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Research Article

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Nutritional, Physicochemical and Sensory Quality of Local and Imported Watermelons Marketed in Beni, Democratic Republic of the Congo

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Abstract

Watermelon (Citrullus lanatus) is widely consumed for hydration, sweetness and its contribution of vitamins, minerals and bioactive compounds. This study compared the physicochemical, nutritional and sensory quality of locally grown watermelons from Beni, Democratic Republic of the Congo, with watermelons imported from Uganda. Twenty fruits were evaluated, comprising two local types (B1 and B2) and two imported types (A1 and A2). Moisture, pH, total soluble solids, vitamins A and C, calcium and magnesium were determined using laboratory procedures described in the source study. A semi-trained panel of 20 consumers evaluated aroma, color, taste, juiciness and texture on a five-point scale. Group means were compared by analysis of variance, and principal component analysis was used for exploratory multivariate visualization. Significant differences were observed for moisture, vitamin C, total soluble solids, vitamin A, calcium and magnesium ($p<0.001$), whereas pH did not differ significantly ($p=0.181$). Local samples had higher soluble solids (7.73-8.10 °Brix), moisture and slightly higher mineral contents, while imported samples contained more vitamin C (7.33-8.10 mg/100 g) and vitamin A (27.67-28.63 µg/100 g). Sensory profiles differed among samples, with B1 showing the highest juiciness score and A1 the highest color score. The findings indicate distinct nutritional and sensory strengths between local and imported watermelons and support greater characterization and valorization of locally produced fruit.

Keywords: Watermelon; Citrullus Lanatus, Nutritional Quality, Soluble Solids, Vitamins, Minerals, Sensory Quality, Beni

Abbreviations
TSS - Total Soluble Solids
PCA - Principal Component Analysis
ANOVA - Analysis of Variance

1. Introduction

Watermelon (Citrullus lanatus) is an African-origin cucurbit that has become one of the most widely consumed fresh fruits worldwide [1]. Its high-water content, natural sugars and refreshing sensory properties make it particularly valuable in warm climates, while its flesh also provides vitamin C, carotenoids, minerals, citrulline and other bioactive compounds [2,3]. Recent reviews emphasize that watermelon quality is not limited to sweetness or appearance: nutritional composition, flesh color, texture, aroma and bioactive compounds together determine both consumer preference and potential health value [2-4].

Fruit quality varies markedly among genotypes and production environments. Genetic background influences sugar accumulation, flesh firmness, carotenoids, organic acids and other traits, while climate, crop management, maturity and postharvest handling can further modify the final composition [4,5]. Postharvest storage is especially relevant for marketed fruit because ascorbic acid and other phytochemicals can decline during extended storage, even when some carotenoids remain stable or increase temporarily [6,7]. Therefore, local production and imported supply chains may produce fruit with different nutritional and sensory profiles even when the fruits are sold in the same market.

In eastern Democratic Republic of the Congo, Beni is an important urban market surrounded by agricultural production zones and connected to regional trade routes. Consumers have access to watermelons produced locally as well as fruit imported from Uganda. However, comparative data on their physicochemical composition, micronutrient content and sensory characteristics are scarce. Such information is useful for consumers, producers and food-sector actors because it can identify attributes that favor local production while also showing nutritional characteristics in which imported fruit may perform better.

The objective of this study was therefore to compare locally grown and imported watermelons marketed in Beni with respect to moisture, pH, total soluble solids, vitamins A and C, calcium, magnesium and sensory attributes. An exploratory PCA was additionally used to visualize the multivariate separation of the four watermelon types.

2. Materials and Methods

2.1. Study Area and Sample Design

The study was conducted in Beni, North Kivu Province, in the northeastern Democratic Republic of the Congo. The source study reports a total of 20 watermelon fruits divided into four sample types: two locally produced types from Beni (B1 and B2) and two types imported from Uganda and purchased in local markets (A1 and A2). The overall sampling plan comprised 10 local and 10 imported fruits, with five fruits representing each sample type. Local fruit was selected to represent available production, whereas imported fruit was obtained from principal points of sale in Beni.

2.2. Physicochemical and Nutritional Analyses

Edible flesh was homogenized before laboratory analysis. Moisture was determined gravimetrically by drying approximately 10 g of homogenized pulp at 105 °C for 24 h and expressing mass loss as percentage moisture. Total soluble solids were measured in filtered juice using a refractometer and expressed as °Brix. The pH was measured potentiometrically in watermelon juice using a calibrated pH meter.

For mineral analysis, samples were subjected to acid digestion before titrimetric determination. Calcium and magnesium were determined by EDTA complexometry using the indicator systems described in the source laboratory protocol. Vitamin C was determined by iodometric titration after acid extraction and starch indication. Vitamin A equivalents were estimated after ethanol/hexane extraction, saponification and iodometric titration as described in the source protocol. Results were expressed on a fresh-weight basis as reported in the original dataset.

2.3. Sensory Evaluation

A semi-trained panel of 20 adult consumers residing in Beni evaluated the four watermelon samples. Panelists were selected on the basis of good health, ability to understand the instructions and familiarity with watermelon consumption. Fruits were washed and cut into portions of approximately 50 g. Samples were coded with random three-digit numbers and served at approximately 20-25 °C in a quiet, well-lit environment. Water and neutral crackers were provided between samples. Aroma, color, taste, juiciness and texture were scored on a five-point scale, with higher values indicating a more favorable or more intense attribute according to the study score sheet.

2.4. Statistical Analysis

Data were summarized as means and standard deviations for the physicochemical and nutritional variables. Overall differences among the four watermelon types were assessed by analysis of variance at $\alpha = 0.05$. Principal component analysis was used as an exploratory visualization of the multivariate nutritional profile. Because the PCA was based on four group-level mean profiles, it was interpreted descriptively rather than as a confirmatory population-level analysis. Sensory results were summarized descriptively using the reported five-point scores.

2.5. Ethical Considerations

Ethical approval for the study was provided by the Centre Interdisciplinaire de Recherche en Éthique (CIRE) of the Université Chrétienne Bilingue du Congo, Beni, under approval reference

CNES 017/DPSK/322PP/2026. The sensory evaluation involved adult human participants who were informed about the purpose and procedures of the study before participation. Written informed consent was obtained, participation was voluntary, participants could withdraw at any time, and anonymity and confidentiality were maintained throughout data collection.

3. Results

3.1. Physicochemical and Nutritional Characteristics

The four watermelon types differed significantly for most of the measured quality variables (Table 1). Moisture ranged from 87.47% in imported sample A2 to 91.67% in local sample B1 ($p<0.001$). Total soluble solids were higher in the local samples, reaching 7.73 °Brix in B1 and 8.10 °Brix in B2, compared with 6.20 °Brix in A1 and 5.60 °Brix in A2 ($p<0.001$). In contrast, the imported fruits showed higher vitamin concentrations. Vitamin C ranged from 7.33 to 8.10 mg/100 g in A1-A2 but from 5.30 to 5.70 mg/100 g in B1-B2. Vitamin A followed the same pattern, with 27.67-28.63 µg/100 g in imported samples versus 21.50-22.33 µg/100 g in local samples ($p<0.001$).

Calcium and magnesium were modestly higher in local fruits overall. Calcium was highest in B1 (6.83 mg/100 g) and magnesium was also highest in B1 (9.20 mg/100 g). The pH ranged narrowly from 5.63 to 5.83 and did not differ significantly among the four sample types ($p = 0.181$).

Parameter	A1	A2	B1	B2	p-value
Moisture (%)	89.00 ± 0.10	87.47 ± 0.35	91.67 ± 0.21	89.50 ± 0.30	<0.001
pH	5.83 ± 0.06	5.70 ± 0.10	5.63 ± 0.06	5.73 ± 0.15	0.181
Vitamin C (mg/100 g)	7.33 ± 0.06	8.10 ± 0.10	5.30 ± 0.20	5.70 ± 0.10	<0.001
TSS (°Brix)	6.20 ± 0.10	5.60 ± 0.10	7.73 ± 0.06	8.10 ± 0.10	<0.001
Vitamin A (µg/100 g)	28.63 ± 0.06	27.67 ± 0.12	21.50 ± 0.10	22.33 ± 0.21	<0.001
Calcium (mg/100 g)	5.63 ± 0.06	6.20 ± 0.10	6.83 ± 0.06	6.33 ± 0.06	<0.001
Magnesium (mg/100 g)	8.87 ± 0.06	8.70 ± 0.10	9.20 ± 0.10	9.07 ± 0.06	<0.001

Table 1: Physicochemical and Nutritional Characteristics of Imported (a1, a2) and Local (b1, b2) Watermelon Samples. Values are Mean ± Sd as Reported in the Source Study

3.2. Exploratory principal component analysis

The exploratory PCA separated the imported and local samples along the first principal component, which explained approximately 80.1% of the variance, while the second component explained approximately 15.7% (Figure 1). Local samples were positioned toward higher soluble solids, moisture and magnesium, whereas imported samples were associated more strongly with vitamins A and C. Calcium contributed particularly to the separation of B1. The PCA is descriptive because only the four group-level mean profiles were included.

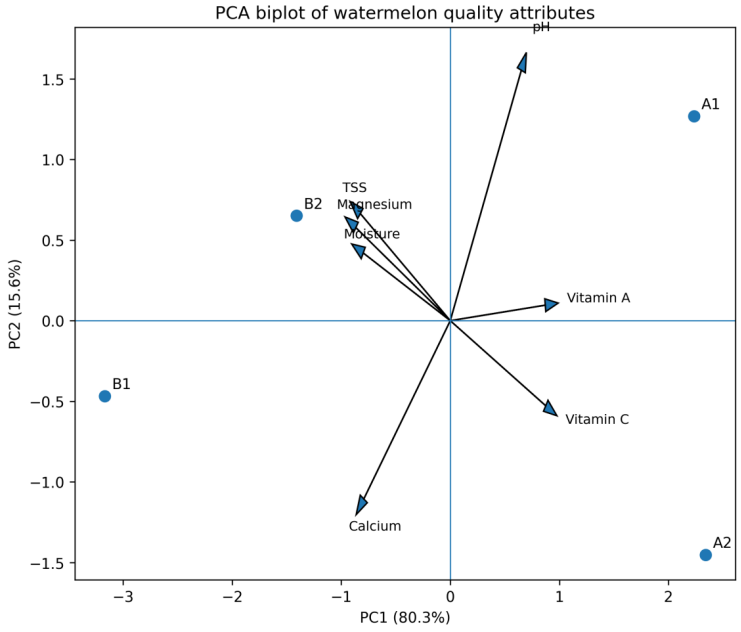


Figure 1: PCA Biplot of Physicochemical and Nutritional Quality Attributes of the Four Watermelon Sample Types

3.3. Sensory Profile

Reported sensory scores also differed among sample types (Table 2 and Figure 2). B1 obtained the highest juiciness score (5) and comparatively favorable taste and texture scores (4). A1 was characterized by the highest color score (5), whereas A2 had the highest aroma score (4). B2 scored relatively well for juiciness (4) but received the lowest color score (1) and a low texture score (2). These results indicate that no single sample dominated every sensory attribute.

Attribute	A1	A2	B1	B2
Aroma	3	4	2	3
Color	5	4	3	1
Taste	3	2	4	3
Juiciness	2	3	5	4
Texture	3	3	4	2

Table 2: Reported Sensory Scores on a Five-Point Scale. Higher Scores Indicate a More Favorable/Intense Attribute According to the Source Score Sheet

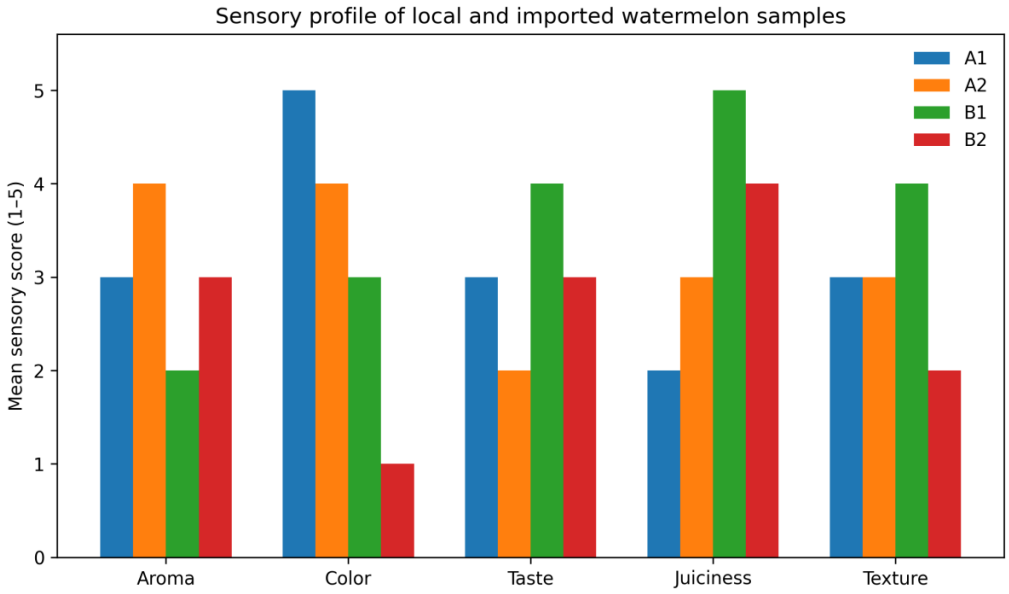


Figure 2: Sensory Profiles of Imported (a1, a2) And Local (b1, b2) Watermelon Samples

4. Discussion

The results show that local and imported watermelons marketed in Beni differ in complementary rather than uniformly superior ways. The local samples were richer in soluble solids and slightly richer in calcium and magnesium, whereas imported samples contained more vitamins A and C. Variation of this type is consistent with current watermelon research showing that fruit quality is strongly influenced by genotype, growing environment and their interaction [4,5]. Soluble solids are particularly sensitive to cultivar and maturity and are closely related to perceived sweetness, while vitamin C and carotenoid-related traits may vary independently among varieties [4,5].

The higher °Brix values of B1 and B2 suggest greater sweetness potential in the locally produced fruits. This agrees with the general role of soluble sugars in watermelon eating quality [4]. However, the sensory data also show that sweetness-related chemistry alone cannot fully explain consumer perception. B1 combined a high °Brix value with strong juiciness and favorable taste, but B2, despite the highest °Brix value, did not receive the strongest scores for all sensory traits. Watermelon acceptability depends on a combination of sweetness, aroma, flesh color, texture and juiciness, and these traits can vary independently [8,9].

The imported samples contained higher vitamin C and vitamin A equivalents. Differences in vitamin composition may reflect cultivar identity, maturity, preharvest conditions or handling after harvest. Watermelon is recognized as a source of vitamin C and carotenoid-related compounds, although concentrations vary substantially among cultivars and flesh colors [2,3,10,11]. Postharvest handling may further influence these nutrients: storage studies have shown that total ascorbic acid can decrease during extended storage, while other phytochemicals may follow different trajectories [6,7]. Because the present study did not standardize

preharvest conditions or transport duration between local and imported fruit, the observed vitamin differences should not be attributed to origin alone.

The calcium and magnesium concentrations reported here fall within the broad ranges described for watermelon pulp in recent nutritional reviews [3]. Their slightly higher values in local samples may be nutritionally relevant from a food-composition perspective, but the absolute differences were small. Similarly, the absence of a significant pH difference indicates that acidity was relatively comparable across the four sample types. This finding supports the interpretation that the stronger differentiation among samples was driven primarily by soluble solids, vitamins and minerals rather than pH.

The PCA provided a useful visual summary of these contrasting profiles, separating local samples toward moisture, soluble solids and magnesium and imported samples toward vitamins A and C. Nevertheless, the PCA was based on only four group-level profiles and should therefore be regarded as exploratory. A larger study with replicate-level multivariate data, cultivar identification and standardized maturity would provide a more robust assessment of nutritional clustering.

This study has several limitations. The sample size was small, cultivar identities were not genetically verified, and production, transport and storage conditions differed between local and imported fruit. Only a limited set of nutrients was measured, and important watermelon constituents such as lycopene, citrulline, potassium, phenolics and dietary fiber were not quantified. The sensory panel included 20 participants and the reported results were summarized on a five-point scale without a full inferential sensory model. Future work should increase the number of fruits and production sites, characterize maturity and storage history, include major bioactive compounds, and use standardized sensory protocols with replicate-level statistical analysis [12].

5. Conclusion

Locally grown and imported watermelons marketed in Beni showed distinct physicochemical, nutritional and sensory profiles. The local samples were generally characterized by higher moisture, higher total soluble solids and slightly higher calcium and magnesium, while imported samples contained more vitamins A and C. pH did not differ significantly among the four sample types. Sensory evaluation showed attribute-specific advantages rather than uniform superiority of one origin: B1 had the strongest juiciness score, A1 had the strongest color score, and A2 showed a favorable aroma score. These findings support the nutritional and sensory value of locally produced watermelon while also highlighting the vitamin contribution of imported fruit. Larger studies that control cultivar, maturity and postharvest history are needed before broad conclusions can be made about local versus imported watermelon quality in eastern Democratic Republic of the Congo.

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Conflict of Interest

The authors declare that they have no financial or non-financial competing interests that could have influenced the work reported in this manuscript.

Data Availability Statement

The datasets generated and analyzed during the current study, together with the relevant raw analytical data and laboratory records, are available from the corresponding author upon reasonable request.

Ethics Statement

Ethical approval for the study was provided by the Centre Interdisciplinaire de Recherche en Éthique (CIRE) of the Université Chrétienne Bilingue du Congo, Beni, under approval reference CNES 017/DPSK/322PP/2026. The study included a sensory evaluation of watermelon samples involving human participants. Before participation, all participants were informed about the purpose and procedures of the sensory evaluation, and their informed consent was obtained. Participation was voluntary, participants were free to withdraw at any time, and the confidentiality of their responses was maintained throughout the study.

Author Contributions

Patrick Mafikiri Bakwanamaha: Conceptualization, methodology, investigation, project administration, data interpretation, and writing – original draft. Synthia Ikembe Badjoko: Investigation, methodology, sample preparation, data collection, and writing – review and editing. Honoré Irenge Mitima: Methodology, laboratory analyses, validation, data interpretation, and writing – review and editing. Ortence Kazige Kanyere: Methodology, formal analysis, interpretation of results, and writing – review and editing. Jonathan Niyukuri, KARIKURUBU Jean Félix, and Parent KULIMUSHI: Formal analysis, data curation, validation, scientific interpretation, and writing – review and editing. All authors critically reviewed the manuscript, approved the final version, and agreed to be accountable for the accuracy and integrity of the work.

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