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Comparative Study of Vitamin C Content in Fresh Cow Milk, Branded Powdered and Branded Liquid Milk Samples Sold in Kaduna Metropolis

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ABSTRACT
Vitamin C is an essential nutrient known for its antioxidant properties and its role in immune function. This study is aimed at comparing the vitamin C content in fresh cow milk, milked directly from the cows, branded powdered and branded liquid milk samples collected from Kaduna State, Nigeria. Samples of branded powdered and liquid milk were collected from retail stores in Kaduna Central Market, while fresh cow milk samples were collected from Fulani herdsmen settlements in Kawo, Badarawa, and Angwan Shanu areas in the region. A total of 18 samples, from which three (3) fresh cow milk, nine (9) branded powdered milk, and six (6) liquid milk were obtained. A colorimetric method was employed to measure the vitamin C concentrations in all the milk samples. Fresh milk samples from Angwan Shanu had the highest vitamin C content of 0.125±0.003 mg/L, Badarawa followed with a slightly lower vitamin C content of 0.111±0.00 mg/L, which was still significantly higher than the content in Kawo with 0.092±0.001 mg/L. For the powered milk samples, Loyal milk had the highest vitamin C content (0.800±0.006 mg/kg), significantly higher than all other samples. Peak followed with 0.192±0.002 mg/kg, marking a notable difference compared to other brands except Loya. For the branded liquid milk samples, Luna with 0.064±0.001 mg/L and Peak 0.058±0.001 mg/L had moderate vitamin C levels, but they were significantly lower than those of 3 Crown and Popular. These findings provide valuable insights into the importance of processing methods in preserving the nutritional quality of milk.

Keywords: Vitamin C, Branded powdered milk, Branded liquid milk, fresh cow milk

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INTRODUCTION

Vitamin C, also known as ascorbic acid, is a water-soluble vitamin that plays a pivotal role in numerous physiological functions in the human body. It is an essential nutrient that must be obtained through diet or supplementation, as humans, unlike many other animals, cannot synthesize it endogenously **(Abdulkadir et al.,2016).** Vitamin C is renowned for its antioxidant properties, which help combat oxidative stress by neutralizing free radicals and reactive oxygen species (**Abiodun et al.,2019**). It is a crucial cofactor in various enzymatic reactions, including the biosynthesis of collagen, which is a structural protein vital for maintaining skin, blood vessels, and connective tissues **(Adebayo et al.,2020).**

Additionally, vitamin C enhances the absorption of non-heme iron from plant-based foods, supports immune system function, and plays a role in the regeneration of other antioxidants such as vitamin E, underscoring its multifaceted importance in human health **(Adekunle et al.,2018).**

However, vitamin C is a water-soluble and highly sensitive nutrient that can easily degrade due to factors such as exposure to heat, light, and air, particularly during food processing and storage **(Adeyemi et al.,2020).** Milk, being a commonly consumed food item, serves as an important dietary source of various nutrients, including proteins, minerals, and vitamins **(Agbaje et al., 2021).** Understanding the vitamin C content in milk products is essential for ensuring that consumers ingest adequate intake of this nutrient, especially in areas where dairy products are frequently consumed **(Akpan and Etim., 2020**).

Milk is a nutrient-rich fluid produced by the mammary glands of mammals, primarily designed to nourish their young **(Arya et al.,2020).** It is a vital source of essential nutrients, including proteins, fats, vitamins, and minerals, making it a cornerstone of human nutrition across cultures. Milk is derived from various sources, including cows, goats, sheep, camels, and buffalo, each offering unique nutritional profiles **(Ball (2006) Carr ; Fred (2018)).**

In some regions, plant-based alternatives like almond, soya, and oat milk are gaining popularity as substitutes for animal-derived milk, particularly among individuals with lactose intolerance or dietary restrictions **(Chandan,2015).** These plant-based options often undergo fortification to mimic the nutritional content of traditional milk, providing a suitable option for those seeking dairy alternatives. The global significance of milk extends beyond nutrition; it forms the basis of numerous food products such as cheese, yogurt, and butter, which contribute to diverse culinary traditions **(Dhuique- Mayer et al., 2018).**

Despite its benefits, milk deficiencies and intolerances can pose challenges to human health. Lactose intolerance, a condition where individuals lack the enzyme lactase needed to digest lactose in milk, is a common issue, particularly among populations in Asia and Africa **(Donkor et al., 2012;Dosedel et al.,2021).** Additionally, reliance on non-fortified milk alternatives can result in deficiencies of key nutrients such as calcium and vitamin D, crucial for bone health and overall development.

Conversely, milk consumption offers numerous benefits, including the prevention of osteoporosis, enhancement of muscle growth, and support for cardiovascular health due to its balanced nutrient composition **(Dhuique-Mayer et al.,2018).** Moreover, fortified milk serves as an excellent vehicle for addressing micronutrient deficiencies in vulnerable populations, thereby improving public health outcomes globally **(Fox et al.,2015).** Thus, milk remains an indispensable dietary component, balancing its potential drawbacks with its profound nutritional advantages.

Milk is available in various forms, including powdered, liquid, and fresh, each with distinct production processes that may affect nutrient content, particularly vitamin C. Liquid milk is often pasteurized or sterilized to extend its shelf life. These processes can lead to the degradation of vitamin C in the milk **(Gargano et al.,2021).** Powdered milk undergoes dehydration, which may also impact its vitamin C content due to exposure to high temperatures **(Kobar,2024).** Fresh cow milk, on the other hand, typically retains a higher concentration of vitamin C when minimally processed but has a shorter shelf life and is more susceptible to spoilage **(Leong and Oey,2012).** These variations in milk forms and processing methods highlight the need for an indepth analysis of vitamin C levels across different milk types to evaluate how these factors influence its retention.

In the context of Kaduna State, Nigeria, milk is a significant part of the local diet, and its nutritional value is essential for the health of the population. Limited studies have examined the vitamin C content in milk products in Kaduna, particularly across different milk forms, making it challenging to assess the adequacy of vitamin C intake from these sources **(Marquez and Aranda, 2021).** With increasing urbanization and a growing market for processed foods, the consumption of various milk types, especially powdered and liquid forms, has surged in Kaduna, driven by their convenience and extended shelf life.

Therefore, it is critical to investigate the vitamin C content in these milk forms to ensure that nutritional recommendations are met and to raise awareness of any potential nutrient losses associated with processed milk products **(Munblit et al.,2017).**

This study aims to determine the concentration of vitamin C in fresh cow milk, branded powdered and liquid milk available in Kaduna State, Nigeria. By employing analytical techniques to quantify the vitamin C levels in each milk form, this research seeks to provide data that could inform nutritional policies and assist consumers in making informed dietary choices. Additionally, this research will contribute to the growing body of literature on food quality in Nigeria, providing insights into the nutritional implications of milk consumption patterns in Kaduna State and potentially guiding future improvements in dairy processing to enhance vitamin C retention **(Nielsen, 2017).**

MATERIALS AND METHODS

Materials

Fresh cow milk, branded powdered milk, liquid milk, distilled water, L-ascorbic acid, 2,6-dichlorophenolindophenol (DCPIP), amber conical flasks, burettes, measuring cylinders, beakers, test tubes, and pipettes.

Study Area and Sample Collection

This study was conducted in Kaduna State, Nigeria, where various milk products are widely available. Samples of branded powdered and liquid milk were collected from retail stores in Nigeria Central Market, while fresh cow milk samples were collected from Fulani herdsmen settlements in Kawo, Badarawa, and Angwan Shanu areas in the region. A total of 18 samples, including three (3) fresh cow milk, nine (9) branded powdered, and six (6) liquid milk, were obtained to ensure a representative sample for each milk form. Each sample was purchased in unopened and sealed packaging to maintain quality. After collection, the samples were transported to the laboratory under refrigerated conditions to preserve their nutrient content until analysis **(Obioha et al.,2019).**

Sample Preparation

Each milk sample was prepared for analyses, for fresh cow milk, and liquid milk, 10 cm^3 of each sample was measured. Powdered milk samples were reconstituted by dissolving 10 g of each in 90 cm^3 of distilled water to create a solution equivalent in consistency to liquid milk. All samples were then filtered with a sieve of 0.1 mm to remove any particulates and were stored in amber containers to protect them from light-induced degradation of the vitamin C content. Samples were processed promptly to minimize any potential loss of nutrients **(Okafor et al.,2020).**

Analytical method for vitamin C determination

A 0.01% DCPIP solution was prepared and standardized using a fresh L-ascorbic acid stock solution. Powdered milk was dissolved (10 g in 90 cm^3 distilled water), and filtered with a 0.1 mm sieve. For the analysis, 5 cm^3 of milk sample was pipetted into a conical flask, and DCPIP solution was added dropwise while swirling the flask until a permanent pink-colored endpoint indicated the reaction was complete. The volume of DCPIP used was recorded, and vitamin C concentration was calculated using a calibration curve from standard ascorbic acid solutions. **(Okoye et al.,2021; Olugunde et al .,2018;Oyetayo et al.,2014).**

Preparation of Standard Vitamin C Solution

A standard solution of ascorbic acid was prepared by dissolving 100 mg of L-ascorbic acid in 100 mL of distilled water to create a 1 mg/mL stock solution. This was further diluted to create a series of standard solutions (0.1 mg/mL, 0.2 mg/mL, and 0.5 mg/mL) used to generate a calibration curve **(Okafor et al., 2021).**

STATISTICAL ANALYSIS

The data obtained for vitamin C concentration across fresh cow milk, branded powdered, and liquid milk samples were analyzed statistically. Analysis of Variance (ANOVA) was conducted to identify any significant differences in vitamin C content among the three milk types. A post-hoc test, Tukey's Honest Significant Difference (HSD) test, was applied to pinpoint specific group differences. Statistical significance was set at $P< 0.05$ **(Pereira et al.,2014**). Results were presented as mean ± standard deviation.

QUALITY CONTROL AND VALIDATION

Quality control measures were implemented throughout the study to ensure data reliability. All reagents, including ascorbic acid and DCPIP, were freshly prepared to prevent any degradation. Duplicate samples and blank controls were analyzed alongside each batch of samples to account for potential procedural errors **(Obioha et al.,2019).** Furthermore, a recovery test was performed by spiking selected milk samples with a known amount of ascorbic acid, confirming an acceptable recovery rate, which validated the accuracy of the method

RESULTS

Table 1: Vitamin C Content (mg/L) in Fresh Milk Samples Collected from Kaduna State.

Location	Vitamin C Content (mg/L)
Angwan Shanu	**0.125 ± 0.003^{a}**
Badarawa	**0.111 ± 0.00^{b}**
Kawo	**0.092 ± 0.001^{c}**
L.S.D	**0.002**
P-value	**≤0.0001**

Where the P-value is the level of marginal significance within a hypothesis and the Least Significant Difference (L.S.D). At $P\leq0.05$ there was a significant difference in Vitamin C Content (mg/L) in fresh milk samples collected from Kaduna State. Values are presented as mean ± standard deviation. Ranking was done across the different types of locations and values with the same superscript are not significant.

The Vitamin C content (mg/L) in fresh cow milk samples collected from Angwan Shanu, Badarawa, Kawo areas of Kaduna State as presented in Table 1, shows significant variation ($P\leq0.05$) among the different locations. Fresh milk samples from Angwan Shanu had the highest Vitamin C content of 0.125±0.003 mg/L, indicating better preservation of Vitamin C, potentially due to better feeding. Badarawa followed with a slightly lower Vitamin C content of 0.111±0.00 mg/L, which was still significantly higher than the content in Kawo 0.092±0.001 mg/L, the lowest among the locations which could be because the animals may not have been fed with pastures. Abiodun and Idowu (2019) also carried out an analysis on fresh cow milk samples and discovered that the concentrations varied due to the feeding habits and environmental conditions of the and possibly the lactation stage of the animals**.(Abiodun and Idowu,2019).**

Table 2: Vitamin C Content (mg/L) in branded Powdered Milk Samples Collected from Kaduna State.

Samples	Powdered Milk
Peak	**0.192 ± 0.002^{b}**
3 Crown	**0.095 ± 0.001^{c}**
Cowbell	**0.016 ± 0.002^{h}**
Dano	**0.057 ± 0.005^{f}**
Loyal	**0.800 ± 0.006^{a}**
Champion	**0.032 ± 0.001^{g}**
Kerry Gold	**0.032 ± 0.001^{g}**
Hollandia	**0.064 ± 0.002^{e}**
Olympia	**0.076 ± 0.001^{d}**
L. S. D	**0.06**
P-value	**≤0.0001**

At P≤0.05 there was a significant difference in Vitamin C Content (mg/L) in Powdered Milk Samples Collected from Kaduna State. Values are presented as mean±standard deviation. The ranking was done across the different types of milk and values with the same superscript are not significant.

The analysis of Vitamin C content (mg/L) in branded powdered milk samples purchased from Kaduna State, as presented in Table 2, demonstrates significant differences (P≤0.05) among the various brands. Loyal had the highest Vitamin C content (0.800±0.006 mg/L), significantly higher than all other samples. Peak followed with 0.192±0.002 mg/L, marking a notable difference compared to other brands except for Loya milk, while 3 Crown (0.095±0.001 mg/L) and Olympia (0.076±0.001 mg/L) showed moderate levels. Brands such as Hollandia (0.064±0.002 mg/L), Dano (0.057±0.005 mg/L), Champion, and Kerry Gold (both 0.032±0.001 mg/L) had relatively lower values, suggesting variations in fortification or degradation during processing. The lowest Vitamin C content was recorded in Cowbell (0.016±0.002 mg/L), which may indicate insufficient fortification or significant loss during processing or storage. The low standard deviation values indicate precise and reliable measurements. In (Ologunde et al 2018) analyzed powdered milk samples of various brands the results ranged from 1.0 mg/dl to 1.20 mg/dl, and recommended that milk that has been supplemented with higher amounts of vitamin C should be purchased for the sake of its health benefits. (**Olugunde et al.,2018).**

Table 3: Vitamin C Content (mg/L) in Liquid Milk Samples Collected from Kaduna State.

Samples	Vitamin C Content (mg/L)
Peak	0.058±0.001[d]
3 Crown	0.094±0.001[a]
Cowbell	0.014±0.001[e]
Hollandia	0.057±0.00[d]
Popular	0.084±0.002[b]
Luna	0.064±0.001[c]
L.S.D	0.06
P-value	≤0.0001

At P≤0.05 there was a significant difference in Vitamin C Content (mg/L) in Liquid Milk Samples Collected from Kaduna State. Values are presented as mean±standard deviation. The ranking was done across the different types of milk and values with the same superscript are not significant.

The Vitamin C content (mg/L) in liquid milk samples collected from Kaduna State, as shown in Table 3, revealed significant differences (P≤0.05) among the various brands. 3 Crown had the highest Vitamin C content of 0.094±0.001 mg/L, followed by Popular with 0.084±0.002 mg/L, which also showed relatively high levels. Luna with 0.064±0.001 mg/L and Peak 0.058±0.001 mg/L had moderate Vitamin C levels, but they were significantly lower than those of 3 Crown and Popular. Hollandia with 0.057±0.00 mg/L exhibited similar levels to Peak, suggesting consistent fortification practices or storage conditions between these brands. The lowest Vitamin C content was observed in Cowbell with 0.014±0.001 mg/L, significantly falling below other samples, which might indicate inadequate fortification or loss during processing. A contrast is seen in the results of the vitamin C of liquid and powdered milk of the same brand.

Comparison among Brands

Powdered Peak milk had a vitamin C value of (0.192 mg/L), while liquid milk has a lower vitamin C content of (0.058mg/L). The lower value obtained for liquid milk could be due to the processing and storage. On the other hand, both powdered and liquid milk samples of 3 crown brand had a similar vitamin C level of 0.094 and 0.095.

For the Cowbell brand, both the powdered and liquid milk showed very low vitamin C levels, we could say that the milk does not have nutrient fortification and they undergo similar processing. Perera et al carried out research in 2017 and the result showed that powdered milk had a higher vitamin C content than fresh cow milk owing to the obvious reason that powdered milk is being fortified during production**.(Perera et al.,2017).** For a robust immune system, the Daily intake of vitamin C is (Recommended ranges from 0 -120) the upper limit for vitamin C is 2000 mg per day.

DISCUSSION

The significant variation in Vitamin C content among fresh cow milk samples from Kaduna State reflects the influence of handling, storage, and environmental factors on nutrient retention. The highest Vitamin C content in Angwan Shanu (0.125±0.003 mg/L) aligns with findings by Perera in 2014, who reported that milk handled and stored under optimal conditions retains higher levels of Vitamin C. Similarly, Badarawa's slightly lower value (0.111±0.00 mg/L) is consistent with studies emphasizing the importance of timely milk processing to preserve nutritional quality. In contrast, the lowest content in Kawo (0.092±0.001 mg/L) supports observations by **Adeyemi et al.,(2020)** who attributed reduced Vitamin C levels to prolonged storage, exposure to light, and microbial activity as the milk from Kawo was the last to be analysed. The low LSD (0.002) and significant P-value (≤0.05) in this study indicate precise analysis and highlight the impact of localized practices on nutrient preservation. Compared to other regions, such as the Northern Nigerian studied by **Adekunle et al.,(2018**), these findings underscore the variability in fresh milk's Vitamin C content due to regional handling and storage disparities.

The findings from the analysis of Vitamin C content in powdered milk samples from Kaduna State reveal notable variations among brands, consistent with the conclusions of other studies that highlight differences in fortification practices and Vitamin C stability during processing and storage. The highest Vitamin C content observed in Loyal (0.800±0.006 mg/L) surpasses the range typically reported for fortified powdered milk in similar research, such as a study by **Okoye et al 2020**, where fortified milk brands averaged 0.4–0.6 mg/L. The moderately high content in Peak (0.192±0.002 mg/L) aligns with findings from other studies suggesting that processing conditions significantly influence retention levels. Conversely, the low Vitamin C levels in Cowbell (0.016±0.002 mg/L) mirrors observations in research by **Adebayo et al.,(2020),** which attributed such deficiencies to inadequate fortification or degradation during storage. Interestingly, the wide disparity in Vitamin C content across brands in this study is larger than those reported by **Agbaje et al.,(2021**), who found less pronounced differences among brands. These discrepancies may stem from differences in fortification practices, or storage conditions across regions.

The Vitamin C content in liquid milk samples from Kaduna State demonstrates significant variability among brands, with 3 Crown (0.094±0.001 mg/L) having the highest concentration, consistent with studies emphasizing the role of effective fortification in maintaining nutritional value. For instance, findings by **Okafor et al.,(2021),** reported similar results, where well-fortified milk brands exhibited higher Vitamin C levels, suggesting that brands like 3 Crown and Popular (0.084±0.002 mg/L) employ superior fortification processes. Conversely, the low Vitamin C content in Cowbell (0.014±0.001 mg/L) aligns with research by **Adebayo et al.,(2018),** which attributed such deficiencies to inadequate fortification or degradation during transportation and storage. The moderate Vitamin C levels in Luna (0.064±0.001 mg/L) and Peak (0.058±0.001 mg/L) are comparable to the findings of **Abiodun and Idowu (2019),** who observed similar levels in samples stored under suboptimal conditions. The consistency between Hollandia (0.057±0.00 mg/L) and Peak suggests uniform storage or similar production protocols, which was also noted in studies highlighting the impact of processing techniques on Vitamin C stability.

The findings on Vitamin C content in fresh, liquid, and powdered milk from Kaduna State show substantial differences that align with, yet contrast the observations of other researchers. In powdered milk, Loya's Vitamin C content (0.800±0.006 mg/L) was exceptionally high, suggesting superior fortification, contrasting with Cowbell's low value (0.016±0.002 mg/L), indicative of inadequate fortification or processing losses. Studies such as those by **Adeyemi et al.,(2020)** corroborate that fortified powdered milk tends to have higher Vitamin C due to deliberate enrichment, but variability exists due to brand-specific practices.

Liquid milk samples exhibited lower Vitamin C concentrations overall, with 3 Crown (0.094±0.001 mg/L) leading, similar to findings by **Obioha et al 2019**, who noted reduced Vitamin C in liquid milk due to degradation during storage. Fresh milk from Angwan Shanu

(0.125±0.003 mg/L) displayed the highest retention, aligning with studies highlighting minimal processing as a key factor in preserving Vitamin C. Compared to liquid and powdered milk, fresh milk showed the least variability, supporting findings by **Olugunde et al.,(2018),** that Vitamin C content in unprocessed milk is influenced primarily by environmental and handling factors rather than fortification. These comparisons underscore the impact of fortification, processing, and storage on Vitamin C retention across milk types.

CONCLUSION

In conclusion, the findings on Vitamin C content in powdered, liquid, and fresh milk samples from Kaduna State revealed significant differences among various brands, reflecting variations in fortification practices, processing, and storage conditions.

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