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Impact of fruit wastes and rates on nutritional and phytochemical compositions of okra (*Abelmoschus esculentus* L.) in Ogbomoso and Oyo town, Oyo state, Nigeria

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Abstract

The study examined the effect of fruit waste types and rates on the mineral, nutritional and phytochemical composition of okra at Lautech Teaching and Research Farms of Ladoke Akintola University of Technology, Ogbomoso, and Federal College of Education (Special), Oyo. The treatments involved three waste types namely: cocoa pod, orange and plantain waste and five rates of application: 0, 25, 50, 75, and 100 kg N/ha. The factorial experiments were laid out in a Randomized Complete Block Design (RCBD) with three replicates. Seeds were sown two weeks after treatments application and agronomic practices such as weeding, thinning, control of pest and diseases were carried out to ensure optimum yield. Data obtained on mineral, nutritional and phytochemical compositions were subjected to the analysis of variance and the means were separated using least significant difference (LSD) at 5% probability level. The result revealed that location, fruit waste type and rate had significant ($p \leq 0.05$) effect on the mineral, nutritional and phytochemical compositions of okra. The mineral, nutritional and phytochemical compositions of okra were higher at Ogbomoso than Oyo. Cocoa waste gave highest crude fiber (21.17%), gross energy (283.19kcal), vitamin C (41.16g/100 g) contents as compared to plantain and orange wastes. Application of 75 kg N/ha gave highest calcium, organic matter and crude protein (583.61g/100 g, 88.80% and 23.01%) while control recorded the least. Therefore, sole application of 75 kg N/ha and cocoa pod waste and their combinations can be recommended for optimum mineral, nutritional and phytochemical compositions of okra in both locations.

Keywords: Okra, application rate, fruits waste, nutritional quality, phytochemical compositions, two locations

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench), also called lady's finger is believed to have originated in Ethiopia and is cultivated mainly for its tender, edible pods. Worldwide, okra is grown on nearly 2 million hectares, with an annual production of about 10 million tons. India ranks as the top producer, yielding approximately 6 million tons of fresh okra, while Nigeria follows with a production of around 2 million tons (Tiamiyu *et al.*, 2012) ^[19].

Scientific research recognizes okra plants because they provide three major health benefits through their anti-diabetic effects and anti-cancer properties together with anti-inflammatory capabilities. Multiple antioxidant and anti-cancer properties together with anti-inflammatory benefits exist in okra as a result of its phenolic compound abundance (Woumbo *et al.*, 2022) ^[20]. Large amounts of the phenolic compound's quercetin derivatives, catechin oligomers and hydroxycinnamic derivatives can be found in both okra pods and seeds. As per Woumbo *et al.*, 2022 ^[20] the vitamin C (ascorbic acid) and vitamin A (beta-carotene) found in fresh okra pods function as antioxidants whereas they provide cancer protection.

Organic fertilizer emerged from fruit wastes which form sustainable economic agricultural by products because of their organic nature. These materials, such as plantain wastes, orange wastes, pineapple residues, and cocoa pods and so on, are rich in essential nutrients that enhance soil fertility and promote better crop growth. The utilization of waste materials minimized environmental waste while promoting sustainability in farming practices.

The application of organic fertilizers derived from fruit wastes has been shown to enhance the nutritional quality of okra by increasing its essential nutrient content (Adekiya *et al.*, 2020) [2]. Plant development and fruit formation benefit from okra fertilized with fruit waste-based additives such as plantain residues because studies show these fertilizers enhance potassium and calcium content (Nweke *et al.*, 2020) [14]. The research by Ibraheem *et al.* (2022) [10] showed cocoa pod compost application increased vitamin A and C in grown okra which improved its nutritional content. Research has not sufficiently explored the optimization of the okra nutritional value through environmentally friendly fertilizer implementation.

In spite of the aforementioned growth promoting potentials of fruit wastes, there is scanty information on appropriate rates of fruit waste and its effects on okra performance. Therefore, it becomes imperative to assess the influence of fruit wastes and rates on mineral, nutritional and phytochemical compositions of okra in Ogbomoso and Oyo, Oyo State, Nigeria.

Materials and Methods

The experiments were carried out at the Teaching and Research Farm of Ladoke Akintola University of Technology, Ogbomoso, and the Research Farm of the Federal College of Education (Special), Oyo. Both locations fall within Nigeria's Guinea Savanna agro ecological zone. Ogbomoso is situated at a latitude of 8°10'N and a longitude of 4°10'E, with temperatures ranging from a minimum of 28°C to a maximum of 33°C, and an annual rainfall exceeding 1000mm (Olaniyi, 2006) [17]. The city of Oyo exists at 7°51'13.2''N 3°55'56.5''E where it encounters an equatorial climate which reveals wet and dry seasons together with significant relative humidity. The daily average temperature in Oyo typically varies between 25 °C and 35°C throughout the year (Geodatos, 2024) [9].

Sources of wastes, preparation for application and their nutrient contents were as reported by Kareem and Olaniyi (2025) [11]. Orange and plantain wastes were collected from the Owode open market in Oyo town, while cocoa pods were obtained from Ibafor village in Ogbomoso. The LD88 variety of okra, known for its excellent growth and yield performance (Akintokun *et al.*, 2019) [5], was procured from the National Horticultural Research Institute in Idi Ishin, Ibadan, Oyo State. To ensure purity, the collected wastes were manually sorted to remove impurities and then dried on a concrete floor for two weeks to reduce moisture content

and extend shelf life. The dried wastes were milled into a powder using a small feed pellet plant equipped with a 600-1000 KG/H milling machine to increase the surface area for better utilization, and subsequently stored at room temperature (Mercy *et al.*, 2014) [12]. The powdered fruit wastes were analyzed at the Institute of Agricultural Research and Training (IAR&T) in Ibadan to assess their nitrogen, phosphorus, and potassium composition. The result of the analysis is presented in Table 1.

Table 1: Result of nutrient components of the fruit wastes type

Parameters determined	Orange waste (%)	Plantain waste (%)	Cocoa waste (%)
Nitrogen	0.26	0.70	1.55
Phosphorus	7.54	8.94	9.84
Potassium	18.69	89.17	47.85
Calcium	52.95	58.20	29.65
Magnesium	0.74	0.79	1.81

Source: Kareem and Olaniyi, (2025) [11]

The treatments consisted of two locations, three types of fruit waste namely: (cocoa pod, plantain and orange waste), and five nitrogen application rates: 0, 25, 50, 75, and 100 kg N/ha. (Amina *et al.*, 2023), resulting in a total of 30 treatment combinations. The experimental site was manually cleared and a total land area measured 32m × 5.6m was used. This was subdivided into three replicates, each containing 15 beds of 1.2m x 1.2m size and separated by a 1m spacing between and within the replicates. The 2 × 3 × 5 factorial experiment was laid out into a Randomized Complete Block Design (RCBD) with three replications.

The treatments were applied to the respective plots two weeks before sowing and seeds were sowed at a spacing of 50cm × 50cm. Regular agronomic practices such as weeding, thinning, and pest and disease management were carried out to enhance okra performance. Mature table-size okra fruits were harvested, dried, and analyzed in the laboratory to determine their nutritional, antioxidant, and proximate compositions.

Statistical Analysis

Data collected were analyzed using analysis of variance with the aid of Genstat 5.2 and significant means were separated using least significant difference (LSD) at 5% probability level.

Results and Discussion

Table 2: Main and interaction effects of location, waste type and rate on anti-oxidant compositions of okra

Anti- Oxidant compositions						
Treatment	VIT.C g/100 g	VIT.E g/100 g	Polyphenol g/100 g	Carotenoid g/100 g	Flavonoid g/100 g	Isoquertcin g/100 g
Location						
Ogbomoso	40.94	0.06	0.16	0.02	0.28	0.03
Oyo	31.74	0.06	0.15	0.01	0.26	0.01
LSD ($p \leq 0.05$)	0.10	0.02	0.03	0.01	0.04	0.02
Waste type						
Cocoa	41.16	0.06	0.16	0.02	0.27	0.02
Orange	33.27	0.06	0.16	0.01	0.26	0.01
Plantain	34.60	0.06	0.15	0.01	0.27	0.02
LSD ($p \leq 0.05$)	0.13	0.03	0.04	0.02	0.01	0.02
Waste rate						
0	27.62	0.05	0.14	0.00	0.25	0.01
25	34.83	0.06	0.15	0.02	0.27	0.01
50	36.41	0.06	0.15	0.02	0.27	0.02

75	39.81	0.06	0.16	0.02	0.28	0.02
100	43.05	0.06	0.18	0.02	0.28	0.02
LSD ($p \leq 0.05$)	0.16	0.04	0.05	0.03	0.01	0.03
Interaction						
L X WT	0.18	0.05	0.05	0.03	0.01	0.03
L X WR	0.23	0.06	0.07	0.04	0.01	0.04
WT X WR	0.28	0.08	0.09	0.05	0.01	0.05
L X WT X WR	0.40	0.01	0.01	0.07	0.02	0.08

LSD ($p \leq 0.05$)

The main and interaction effect of location, waste type and rate, and various interaction on anti-oxidant compositions of okra fruit is shown in table 2. Location had significant ($p \leq 0.05$) influence on anti-oxidant compositions of okra. Ogbomoso, recorded highest vit. C, polyphenol, carotenoid, flavonoid and isoquertin (40.94, 0.16, 0.02, 0.28 and 0.03 g/100 g) components while oyo gave the least values. Both locations had the same value (0.06 g/100 g) of vitamin E. The significant higher concentrations of vitamin C, polyphenols, carotenoid, flavonoids, and isoquercetin obtained from Ogbomoso okra fruits as compared to okra fruits from Oyo, underscore the potential nutritional superiority of Ogbomoso okra, which might be attributed to genetic, environmental, or agronomic factors specific to the region.

Vitamin C functions as an essential antioxidant in human body which helps with immune responses as well as collagen production and iron utilization (Ahmed *et al.*, 2022) [4]. The increased vitamin C content in Ogbomoso okra fruits makes them an attractive dietary option for protecting against oxidative stress and health improvement. Vitamin C is a vital antioxidant substance that supports immunity and builds collagen fibers and helps your body absorb iron (Ahmed *et al.*, 2022) [4]. The high vitamin C content in Ogbomoso okra fruits indicates this variety could serve as an excellent nutritional source to fight oxidative stress and enhance general health.

Plants treated with Cocoa waste recorded highest Flavonoid, Isoquertcin, vitamin C, polyphenol and carotenoid values of 0.27, 0.02, 41.16, 0.16 and 0.02 respectively. Cocoa, Orange and Plantain waste gave the same Vit. E value (0.06.). The research proved that various types of organic fertilizer affect okra phytochemical composition through their impacts on nutritional and functional properties.

Data shows that okra treated with cocoa waste contains significantly greater vitamin C amounts which indicates its capability to strengthen antioxidant mechanisms. The

identical flavonoid along with isoquercetin content between cocoa fertilizer and plantain fertilizer shows these treatments may produce comparable effects during compound biosynthesis. These organic wastes from cocoa orange and plantain display a consistent effect on fat-soluble vitamin E levels present in treated okra because this antioxidant supports membrane protection and skin health (Oluwafemi *et al.*, 2020) [16]. The research shows cocoa waste provides better outcomes than other waste materials when it comes to improving the nutritional features in okra products mainly for vitamin C and polyphenols and carotenoids. Plantain and orange waste provided similar advantages to the tested phytochemicals along with vitamin E and flavonoids. Application of 100kgN/ha recorded highest highest vit. C., polyphenol and flavonoid values (43.05, 0.18 and 0.28 respectively) while control gave the least values. Study results show that the maximum phytochemical values for vitamin C polyphenols and flavonoids occur at the 100 kg N/ha waste rate which proves that adequate nutrient supply enables optimal okra antioxidant potential. Research findings show that homeostasis occurs with vitamin E and the shared isoquercetin amounts at 50% 75% and 100% because some nutrients reach their biosynthetic saturation point (Oluwafemi *et al.*, 2020) [16].

There is no meaningful variation in vitamin E content at waste rates increasing from 25 to 100kgN/ha because the biosynthesis of this fat-soluble antioxidant appears to have reached its maximum levels. Results by Oluwafemi *et al.* (2020) [16] demonstrate that vegetables reach vitamin E stabilization when excess nutrient thresholds are exceeded. Analysis of the 0kgN/ha control condition demonstrates that fertilizer acts as a key factor for developing superior nutritional values and functional properties in okra. The research findings agree with past studies demonstrating how fertilizer application enhances vegetable phytochemical content (Adetunji *et al.*, 2018; Ekanem *et al.*, 2019) [2, 8].

Table 3: Main and interaction effect of location, waste type and rate on mineral compositions of okra

Mineral compositions						
Treatment	calcium	Iron	Potassium	Sodium	Phosphorus	Zinc
	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g
Location						
Ogbomoso	584.91	1.98	1457.50	71.85	71.69	1.70
Oyo	558.30	1.81	1481.70	74.69	62.06	1.67
LSD ($p \leq 0.05$)	0.47	0.02	4.73	0.43	0.81	0.04
Waste type						
Cocoa	570.25	2.07	1472.90	77.56	68.93	1.70
Orange	580.30	1.77	1474.70	68.22	65.69	1.67
Plantain	564.26	1.83	1461.10	74.03	66.00	1.69
LSD ($p \leq 0.05$)	0.57	0.02	5.80	0.53	1.00	0.01
Waste rate (KgN/ha)						
0	549.76	1.69	1438.60	63.83	56.81	1.58
25	574.25	1.85	1458.30	73.68	68.85	1.69
50	572.58	1.92	1463.40	76.01	67.19	1.70

75	583.61	1.98	1477.60	75.74	69.29	1.74
100	577.83	2.02	1510.00	77.08	72.23	1.73
LSD ($p \leq 0.05$)	0.74	0.03	7.48	0.69	1.29	0.01
Interaction						
L X WT	0.81	0.03	8.20	0.75	1.41	0.01
L X WR	1.04	0.04	10.58	0.97	1.82	0.01
WT X WR	1.27	0.05	12.96	1.19	2.23	0.01
L X WT X WR	1.80	0.07	18.33	1.68	3.15	0.02

The mineral compositions of okra fruits as significantly ($p \leq 0.05$) influenced by location, fertilizer type and rate, and various interaction effects. is presented in table 3. In Ogbomoso, the highest calcium (584.91 mg/100 g), iron (1.98 mg/100 g), phosphorus (71.69 mg/100 g) and zinc (1.70 mg/100 g) were recorded, but Oyo had potassium (1457.50 mg/100 g) and sodium (74.69 mg/100 g) contents. In Ogbomoso, lowest values (1457.50 mg/100 g and 71.85 mg/100 g) for potassium and sodium respectively were noted Ogbomoso okra contains higher mineral contents which supports its overall advantageous nutritional value because of its superior antioxidant components. This reinforces the potential of Ogbomoso okra as a more mineral rich dietary source (Adebayo *et al.*, 2020) [1].

Research indicates that Oyo okra is suitable for electrolyte replenishment because its elevated potassium and sodium levels support essential nerve signaling and fluid balance functions and muscle performance (Ekanem *et al.*, 2019) [8]. A minor elevation of sodium in Oyo okra should be considered by individuals dealing with hypertension while other consumers can incorporate it freely. The complex relationship between fertilizer use and geographic zone helps to explain how environmental elements affect the content of both minerals and phytochemicals found in okra Plants treated with Orange recorded highest value for calcium (580.30 mg/100 g), and potassium (1474.50 mg/100 g) while cocoa produced highest value of iron (2.07

mg/100 g), sodium (77.56 mg/100 g), phosphorus (68.93 mg/100 g) and zinc (1.70 mg/100 g). Orange fertilizer contains elevated potassium and calcium concentrations which demonstrate its ability to enhance nutritional value in okra so plants obtain necessary elements that support bones plus electrolyte maintenance. The essential nutrients potassium and calcium together contribute to blood pressure regulation along with nerve function and muscle contraction while calcium remains vital for healthy bones and teeth development and enzymatic processes (Adebayo *et al.*, 2020) [1].

The increased micronutrient content in okra caused by cocoa fertilizer treatment was attributed to its elevation of both sodium and zinc as well as phosphorus and iron amounts. The process of hemoglobin synthesis requires iron and its transport of oxygen through the body depends on this element but zinc is vital for immune health and proper functioning of enzymes. The vital functions of maintaining fluid balance along with energy metabolism result from sodium alongside phosphorus in the human body (Ekanem *et al.*, 2019; Oluwafemi *et al.*, 2020) [8, 16]. Application rate of 100 kg N/ha recorded highest value for potassium (1510 mg/100 g), sodium (77.08 mg/100 g) and phosphorus (72.23 mg/100 g) but not significantly different from that of 75 kg N/ha which also recorded highest calcium (583.61) and zinc (1.74) contents. The least value of all the mineral components were produced at 0kgN/ha application.

Table 4: Main and interaction effects of Location, waste type and rate on the proximate compositions of okra

Proximate Compositions							
Treatment	Organic Matter (%)	Ash (%)	Fat (%)	Moisture Content (%)	Crude Fibre (%)	Crude Protein (%)	Gross Energy(kcal)
Location							
Ogbomoso	88.66	7.09	2.77	11.33	21.07	21.40	282.03
Oyo	88.19	6.38	2.16	11.81	19.69	20.90	280.37
LSD ($p \leq 0.05$)	0.07	0.01	0.03	0.09	0.05	0.02	0.21
Waste type							
Cocoa	88.38	6.56	2.71	11.49	21.17	21.46	283.19
Orange	88.52	6.90	2.22	11.49	19.82	20.37	282.07
Plantain	88.37	6.75	2.47	11.72	20.15	21.62	278.33
LSD ($p \leq 0.05$)	0.09	0.01	0.04	0.11	0.06	0.02	0.25
Waste rate (KgN/ha)							
0	87.66	6.21	2.29	12.15	19.68	16.65	271.15
25	88.61	6.76	2.47	11.41	19.88	21.67	279.67
50	88.62	6.95	2.43	11.39	19.94	21.77	280.61
75	88.80	6.92	2.48	11.31	21.03	23.01	286.42
100	88.44	6.84	2.66	11.57	21.37	22.66	288.14
LSD ($p \leq 0.05$)	0.12	0.01	0.01	0.14	0.08	0.03	0.33
Interaction							
L X WT	0.13	0.01	0.01	NS	0.09	0.03	0.36
L X WR	0.17	0.02	0.01	0.20	0.11	0.04	0.46
WT X WR	0.20	0.12	0.01	0.25	0.14	0.05	0.57
L X WT X WR	0.29	0.03	0.01	0.35	0.19	0.08	0.08

The sole effect of location, waste type and rate and their interaction had significant ($p \leq 0.05$) influence on proximate compositions of okra as shown in Table 4. At Ogbomoso, highest organic matter (88.66), Ash (7.09), Fat (2.77), Crude

fiber (21.07), Crude protein (21.40) and Gross energy (282.03) contents while Oyo gave the least values except for moisture content (11.81). This may be attributed to regional environmental factors and growing conditions that influence

water retention in the plant. This research confirms previous scientific studies about how geographical factors influence chemical contents in okra plants. The nutritional profile of vegetables depends heavily on three essential factors which include soil quality and climatic conditions together with agronomic practices according to research by Adebayo *et al* (2020) ^[1]. The nutrient levels measured in Ogbomoso okra surpass levels in other locations because the plant-growing conditions in the area effectively enhance the nutritional properties of this vegetable according to Owoade *et al* (2019) ^[18]. Plants treated with Orange waste gave the highest Organic matter (88.52) and Ash (6.90) contents, followed by Cocoa waste which recorded the highest Fat (2.71), Crude fibre (21.17) and Gross energy (283.19) contents while Plantain waste recorded the highest for moisture (11.72) and Crude protein (21.62) contents. The result of this findings may be attributed to time required by the individual fruit waste to decomposed and absorbed by the crop.

Application of 100 kg N/ha gave the highest record for Fat (2.66), Crude fibre (21.37) and Gross energy (288.14) contents, followed by 75 kg N/ha which gave the highest Organic matter (88.80) content while 0 kg N/ha recorded lowest values for all proximate components of okra except for moisture contents. Additional nutrients induced by complete fertilizer utilization result in increased caloric value of okra plants according to Oluwafemi *et al.* (2020) ^[16]. The research showed that fertilizer quantity directly affected okra nutrition levels because the 75% fertilizer application produced maximum organic matter (88.80%) alongside crude protein (21.62%). Soil fertility and nutrient availability together with water maintenance depend on organic matter because it stands as a fundamental soil component (Adebayo *et al.*, 2020) ^[1].

Conclusion

The result showed that location, fruit waste type and rate and interaction effects had significant ($p \leq 0.05$) influence on the anti-oxidants, nutritional and proximate compositions of okra. Therefore, it can be concluded that Cocoa waste gave the highest nutritional and phytochemical composition of okra, while orange waste recorded the least values in both locations. The application of 75 kg N/ha rate irrespective of waste type gave optimum nutritional and phytochemical compositions. Therefore, sole application of cocoa waste and 75 kg N/ha rate of application, and their combination can be recommended for optimum mineral, nutritional and phytochemical compositions of okra at both locations.

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