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ORIGINAL ARTICLE

Effect of Gas Flaring on the Proximate, Phytochemical and Vitamin Composition of Leaves and Tubers of Three Cassava (*Manihot esculenta* Crantz) Cultivars

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ABSTRACT

This study evaluated the proximate, phytochemical and vitamin composition of leaves and tubers of matured three cassava (*Manihot esculenta* Crantz) cultivars—BABA70, NR87/184 and TME 419—collected within 500 meters from farms within gas-flaring-impacted location in Ebedi community, Ukwuani Local Government Area, Delta State, and a comparison site in Umudike, Ikwuano Local Government Area, Abia State with a distance of 190km. Samples were analysed for proximate constituents, selected phytochemicals and vitamins using Official Methods of Analysis of AOAC International. Results from the study indicated that proximate composition showed a significant increase in the test area from the control ($p \leq 0.05$). Phytochemical concentrations in leaves also exhibited significant increases in the test area from the control ($p \leq 0.05$). Vitamins levels were lowered ($p \leq 0.05$) under gas flaring. Statistical analysis was made using Student's t-test at $P \leq 0.05$. A statistical program known as R Studio, 2026.01.0+392, version 2.30, was used for the analysis. Tidy verse package from R program was used for data visualization. Significance was accepted at the 5% probability ($p \leq 0.05$) and result shown as mean ± standard deviation.

Keywords: Gas flaring; *Manihot esculenta*; Proximate composition; Phytochemicals; Vitamin profile; Cultivar-dependent response.

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1.0 INTRODUCTION

Gas flaring is the combustion of associated natural gas during oil extraction and has been a persistent environmental concern in Nigeria's Niger Delta region. The environmental effects associated with flaring include the release of air pollutants and particulate matter, as well as localized changes in temperature and deposition on nearby land. Potential environmental consequences of gas flaring include emissions of sulphur oxides (SO_x), nitrogen oxides (NO_x), carbon monoxide (CO), hydrogen sulphide (H_2S) and particulate matter. Njoku-Tony *et al.,* (2020) reported effects associated with gas-flare emissions on biochemical variables in cassava leaves near the Utorogu Gas Plant. Cassava (*Manihot esculenta* Crantz) is an important tropical food crop cultivated primarily for its starchy storage roots. Its ability to grow under a range of conditions makes it an important crop for many smallholder farming systems (FAO, 2018). Previous research has examined the effects of gas flaring on cassava, like cassava plants grown closer to gas flare points exhibit decreased leaf dimensions, reduced tuber yields, and diminished starch and ascorbic acid content (Ishisone, 2004). Dada and Ogboru, 2024 observed that cassava tubers decreased in length and weight with decreasing distance from flares, correlating with reductions in starch and ascorbic acid (vitamin C) content. High soil temperatures around the flare point have been identified as the most likely cause of this retardation.

Despite earlier works on gas-flaring impacts, comparative information on the proximate composition, phytochemical profile and vitamin contents of different cassava cultivars and plant parts remains limited in the context addressed by this study. This study aimed to compare these parameters in leaves and tubers of three cassava cultivars—BABA 70, NR 87/184 and TME419—collected from a gas-flaring-impacted site and a comparison site. The study hypothesis was that measured composition would differ between sites and that the pattern of differences would vary by cultivar.

2.0 MATERIALS AND METHODS

2.1 Study site and experimental design

The study compared three cassava cultivars—BABA70, NR87/184 and TME419 harvested 500 meters away from a gas-flaring site in Ebedi community (5.8190° N latitude and 6.6721° E longitude) in Ukwuani Local Government Area, Delta State, and a comparison site in Umudike community (5.4722°N latitude and 7.5427°E longitude) in Ikwuano Local Government Area, Abia State. The distance from the flare site to the control site is 190km apart. The cassava samples were sourced from farmlands within the test and control sites. The samples were randomly selected and the analysis done three times for each parameter and the mean ± standard deviation was determined.

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2.2 Sample collection and preparation
Five different root and leaf samples were collected from each cultivar randomly at both the gas flaring and control sites. Samples were put in a clean container and transported to the laboratory for analysis. All analyses were performed in triplicate.

2.3 Proximate composition analysis
Proximate composition of the specified plant part(s) was determined using Association of Official Analytical Chemists (AOAC, 2019) methods. The parameters analysed were moisture, ash, crude fat, crude protein, crude fibre and carbohydrate.

2.4 Phytochemical analysis
Phytochemical concentrations of the specified plant part(s) was determined using Association of Official Analytical Chemists (AOAC, 2019) methods. The parameters analysed were alkaloids, flavonoids, tannins, saponins and phenolics.

2.5 Vitamin analysis
Vitamin concentrations in leaves and tubers of the specified plant part(s) was determined using Association of Official Analytical Chemists (AOAC, 2019) methods. The vitamins analysed are ascorbic acid (vitamin C), thiamine (B_1), riboflavin (B_2), niacin (B_3) and tocopherols (vitamin E).

2.6 Statistical analysis
The statistical analysis was carried out using Student T-test. A statistical program known as R Studio, 2026.01.0+392, version 2.30, was used for the analysis. Tidy verse package from R program was used for data visualization. Significance was accepted at the 5% probability ($p \leq 0.05$).The results were reported as the mean ± SD.

3.0 RESULTS

3.1 Result of proximate content in cassava tubers
The proximate composition of the tubers of the three cassava (*Manihot esculenta* Crantz) cultivars—BABA 70, NR87/184 and TME 419—was evaluated to determine variations between samples collected from the gas-flaring-impacted site and the control site. The parameters assessed included moisture, ash, crude fat, crude protein, crude fibre and carbohydrate contents. The results presented in Figure 1 illustrate the differences in proximate composition between the two locations and provide a basis for evaluating the variation in nutritional composition among the cassava cultivars under the study conditions. Data represent the mean ±SD of three independent measurements (n=3)

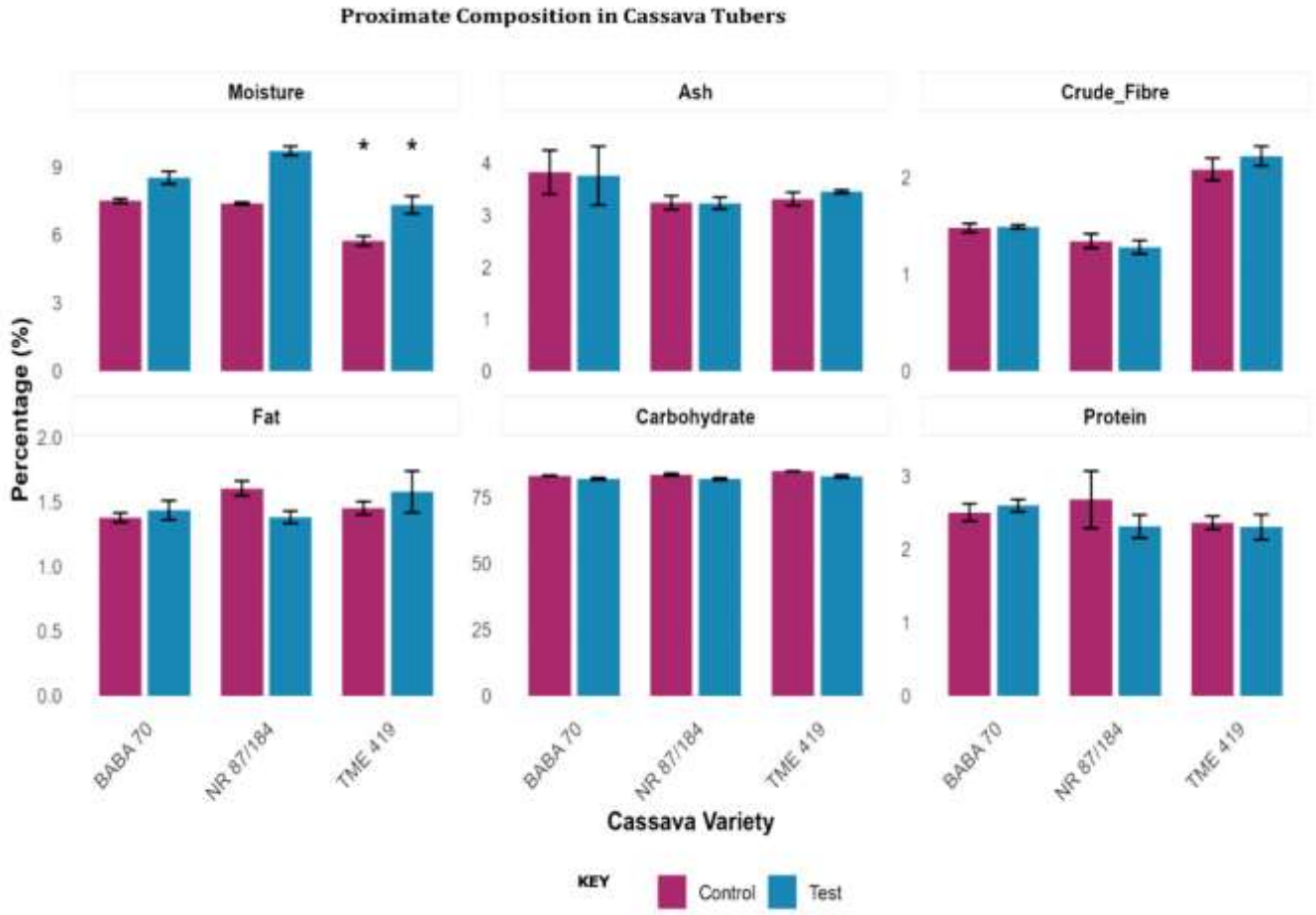


Figure 1: *presents the proximate composition of the tubers of three cassava (Manihot esculenta Crantz) cultivars—BABA 70, NR87/184 and TME 419—collected from the gas-flaring-impacted and control sites. The parameters assessed were moisture, ash, crude fat, crude protein, crude fibre and carbohydrate contents. The results indicate differences in the proximate composition of cassava tubers between the two locations, with the overall findings showing a significant increase in proximate composition in samples from the gas-flaring-impacted site compared with the control ($p \leq 0.05$). The observed variations suggest that the response to gas-flaring exposure may differ among the cultivars and the individual nutritional parameters. Data represent the mean ± SD of three independent measurements ($n = 3$).*

3.2 Result of phytochemical content in cassava leaves and tubers
The phytochemical composition of the leaves and tubers of BABA 70, NR87/184 and TME 419 was assessed to compare the concentrations of selected bioactive constituents in cassava samples obtained from the gas-flaring-impacted and control sites. The phytochemicals analysed included alkaloids, flavonoids, tannins, saponins and phenolics. Figure 2 presents the phytochemical composition of the cassava leaves, while Figure 3 shows the corresponding composition of the tubers. These comparisons illustrate the distribution of the investigated phytochemicals across the three cultivars and the two sampling locations**.** Data represent the mean ±SD of three independent measurements (n=3).

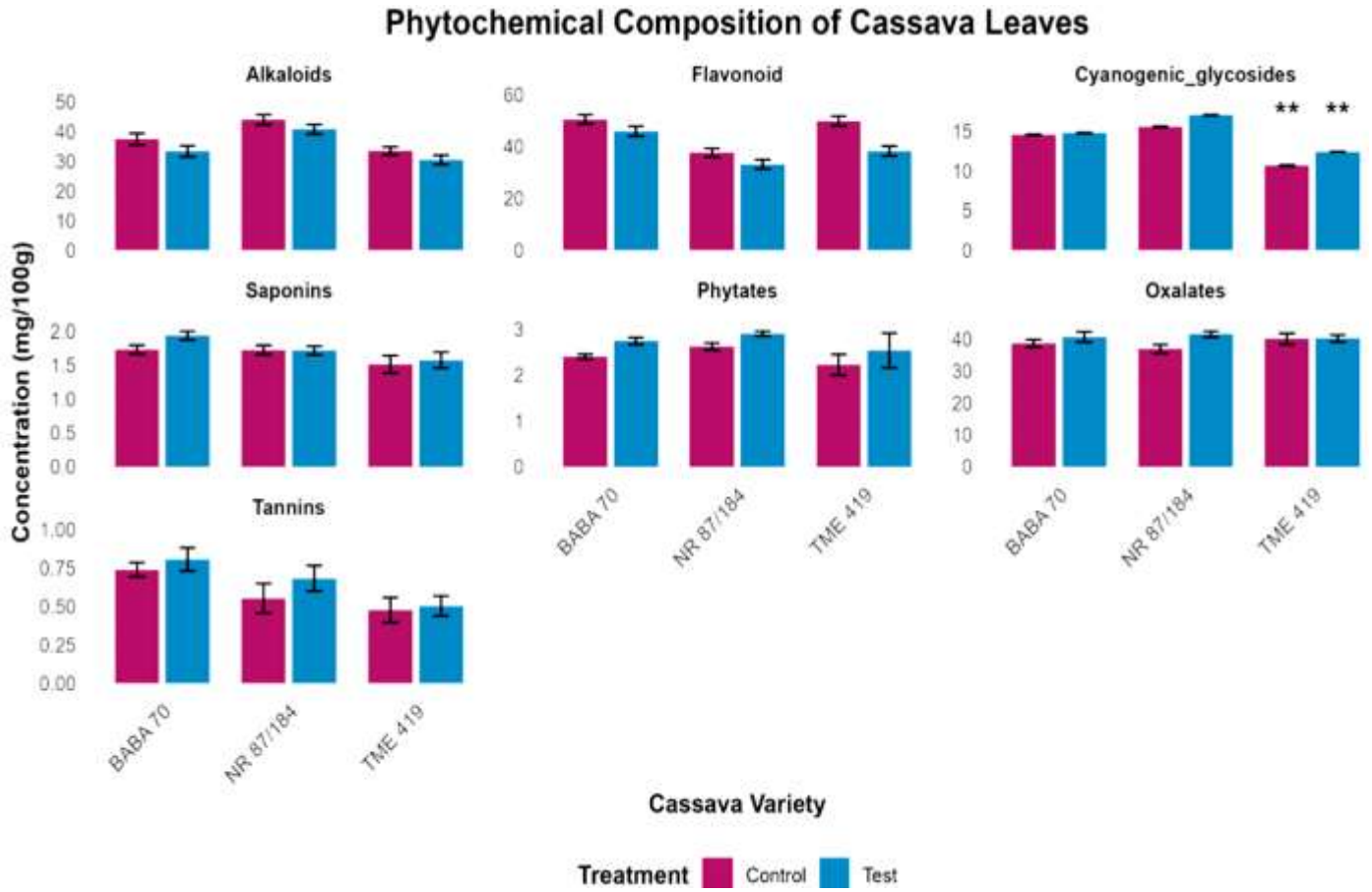


Figure 2: *shows the phytochemical composition of the leaves of BABA 70, NR87/184 and TME 419 obtained from the gas-flaring-impacted and control sites. The phytochemicals evaluated included alkaloids, flavonoids, tannins, saponins and phenolics. The results indicated differences in the concentrations of these bioactive compounds between the two locations. Overall, the study findings showed significantly higher phytochemical concentrations in cassava leaves from the gas-flaring-impacted site compared with the control ($p \leq 0.05$). These variations suggest that exposure to gas flaring may influence the accumulation of phytochemicals in cassava leaves. Data represent the mean ±SD of three independent measurements (n=3)*

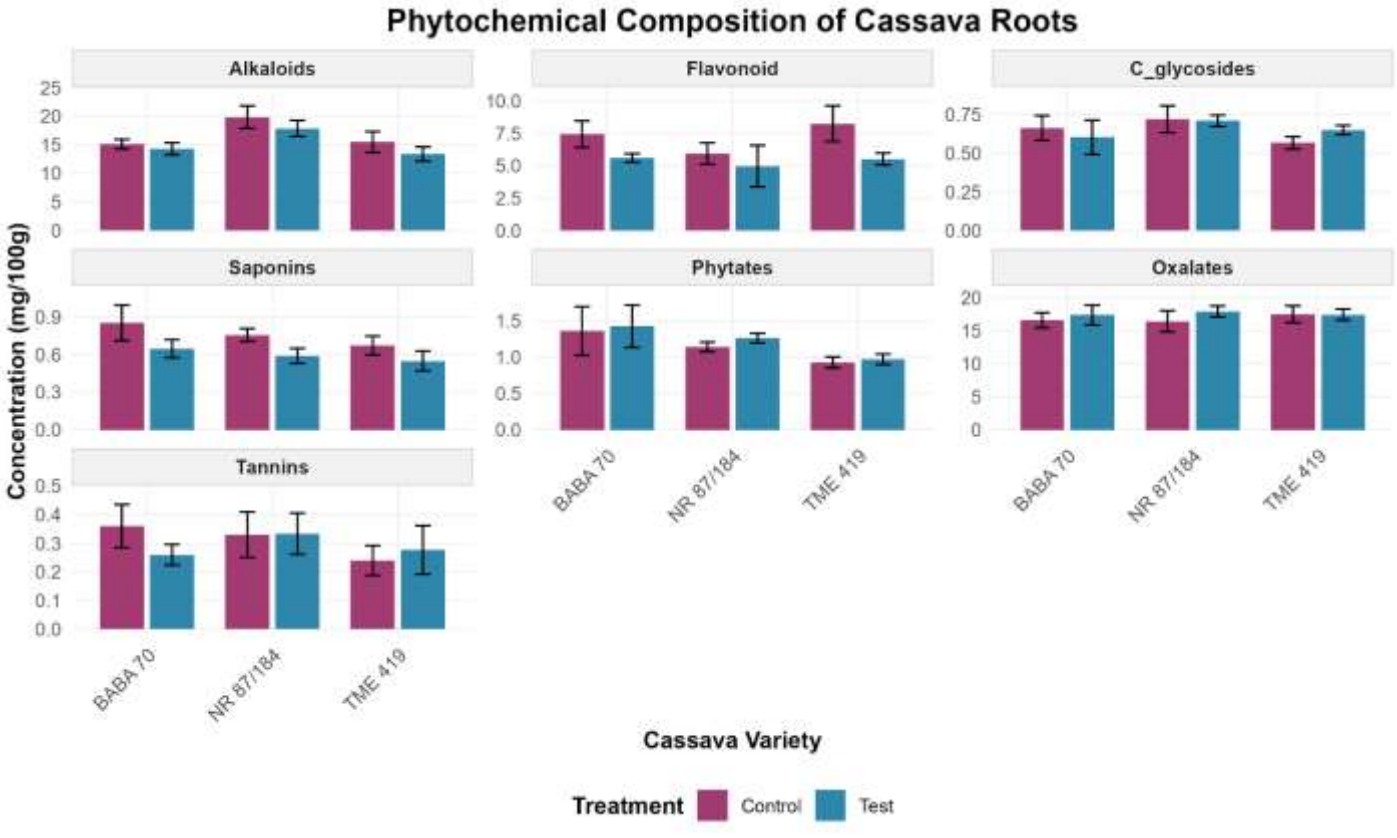


Figure 3: *illustrates the phytochemical composition of the tubers of the three cassava cultivars collected from the gas-flaring-impacted and control sites. The analysis focused on alkaloids, flavonoids, tannins, saponins and phenolics. The results revealed variations in the phytochemical profiles of the tubers across the cultivars and sampling locations. The study findings indicated that gas-flaring exposure was associated with changes in phytochemical concentrations, with some compounds showing increases and others decrease relative to the control. These differences suggest that the effects of gas flaring on phytochemical composition depend on both the specific compound and the cassava cultivar. Data represent the mean ±SD of three independent measurements (n=3)*

3.3. Result of vitamin content in cassava leaves and tubers

The vitamin composition of the cassava tubers and leaves was analysed to evaluate differences in the nutritional profiles of the three cultivars sampled The vitamin composition of the tubers and leaves of the three cassava (*Manihot esculenta* Crantz) cultivars (BABA 70, NR87/184 and TME 419) was investigated to determine the effect of gas flaring on their vitamin contents. The vitamins analysed included ascorbic acid (vitamin C), thiamine (vitamin B_1), riboflavin (vitamin B_2), niacin (vitamin B_3) and tocopherols (vitamin E). The results presented in Figure 4 show the vitamin composition of cassava tubers collected from the gas-flaring-impacted and control sites, while Figure 5 presents the vitamin composition of the corresponding cassava leaves. The comparison provides insight into variations in vitamin levels between the two sampling locations and among the three cassava cultivars. Overall, the findings indicate that exposure to gas flaring was associated with reduced vitamin levels in the cassava samples compared with those from the control site. Data represent the mean ±SD of three independent measurements (n=3).

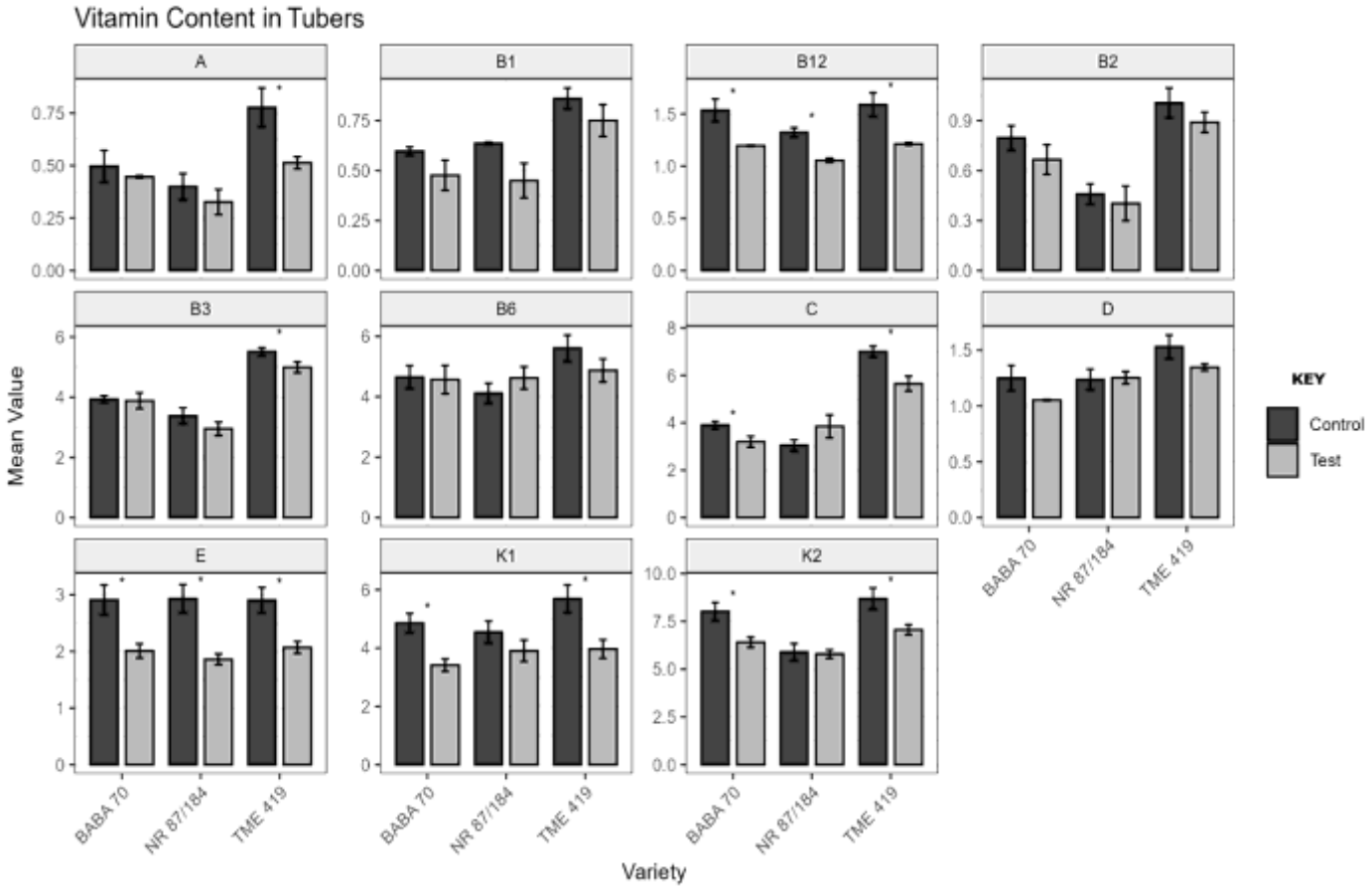


Figure 4: *presents the vitamin composition of the tubers of BABA 70, NR87/184 and TME 419 collected from the gas-flaring-impacted and control sites. The vitamins analysed were ascorbic acid (vitamin C), thiamine (vitamin B_1), riboflavin (vitamin B_2), niacin (vitamin B_3) and tocopherols (vitamin E). The results indicate differences in vitamin levels between the two sampling locations. Overall, the study findings showed that vitamin levels were significantly lower in cassava samples from the gas-flaring-impacted site than in those from the control site ($p \leq 0.05$). This reduction suggests that exposure to gas flaring adversely affected the vitamin composition and nutritional quality of cassava tubers. Data represent the mean ±SD of three independent measurements (n=3)*

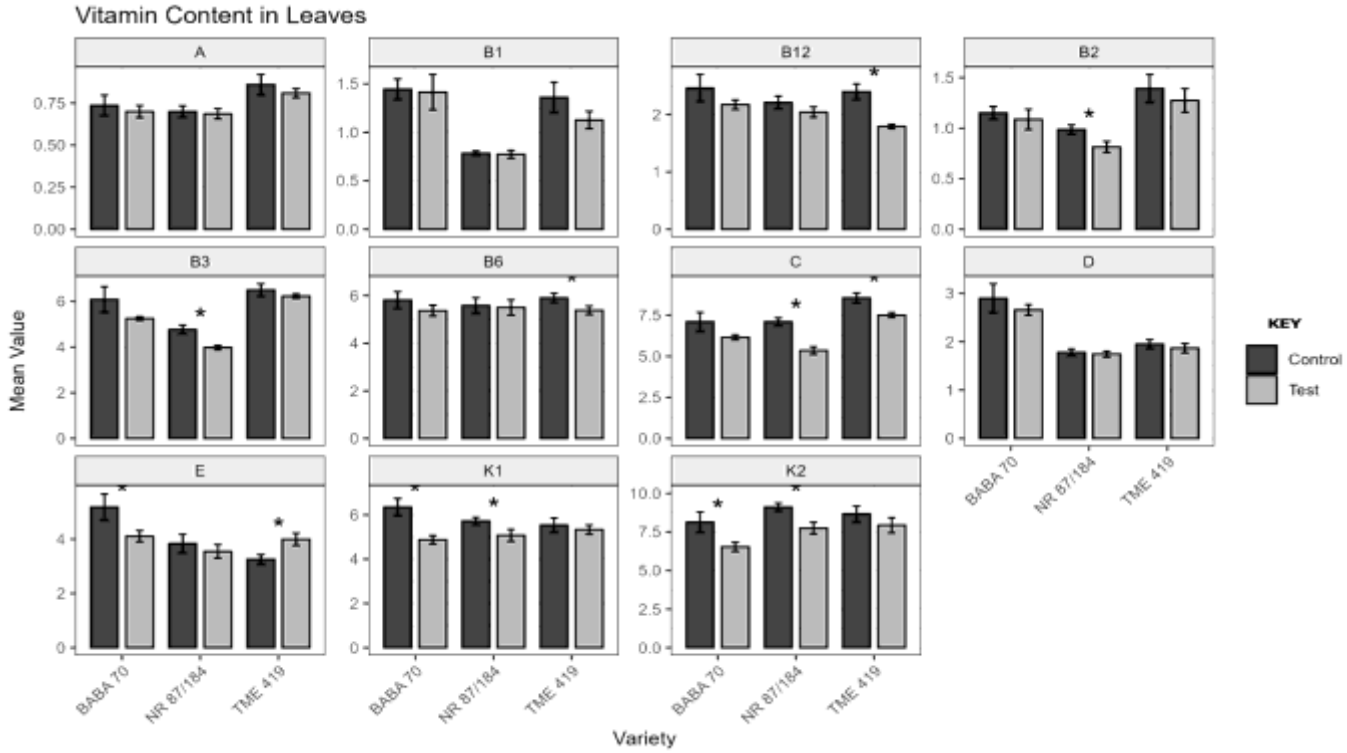


Figure 5: *presents the vitamin composition of the leaves of the three cassava cultivars collected from the gas-flaring-impacted and control sites. The vitamins assessed included ascorbic acid (vitamin C), thiamine (vitamin B_1), riboflavin (vitamin B_2), niacin (vitamin B_3) and tocopherols (vitamin E). The results show differences in the vitamin profiles of the leaves between the two locations. In line with the overall findings of the study, vitamin levels were lower in samples from the gas-flaring-impacted site than in those from the control site ($p \leq 0.05$). These findings suggest that gas-flaring exposure compromised the vitamin content of cassava leaves and potentially reduced their nutritional contribution. Data represent the mean ±SD of three independent measurements (n=3)*

4.0 DISCUSSION

The effect of gas flaring on cassava roots from cultivarsBABA70, NR87/184,and TME419 revealed cultivar-dependent variations in proximate constituents under gas flaring stress. Significant differences ($p \leq 0.05$) were observed in several proximate parameters when compared with control samples, as indicated by the superscript "*" notation. These findings are consistent with earlier observations by Lawanson *et al.,*1984 who reported decreased starch contentin cassavatubersfromgasflare-impacted area.Theobservedalterationsin proximate composition likely reflect the physiological stress imposed by elevated temperatures, pollutant exposure, and altered soil conditions associated with gas flaring activities (Ishisone, 2004). There sults significantly altered phytochemical profiles in both tubers and leaves, with cultivar-specific responses observed. Some phytochemicals showed significant increases or decreases ($p \leq 0.05$) under gas flaring conditions compared with controls. These alterations may reflect adaptive metabolic responses to oxidative stress induced by air pollutants, including SO_x, NO_x, and CO. The results significantly affected vitamin profiles in both plant parts. Notably, ascorbic acid (vitamin C) content was affected, corroborating previous findings that cassava grown closer to gas flares exhibits decreased ascorbic acid concentrations (Lawanson et al., 1984). Dada & Ogboru (2024) similarly reported that ascorbic acid contents in crops from polluted sites varied seasonally. There duction in vitamin content under gas flaring stress has significant implications for the nutritional quality of cassava as a staple food, particularly in communities where cassava constitutes a major dietary component. The cultivar-dependent nature of these responses suggests that genetic selection for stress-tolerant varieties could mitigate some of the adverse effects of gas flaring on cassava production. The broader implications of these findings extend beyond cassava cultivation to food security and public health in the Niger Delta region. Gas flaring not only reduces crop yields but also compromises the nutritional quality of staple foods, potentially exacerbating malnutrition in vulnerable populations. As noted by Dada & Ogboru (2024), crops grown in gas flaring areas exhibit sensitive traits to air pollutants and can serve as bio-monitors of abiotic pollution. This is similar to findings by Iyorah-Elliot and Olayinka (2026) and Ivie *et al*., (2022) of possible contamination of non contaminated areas as a result of exposure to high contaminant areas.

Conclusion

This study examined the proximate composition, phytochemical profile and vitamin content of leaves and tubers of three cassava cultivars sampled at a gas-flaring-impacted site and a comparison site. Significant alterations were observed in proximate constituents, phytochemical profiles and vitamin content concentrationsunder gas flaring conditions. The reductions in starch, vitamins and ascorbic acid are of particular concern given their implications for food quality, nutritional security, and crop productivity.

It is recommended that environmental regulatory agencies and oil exploration companies intensify efforts to reduce gas flaring through the implementation of gas capture and utilization technologies, as well as the enforcement of stricter emission standards. Further research is warranted to elucidate the molecular mechanisms underlying cultivar-specific stress responses and to develop comprehensive strategies for mitigating the agricultural impacts of gas flaring in affected communities.

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Conflict of interest

The authors declare that they have no conflicts of interest regarding the research, authorship, or publication of this article.

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