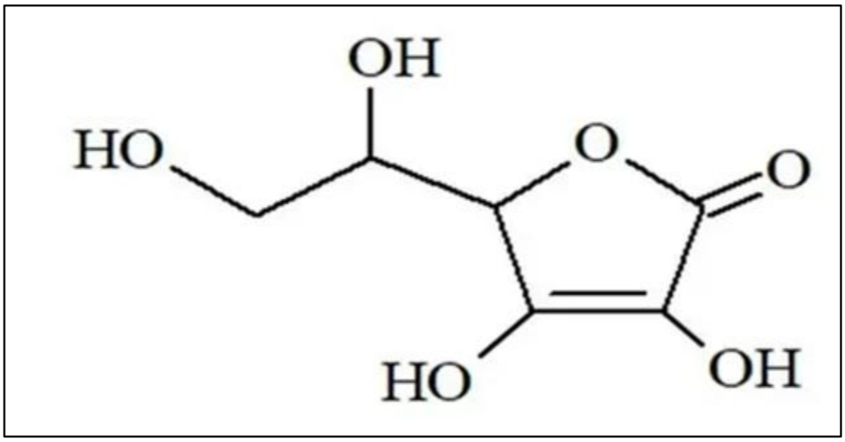

Figure 1. Molecular structure of Vitamin C (Ascorbic acid).

From a biochemical perspective, Vitamin C serves as a potent reducing agent and antioxidant. It effectively neutralizes reactive oxygen species (ROS) and protects cellular components—such as lipids, proteins, and DNA—from oxidative damage (Salem & Mohamed 2025), which is a major precursor to chronic pathologies including cardiovascular diseases, neurodegenerative disorders, and various types of cancer (Rodríguez-Bernaldo de Quirós et al., 2009). Beyond its protective capabilities, ascorbic acid is an indispensable cofactor for the hydroxylation of proline and lysine residues during collagen biosynthesis (Amheisen et al.,2025). This process is vital for maintaining the structural integrity of connective tissues, skin, tendons, bones, and blood vessels (Silva et al., 1999). Additionally, it significantly bolsters the immune system by enhancing white blood cell function and promoting the production of interferon (Levine et al., 1999).

Nature provides a rich variety of Vitamin C sources, predominantly within the plant kingdom. Citrus fruits (such as oranges and lemons), kiwis, strawberries, and cruciferous vegetables like broccoli and peppers are renowned for their high ascorbic acid content (Kapur et al., 2012). While animal-derived products, including liver and milk, contain trace amounts, their overall contribution to the human daily requirement is marginal compared to botanical sources (Ijeri et al., 2004). A prolonged inadequate intake of this vitamin leads to the clinical manifestation of scurvy. This condition is characterized by systemic symptoms such as extreme lethargy, impaired wound healing, gingival inflammation (swollen gums), and increased capillary fragility leading to subcutaneous hemorrhaging (Levine et al., 1999).

The quantification of Vitamin C in food matrices has been a focal point of global nutritional research. For instance, a comprehensive analytical study conducted in India demonstrated significant variability in vitamin levels among local produce, revealing that lemons contain approximately 40.48 mg/100g, while bananas provide a more modest 18.65 mg/100g (Kapur et al., 2012). Locally, Al-Ajtal et al. (2018) evaluated the quality of commercial juices in the Misrata region, Libya. Their findings indicated that orange juice consistently yielded the highest ascorbic acid concentrations (up to 0.938 g/L), whereas apple juice presented the lowest levels (0.352 g/L). Notably, their research emphasized that the stability of ascorbic acid is highly susceptible to external stressors, particularly thermal fluctuations and oxygen exposure during storage (Al-Ajtal et al., 2018).

Given the vulnerability of Vitamin C to industrial processing, there is a critical need to evaluate the nutritional gap between fresh and packaged products. The primary objective of this research is to quantify and compare the concentration of ascorbic acid in a selection of natural versus processed fruit juices. This assessment is performed using the iodometric titration method, a classic and reliable redox-based analytical technique. In this process, ascorbic acid is oxidized to dehydroascorbic acid, while the iodine titrant is reduced to iodide ions (Silva et al., 1999). The transition to a dark blue-black complex, triggered by the reaction between excess iodine and a starch indicator, marks the precise endpoint of the analysis. Through this comparative study, we aim to provide data-driven insights into the nutritional quality of commercial juices and establish the necessary intake portions required to satisfy daily human physiological demands.

Materials and Methods

Sample Collection

Natural fruit samples (mango, strawberry, guava, pineapple, banana, orange, and lemon) were purchased from local fruit markets. Corresponding manufactured/canned juice samples for each fruit type were also collected from local commercial markets.

Sample Preparation

Fresh fruits were thoroughly washed, peeled, and deseeded. The pulp was processed using an electric blender, and the resulting juice was filtered to ensure a residue-free liquid. Titrations were performed on the same day as extraction to prevent vitamin degradation.

Table 1. Fresh fruit samples used in the study.

Sample number	**Sample Name**
1	mango
2	strawberry
3	guava
4	pineapple
5	banana
6	orange
7	lemon

Table 2. Processed/Canned juice samples used in the study.

Sample number	Sample Name
1	mango juice
2	strawberry juice
3	guava juice
4	pineapple juice
5	banana juice
6	orange juice
7	lemon juice

Chemical Principle

Analyzing ascorbic acid (Vitamin C) in juices using iodine titration is a classic redox experiment. The method relies on the fact that ascorbic acid is a strong reducing agent that reacts quantitatively with iodine The titration involves a redox reaction. When iodine (I_2) is added to the juice, it is immediately reduced to iodide ions (I^-) by the ascorbic acid ($C_6H_8O_6$) (Silva et al., 1999). Once all the ascorbic acid is consumed, the next drop of iodine remains in the solution and reacts with a starch indicator to form a blue-black complex, signaling the endpoint.

Reaction of the following with iodine: -

$$C_6H_8O_6\ (aq) + I2\ (aq) \rightarrow\ C_6H_6O_6\ (aq) + 2H^+\ (aq) + 2I^-\ (aq)$$

Materials and tools used: -

Volumetric flasks, conical flasks, cups, pipettes, stirring rods, glass rods, filter paper, balances, iodine, potassium iodide, and starch.

Sample Preparation: -

A 1% starch solution is prepared and dissolved in 100 ml of distilled water, and an iodine solution with a concentration of 0.1 N is prepared and used to fill the pipette. Juice samples are well filtered through filter paper so that no fruit residues remain.

Calibration: -

The titration is carried out by oxidizing ascorbic acid with iodine to dehydroascorbic acid, and iodine is also reduced to iodide. Ascorbic acid is oxidized, and iodine reacts with the starch indicator, which serves as a reagent, turning blue. This color indicates the endpoint of the titration. We wash the burette with iodine to standardize it, then we fill the burette with iodine. The burette is wrapped with cellophane, and the flask containing the juice sample is also wrapped with cellophane. We carry out the titration until we get a blue color, and this is repeated three times, taking the average volume.

Taking account that 1 mole of iodine reacts with 1 mole of ascorbic acid.
Mole of iodine = Mass of ascorbic acid / Molar mass of ascorbic acid.
Mole of iodine = 0.01g ascorbic acid ×1mol ascorbic acid / l76.12g.
where the number 176.12 represents the partial weight of ascorbic acid.

$$1ml \text{ of } I_2 = 176.12 / 1000*10*2 = gm \text{ of ascorbic acid.}$$

Additionally, it is necessary to convert ascorbic acid from one unit (mol/L) to unit (mg/100mL) we use the following: -

$$C_{(mg/100ml)} = C_{(mol/l)} *Am*100$$

Results and Discussion

In this study, oranges and guavas were identified as the primary sources of vitamin C among the sampled juices. According to the experimental results, natural orange juice contained the highest concentration of ascorbic acid, whereas the lowest value in the natural category was recorded in bananas. Specifically, natural orange juice yielded 69.70 mg/100 ml, compared to 59.17 mg/100 ml in its canned counterpart. Guava followed closely with 58.30 mg/100 ml in natural form and 44.37 mg/100 ml in canned form. These findings align with previous research indicating that citrus fruits and guavas are superior sources of ascorbic acid (Kapur et al., 2012).

Table 3. Vitamin C concentrations in natural fruit samples.

	Ascorbic acid (mg/ml)	Standard deviation
1	7.33	2.52
2	12.83	2.26
3	58.3	7.60
4	28.66	2.50
5	6.33	1.02
6	69.7	9.51
7	47.3	3.05

The concentration of vitamin C in natural mango (7.33 mg/100 ml) is significantly lower than in citrus fruits, which is biologically expected. The variations observed between readings can be attributed to the high viscosity of mango juice, which complicates the extraction process and the observation of the color change during titration compared to clearer juices.

Natural strawberry juice contained an average concentration of 12.83 mg/100 ml. The coefficient of variation was 17.6%, indicating acceptable laboratory precision. The observed variability is likely due to differences in fruit ripeness and the rate of oxidation between samples (Hernandez et al., 2006). For natural pineapple juice, the vitamin C content was moderate. It is important to note that commercial pineapple juices are often fortified with synthetic ascorbic acid, which may occasionally result in higher laboratory values for canned versions compared to natural ones.

Bananas, while nutritionally valuable for potassium and vitamin B6, were confirmed not to be a primary source of vitamin C. This study observed a 27% decrease in vitamin C content in canned bananas compared to fresh ones. This decline is logical, as bananas are highly sensitive to oxidation and thermal pasteurization (Al-Ajtal et al., 2018).

Table 4. Vitamin C concentrations in canned/processed juice samples.

	Ascorbic acid (mg/ml)	Standard deviation
1	3.4	0.82
2	5.30	0.14
3	44.37	3.44
4	27.00	2.00
5	5.33	0.97
6	59.17	3.33
7	43.33	3.51

In canned strawberry and mango juices, the vitamin C content was significantly lower than in natural juices. This reduction is primarily due to thermal pasteurization, where high temperatures cause the breakdown of chemical bonds in ascorbic acid. Furthermore, trapped oxygen inside the packaging promotes oxidation, converting ascorbic acid into dehydroascorbic acid, which lacks the same biological effectiveness (Rodríguez-Bernaldo de Quirós et al., 2009).

Comparing these results with previous literature, the levels are consistent. Variations in natural fruits are typically due to factors such as soil composition, climate, and ripeness at the time of harvest (Kapur et al., 2012). For canned juices, discrepancies are often linked to poor preservation and exposure to light or heat during storage.

Conclusion

The present study conducted a comparative quantitative analysis of ascorbic acid levels across 14 distinct juice samples. The experimental data confirms a consistent inverse relationship between industrial processing (canning) and vitamin C concentration. A significant reduction in ascorbic acid was observed in all processed samples compared to their natural counterparts. Notably, strawberries and mangoes exhibited the highest sensitivity to manufacturing, with degradation rates exceeding 50%. This loss is primarily attributed to thermal pasteurization and oxidation during storage (Rodríguez-Bernaldo de Quirós et al., 2009). Conversely, lemon and pineapple juices demonstrated remarkable chemical stability throughout the processing phase. This resilience is likely due to their inherently low pH levels, which provide a natural protective acidic environment that shields the ascorbic acid molecule from rapid thermal degradation (Spínola et al., 2013). Natural orange juice was identified as the superior nutritional source, maintaining the highest concentration (69.70 mg/100 ml). From a statistical perspective, canned juice samples exhibited a significantly lower standard deviation than natural fruits. This disparity highlights the high precision and standardization of industrial quality control protocols in production lines, which contrast with the inherent biological variability found in fresh produce—factors such as ripeness, soil conditions, and harvest timing.

Recommendations

Nutritional Choices

To ensure maximum dietary intake of Vitamin C, it is highly recommended that consumers prioritize fresh orange and guava juices. These fruits consistently provide the highest biological concentrations of ascorbic acid required for human health.

Processed Juice Selection

When fresh alternatives are unavailable and consumers opt for processed juices, lemon or pineapple varieties are preferable. Their capacity to retain nutritional integrity after heat treatment makes them a more reliable source of Vitamin C among commercial options.

Storage and Preservation

To maintain the nutritional quality of natural juices, they must be stored at low temperatures and shielded from direct light exposure. These measures are essential to minimize the rates of oxidation and photochemical degradation of the ascorbic acid content.

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