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Antioxidants and Nutrients Composition in Selected Cultivated African Vegetables and Herb: the Impact of Maturity and Drying

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ABSTRACT
Ocimum gratissimum, *Phyllanthus amarus* and *Lactuca taraxacifolia* are good sources of phytochemicals and they have gained attention for their potential to provide natural remedies for various ailments. This study was carried out to evaluate the effect of maturity stages and drying methods (oven drying (50^{o}C) and air drying at room temperature (28-32^{o}C) on the antioxidative properties, vitamins and mineral contents of three cultivated plants. The plantas were harvested at two different stages of maturity and subjected to two different drying methods. The antioxidants of the plants ranged from 25.21-70.94 % (Reducing power (DPPH)), 0.57-0.73 mg/g (Total antioxidants contents (TAC)), 0.55-4.66 mg/g (Total flavonoids contents (TFC)), 0.03-0.72mg/g (Free radicals scavenging ability (FRAP)) and 0.18-0.39 (Total phenolic content(TPC)).The vitamin composition varied from 2.45-3.41 mg/g (vitamin C), 0.01-0.35 mg/g (vitamin D), 0.13-0.14 mg/g (vitamins B1), while its mineral compositions ranged from 278.41-1360.66 mg/100g (K), 222.73-1088.53mg/100g (Ca), 213.27-612.08mg/100g (Mg). The PCA biplot revealed a data variance of about 69.42% and the preference for the samples A1O C1O (Ocimum gratissimum at young age oven dried at 50 ^{o}C) and C1O (*Phyllatus amarus* at young age oven dried at 50^{0}C) might be attributed to their high antioxidant capacities retention, while sample B1N (*Lactuca taraxacifolia* air dried at young age) might also be considered because of its richness in vitamin B1, vitamin C and FRAP.

Keywords: Plants; Maturity stage, Drying, Antioxidants; Phyto-chemicals

INTRODUCTION

Recently, plant based natural products exploration has gained considerable attention due to their potential therapeutic applications and health-promoting effects [1] (Zhu et al., 2021). Out of these, African herbs have been found to possess diverse bioactive compounds, including phenolic compounds, terpenoids, essential oils, alkaloids and flavonoids (Asfaw et al., 2022). The phytochemicals present in these herbs make them to possess distinctive aromas, flavors and potential medicinal properties (Aye *et al.*, 2019). However, several factors influences the composition of phytochemicals in plants, this also include the maturity stages and drying methods (Min*et al.*, 2009).

Ocimum gratissimum L., popularly known as scent leaf, is one of the medicinal plants that possess medicinal properties; it has the potential to serve as source of a new drug or an alternative therapy for the treatment of various ailments (Mohr *et al.,* 2017). It is a commercially viable perennial herbaceous and widespread plant that possesses a very strong aromatic smell, which can be found in Africa, Asia, and South America (Sarı *et al.*, 2023).Apart from its medicinal properties, it can also be used a natural flavouring agent or vegetable in food preparations. Traditionally, it is used for the treatment of anaemia, diarrhoea, pains, cough, pneumonia, fever, inflammation, fungal and bacterial infections (Sarı *et al.*, 2023).

Phyllanthus amarus is an herbaceous plant which belongs to the family Euphorbiaceae. Its utilization in traditional medicine is not limited to Nigeria, but in many Asian and other African countries. In Nigeria, the Yorubas call it "Iyin Olobe", "Oyomoke isoamankedem" in Efik and "Ebebenizo" in Bini (Etta, 2008). It is rich in alkaloids, flavonoids, hydrolysable tannins, triterpenes, lignans, polyphenols, alkaloids, sterols and oils (Ogbodo et al., 2017). *Phyllantus amarus* extract possesses antibacterial, antimicrobial, anti-inflammatory, anticancer, hypolipidemic, antidiabetic, antioxidant and antiviral activities (Patela et al., 2011).

Lactuca taraxacifolia is a traditional tropical plant which is used in Africa for treatment of liver disease, dyslipidemia, cough, high blood pressure and diabetes (Rosine *et al.*, 2022). It is a rich source of phyto-constituents such as polyphenols, flavonoids, saponins, terpenoids, alkaloids, and tannins (Gbadamosi *et al.*, 2020). It also possesses antidiabetic, antioxidant, and lipid-lowering (Adinortey *et al.*, 2018).

The maturity stage is the plant developmental phase that is characterized by changes in physiology, morphology and biochemical composition (Xiong *et al.*, 2021). The stages of mature have significant impact on the phyto-chemical profile of plants.

During the early growth stages, plants tend allocate more resources for growth and reproduction, thereby resulting in lower concentrations of certain phyto-chemicals. As plants develop, there is always a shift in the accumulation and synthesis of secondary metabolites, which provide the unique flavors, scents, and medicinal properties of herbs. As maturity set in, plants allocate more resources for defense mechanisms, which subsequently leads to higher concentrations of bioactive compounds (Dambreville *et al.*, 2015). However, the changes in phyto-chemical composition during maturation can vary widely among different herbs.

Drying is a common preservation method used to extend the shelve life of herbs and concentrate their bioactive constituents (Rao and Murugan, 2021). The choice of drying method has significant effect on the phyto-chemical composition and overall quality of the herbs (Tagnamas *et al.,* 2022). Air drying involves hanging herbs in well-ventilated areas to allow moisture evaporation.This method has ability to preserve some phytochemicals, but it is highly prone to microbial contamination (Lamidi *et al.,* 2019). Oven drying method uses low heat, but it may cause thermal degradation of heat-sensitive phytochemicals if not carefully controlled.

Phyto-chemicals are bioactive compounds found in plants that contribute to their potential health-promoting effects. The composition and concentration of these compounds can vary significantly depending on factors such as the plant's growth stage and the post-harvest processing methods employed (Aung *et al.,* 2016). African herbs such as *Occimum gratissimum, Phyllantus amarus, Lactuca taraxifolia*have gained attention for their potential to provide natural remedies for various ailments, but the influence of maturity stages and drying methods on their phytochemical properties remains largely unexplored. By elucidating the relationship between these factors and phyto-chemical contents, this research can contribute to enhancing the utilization of these herbs for both medicinal and culinary purposes. This study aims to determine the effect of maturity stages and drying methods on the phyto-chemical properties of some cultivated african herbs.

MATERIALS AND METHODS

Sample Preparation

Occimum gratissimum, Phyllantus amarus, Lactuca taraxifolia leaves were obtained from the Teaching and Research Farm Kwara state University, Malete, Kwara State. The herbs were harvested at young (3-4 weeks) and matured (8 weeks) stages. However, the samples were prepared as described in Figure 1.

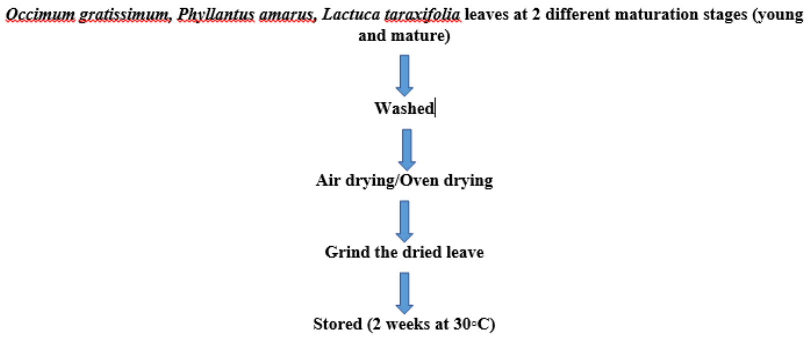

Figure 1: Production of dried vegetables and herb

Analyses

Determination of Antioxidant Parameters of the Cultivated Herbs

DPPH Radical Scavenging assay, ABTS radical scavenging assay, Ferric reducing antioxidant power, Total phenolic content and total flavonoid content were determined following Raji *et al*. (2022) method.

Determination of the Vitamin Contents of the Cultivated Herbs

Vitamin D and B1 (thiamine) were determined by the spectrophotometric methods reported by Onwuka (2005), whereas the vitamin C (ascorbic acid) content was determined by the method described by Okwu and Josiah (2006).

Determination of the Mineral Contents of the Cultivated Herbs

The calcium, potassium and magnesium contents of the samples were determined using AOAC (2005) methods.

Statistical Analysis

Data obtained were analyzed in three replications by one-way analysis of variance (ANOVA) in completely randomized design using Statistical package for social science (SPSS) version 23. The statistically significant differences ($P<0.05$) among means were separated using the Duncan Multiple Range Test.

RESULTS AND DISCUSSION

Maturity Stages and Drying Methods on the Antioxidant Properties of Selected Vegetables and Herb

Table 1 shows the effect of maturity stages and drying methods on the antioxidant properties of *Ocimum gratissimum* (Efinrin).There was significant difference (p<0.05) in the DPPH values of all the efirin samples. DPPH value was highest in the A1N sample, while the least DPPH value was observed in the A20. It was observed that as the maturity increased, the DPPH value decreased. No significant difference (p>0.05) was observed in the total antioxidant content of all the efinrin samples, but sample A20 exhibited the least value for antioxidant content. Sample A10 had the highest level of flavonoid, while lowest value was observed in sample A20. The ferric ion reducing antioxidant power assay was highest in sample A2N, while the least FRAP value was recorded in sample A10. Significant difference (p<0.05) existed in the total phenolic content of the four samples, Sample A10 had the highest, while sample A20 had the lowest total phenolic content.

Table 1: Effect of Maturity Stages and Drying Methods on the Antioxidant Properties of *Ocimum Gratissium (Efinrin)*

Samples	DPPH (%)	TAC (mg/g)	TFC (mg/g)	FRAP (mg/g)	TPC (mg/g)
A1N^{2}	$66.32\pm0.35^{1)a}$	0.71 ± 0.00^{a}	2.77 ± 0.02^{b}	0.21 ± 0.00^{b}	0.29 ± 0.00^{c}
A2N	34.44 ± 1.19^{c}	0.64 ± 0.05^{a}	2.16 ± 0.00^{c}	0.33 ± 0.00^{a}	0.31 ± 0.00^{b}
A1O	48.89 ± 1.19^{b}	0.73 ± 0.10^{a}	4.66 ± 0.00^{a}	0.03 ± 0.01^{d}	0.39 ± 0.00^{a}
A2O	25.21 ± 0.35^{d}	0.57 ± 0.03^{ab}	1.78 ± 0.02^{d}	0.13 ± 0.00^{c}	0.18 ± 0.00^{d}

Mean value with the same alphabets along the column shows no statistically significance difference at p>0.05

Keys:
A1N = *Ocimum gratissium* air dried at young age
A2N = *Ocimum gratissium* air dried at mature age
A1O = *Ocimum gratissium* at young age oven dried at 50^0C
A2O = *Ocimum gratissium* at mature age oven dried at 50^0C
TPC = Total phenolic content
TFC = Total flavonoids content
TAC = Total antioxidants
DPPH = Reducing power
FRAP = Free radicals scavenging ability

Table 2 shows the effect of maturity stages and drying methods on the antioxidant properties of *Launaea taraxacifolia* (Efo yanrin).There was significant difference (p<.05) in the DPPH values of all the samples. B1N had the highest Dpph value, while B20 had the lowest value. There was significant difference (p<0.05) in the total antioxidant values of all the samples. Highest total antioxidant capacity was recorded in sample B1N, while sample B1O had the lowest value. Sample B1N possessed the highest level of flavonoid, while the lowest flavonoid occurred in sample B2N. Sample B20 had the highest value for ferric ion reducing antioxidant power assay, while sample B2N had the lowest. Highest phenolic content value was recorded in sample B1N, while sample B2N had the lowest value for phenolic content.

Table 2: Effect of Maturity Stages and Drying Methods on the Antioxidant Properties of *Launaeataraxacifolia*

Samples	DPPH (%)	TAC (mg/g)	TFC (mg/g)	FRAP (mg/g)	TPC (mg/g)
B1N[2]	$26.26\pm1.58^{1)a}$	0.61 ± 0.00^a	3.11 ± 0.12^a	0.19 ± 0.80^b	0.36 ± 0.00^a
B2N	24.31 ± 0.83^b	0.57 ± 0.35^b	0.55 ± 0.12^d	0.15 ± 0.06^b	0.18 ± 0.00^b
B1O	25.07 ± 0.47^{ab}	0.60 ± 0.06^{ab}	2.84 ± 0.029^b	0.20 ± 0.0^b	0.24 ± 0.00^a
B2O	24.95 ± 0.21^b	0.59 ± 0.11^{ab}	1.96 ± 0.16^c	0.39 ± 0.019^a	0.32 ± 0.00^c

Mean value with the same alphabets along the column shows no statistically significance difference at p>0.05
Keys:
B1N = *Launaea taraxacifolia* air dried at young age
B2N = *Launaea taraxacifolia* air dried at mature age
B1O = *Launaea taraxacifolia* at young age oven dried at 50^0C
B2O = Launaea taraxacifolia at mature age oven dried at 50^0C
TPC = Total phenolic content
TFC = Total flavonoids content
TAC = Total antioxidants
DPPH = Reducing power

Table 3 shows the effect of maturity stages and drying methods on the antioxidant properties of *Phyllatus amarus* (Eyinlobe). There was significant difference (p<.05) in the DPPH values of all the eyinlobe samples. Dpph was highest in the C10 sample followed by C20, C1N and the least DPPH value was observed in sample C2N. No significant was observed in the total antioxidant content of sample C1N and C10. Sample C20 exhibited the least value for antioxidant content.

Sample C10 had the highest level of flavonoid, while the lowest value of flavonoid occurred in sample C2N. The ferric ion reducing antioxidant power assay was highest in sample C20 and the least FRAP occurred in sample C2N. Sample C10 had the highest phenolic content, while sample C2O had the lowest.

Table 3: Effect of Maturity Stages and Drying Methods on the Antioxidant Properties of *Phyllatus Amarus*

Samples	DPPH (%)	TAC (mg/g)	TFC (mg/g)	FRAP (mg/g)	TPC (mg/g)
C1N[2]	$36.50\pm1.19^{1)c}$	0.69 ± 0.01^a	1.76 ± 0.00^c	0.37 ± 0.00^c	0.36 ± 0.01^b
C2N	31.19 ± 0.35^d	0.67 ± 0.00^b	1.07 ± 0.00^d	0.13 ± 0.02^d	0.35 ± 0.00^b
C1O	70.94 ± 2.386^a	0.71 ± 0.00^a	3.61 ± 0.00^a	0.45 ± 0.03^b	0.39 ± 0.00^a
C2O	48.89 ± 1.19^b	0.64 ± 0.00^c	2.78 ± 0.02^b	0.72 ± 0.03^a	0.34 ± 0.00^c

Mean value with the same alphabets along the column shows no statistically significance difference at p>0.05
Keys:
C1N = *Phyllatus amarus* air dried at young age
C2N = *Phyllatus amarus* air dried at mature age
C1O = *Phyllatus amarus* at young age oven dried at 50^0C
C2O = *Phyllatus amarus* at mature age oven dried at 50^0C
TPC = Total phenolic content
TFC = Total flavonoids content
TAC = Total antioxidants
DPPH = Reducing power
FRAP = Free radicals scavenging ability

Tables 1-3 show the effects of maturity stages and drying methods on the antioxidants contents of three plant species: Ocimum gratissimum (Efinrin), Launaea taraxacifolia (Efoyanrin), and Phyllanthus amarus (Eyinlobe). The DPPH assay revealed distinct variations in antioxidant activity among the studied plants. Phyllanthus amarus, particularly when harvested at a young age and dried in a 50°C oven, exhibited the highest DPPH content, indicating its robust free radical scavenging capabilities. This observation is supported by previous research attributing Phyllanthus amarus's radical scavenging potential to its high flavonoid and phenolic content (Ujah, et al., 2021). Conversely, Launaea taraxacifolia, when mature and subjected to oven drying, showed the lowest DPPH content, suggesting lower antioxidant activity. This aligns with earlier studies indicating relatively lower antioxidant activity in Launaea taraxacifolia compared to other plant species (Oyagbemi, et al., 2022). Ocimum gratissimum, especially when young and naturally dried, demonstrated noteworthy DPPH content. Although direct studies relating to this specific combination are limited, research has demonstrated the antioxidant potential of Ocimum gratissimum leaves, supporting the observed results (Oboh et al., 2015). Total antioxidant capacity was influenced by various factors, with Ocimum gratissimum at a young age, dried in a 50°C oven, exhibiting the highest capacity. This finding aligns with previous research highlighting the antioxidant potential of Ocimum gratissimum leaves (Agunbiade et al., 2024). Phyllanthus amarus at a young age, dried at 50°C in an oven, also displayed significant total antioxidant capacity. This corresponds to studies emphasizing the high levels of phenolic compounds in Phyllanthus species contributing to their antioxidative properties (Ibobo et al., 2024). The lowest total antioxidant capacity observed in mature, naturally dried Launaea taraxacifolia is consistent with research indicating variability in antioxidant capacities among different plant species (Adetutu et al., 2020). Ocimum gratissimum at a young age, dried in a 50°C oven, exhibited the highest total flavonoid content. This aligns with previous studies demonstrating the presence of flavonoids in Ocimum gratissimum leaves and their potential antioxidant effects (Enenebeaku et al., 2024). Phyllanthus amarus at a young age, dried at 50°C in an oven, also displayed substantial total flavonoid content, consistent with research attributing the antioxidant activity of Phyllanthus species to their flavonoid content (Saini et al., 2024). The lower total flavonoid content in mature Launaea taraxacifolia aligns with research exploring the flavonoid content of various plant species and noting variations based on species and age (Anyanwu et al., 2022). Phyllanthus amarus, both at a mature age dried in an oven and at a young age dried at 50°C, demonstrated the highest free radical scavenging ability. This finding is in line with previous research highlighting the antioxidant and free radical scavenging activity of Phyllanthus amarus (Nguyen et al., 2015). Conversely, Ocimum gratissimum at a young age, dried in a 50°C oven, exhibited the lowest free radical scavenging ability.

Effects of Maturity Stages and Drying Methods on the Vitamins of Selected Vegetables and Herb

Table 4 shows the effect of maturity stages and drying methods on the vitamins of Ocimum gratissimum (Efinrin). Highest vitamin C content was recorded in sample A2O, while sample A1N exhibited lowest value of vitamin C. Sample A20 exhibited the highest value of vitamin D content, while both samples A2N and A1O had the lowest value. Sample A1N had the highest vitamin B1 among others.

Table 4: Effect of Maturity Stages and Drying Methods on the Vitamins of *Ocimum Gratissium*

Samples	Vitamin C (mg/g)	Vitamin D (mg/g)	Vitamin B1 (mg/g)
A1N²)	2.45±0.00$^{1)c}$	0.23±0.00^{b}	0.13±0.00^{c}
A2N	2.57±0.094^{b}	0.17±0.00^{c}	0.13±0.00^{c}
A1O	2.69±0.030^{a}	0.17±0.00^{c}	0.13±0.00^{a}
A2O	3.22±0.00^{a}	0.29±0.00^{a}	0.14±0.00^{b}

Mean value with the same alphabets along the column shows no statistically significance difference at p<0.005.
Keys:
A1N = *Ocimum gratissium* air dried at young age
A2N = *Ocimum gratissium* air dried at mature age
A1O = *Ocimum gratissium* at young age oven dried at 50^{0}C
A2O = *Ocimum gratissium* at mature age oven dried at 50^{0}C

Table 5 shows the effect of maturity stages and drying methods on the vitamins of *Launaea taraxacifolia*. Sample B20 had the highest value of vitamin C content, while sample B1O had the lowest value. Highest vitamin D content was recorded in sample B2N, while sample B1Nexhibited the lowest value of vitamin D. There was significant difference (p<0.05) in the of vitamin B1 content of all the samples. Sample B20 had the highest vitamin B1 content and sample B10 had the lowest value for vitamin B1.

Table 5: Effect of Maturity Stages and Drying Methods on the Vitamins of *Launaea Taraxacifolia (Efoyanrin)*

Samples	Vitamin C (mg/g)	Vitamin D (mg/g)	Vitamin B1 (mg/g)
B1N²)	2.88±0.03^{b}	0.06±0.00^{d}	0.14±0.00^{b}
B2N	2.89±0.05^{b}	0.35±0.008^{a}	0.13±0.00^{c}
B1O	2.69±0.10^{d}	0.07±0.00^{c}	0.13±0.00^{d}
B2O	3.22±0.07^{c}	0.19±0.00^{b}	0.14±0.00^{a}

Mean value with the same alphabets along the column shows no statistically significance difference at p>0.05
Keys:
B1N = *Launaea taraxacifolia* air dried at young age
B2N = *Launaea taraxacifolia* air dried at mature age
B1O = *Launaea taraxacifolia* at young age oven dried at 50^{0}C
B2O = Launaea taraxacifolia at mature age oven dried at 50^{0}C

Table 6 shows the effect of maturity stages and drying methods on the vitamins of Phyllantus amarus (Eyinlobe). Sample CIN had the lowest vitamin C content, while sample C2O had the highest value. Sample C10 exhibited the highest value for vitamin D and lowest value was recorded in both samples C2O and C2N. The vitaminB1 of sample of C20 was the highest among others.

Phyllanthus amarus at a mature age, when subjected to oven drying, exhibited the highest Vitamin C content, supported by the nutritional composition of Phyllanthus species (Saini et al., 2024). Interestingly, air-dried Phyllanthus amarus at a mature age also displayed relatively high Vitamin C content, in line with findings that certain drying methods, such as air drying, can preserve Vitamin C (Olaleye & Rocha, 2008). Conversely, Ocimum gratissimum showed lower Vitamin C content, highlighting the influence of both species and drying methods on Vitamin C retention (Pham et al., 2024).

Launaea taraxacifolia at a mature age and dried naturally exhibited the highest Vitamin D content, an intriguing finding given the limited exploration of Vitamin D content in plants (Bonazzi & Dumoulin, 2011). Ocimum gratissimum at a mature age, dried through oven drying, also contained significant Vitamin D, consistent with research indicating that different drying methods can impact Vitamin D retention in plants (Khan et al., 2022).

The lowest Vitamin D content was observed in air-dried Phyllanthus amarus at a mature age, underlining the complex relationship between plant species, drying methods, and Vitamin D preservation. The study found no significant changes in Vitamin B1 content across all samples, in line with the stability of Vitamin B1 even under various processing conditions (Watanabe et al., 2017).

Table 6: Effect of Maturity Stages and Drying Methods on the Vitamins of *Phyllanthus Amarus (Eyinolobe)*

Samples	Vitamin C (mg/g)	Vitamin D (mg/g)	Vitamin B1 (mg/g)
C1N²)	3.08±0.18[b]	0.02±0.00[b]	0.13±0.00[c]
C2N	3.29±0.57[a]	0.01±0.00[c]	0.13±0.00[c]
C1O	3.23±0.50[ab]	0.07±0.00[a]	0.13±0.00[b]

Mean value with the same alphabets along the column shows no statistically significance difference at $p>0.05$

Keys:

C1N = *Phyllatus amarus* air dried at young age

C2N = *Phyllatus amarus* air dried at mature age

C1O = *Phyllatus amarus* at young age oven dried at 50^0C

C2O = *Phyllatus amarus* at mature age oven dried at 50^0C

Effect of Maturity Stages and Drying Methods on the Minerals of *Ocimum Gratissium*

Table 7 shows the effects of maturity stages and drying methods on Ocimum gratisimum (Efinrin). There was significant difference in the potassium level among all the samples, Potassium level in sample A1N was the highest and was the lowest in sample A20. There was significant difference in the calcium level among all the samples, calcium level was significantly higher in sample A1N followed by A2N, A10 and sample A20 had the lowest calcium level. Magnessium level in sample A1N was the highest and it was the lowest in sample A20.

Table 7: Effect of Maturity Stages And Drying Methods On The Minerals Of *Ocimum Gratissium(Efinrin)*

Sample	Potassium (mg/100g)	Calcium (mg/100g)	Magnesium (mg/100g)
A1N²)	800.23±0.000[a]	640.18±0.000[a]	359.98±0.000[a]
A2N	824.19±0.000[b]	659.35±0.000[b]	370.76±0.000[b]
A1O	852.15±0.000[c]	681.72±0.000[c]	383.33±0.000[c]
A2O	896.08±0.000[d]	716.86±0.000[d]	403.09±0.000[d]

Mean value with the same alphabets along the column shows no statistically significance difference at $p<0.001$

Keys:

A1N = *Ocimum gratissium* air dried at young age

A2N = *Ocimum gratissium* air dried at mature age

A1O = *Ocimum gratissium* at young age oven dried at 50^0C

A2O = *Ocimum gratissium* at mature age oven dried at 50^0C

Table 8 shows the effects of maturity stages and drying methods on *Launaea taraxacifolia* (Efo yanrin). There was significant difference ($p>.05$) in the potassium level of all the samples. Sample B1N had the highest value for potassium, while sample B1N had the least potassium level (Table 8). There was significant difference ($p<0.05$) in the calcium level of all the samples. Sample B2N had the highest value for potassium, while the least calcium level was recorded in sample B1N. However, sample B2N had the highest value, while sample B1N had the least magnessium level.

Table 8: Effect of Maturity Stages and Drying Methods on the Mineral of *Launaea Taraxacifolia*

Sample	Potassium (mg/100g)	Calcium (mg/100g)	Magnesium (mg/100g)
B1N²)	719.02±2.30)[b]	575.22±1.84[d]	323.45±1.03[d]
B2N	1360.66±4.61[a]	1088.53±3.68[a]	612.08±2.07[a]
B1O	908.06±0.00[c]	726.45±0.00[c]	408.48±0.00[c]
B2O	1101.08±4.61[b]	880.86±3.68[b]	495.31±2.07[b]

Mean value with the same alphabets along the column shows no statistically significance difference at $p>0.05$

Keys:

B1N = *Launaea taraxacifolia* air dried at young age

B2N = *Launaea taraxacifolia* air dried at mature age
B1O = *Launaea taraxacifolia* at young age oven dried at 50^0C
B2O = Launaea taraxacifolia at mature age oven dried at 50^0C.

Table 9 shows the effects of maturity stages and drying methods on the minerals content of Phyllatus Amarus (Eyin olobe). Sample C2N had the highest potassium,calcium and magnesium levels, while the lowest values were recorded in sample C1N. There was significant difference (p<.05) in the mineral contents of all the samples.

The mineral composition of the samples was also investigated. Ocimum gratisimum (Efinrin) at a mature age, dried naturally, exhibited the highest potassium level, supported by prior research on the mineral content of this plant (Ajayi, 2015). Similarly, at a mature age, dried through oven drying, displayed significant potassium content, consistent with studies exploring the mineral composition of leafy vegetables (Asaolu et al., 2012). In contrast, air-dried Phyllanthus amarus at a mature age exhibited the lowest potassium level, emphasizing Launaea taraxacifolia the influence of plant species and drying methods on mineral concentration (Ocran et al., 2012). Launaea taraxacifolia at a mature age, dried naturally, had the highest calcium level, a result consistent with research on its mineral composition (Ocran et al., 2012). Launaea taraxacifolia at a mature age, dried through oven drying, also contained significant calcium content, supporting findings that drying methods can affect mineral levels (Odukoya & Oshodi, 2018).Conversely, air-dried Phyllanthus amarus at a young age displayed the lowest calcium level, highlighting the interplay of plant species and drying methods in mineral concentration (Omoregie et al., 2020). Regarding magnesium, Launaea taraxacifolia at a mature age, dried naturally, exhibited the highest magnesium level, consistent with earlier research on the mineral content of this plant (Okunlola et al., 2023). Launaea taraxacifolia at a mature age, dried through oven drying, also contained significant magnesium content, reflecting the impact of drying methods on mineral concentration (Shi et al., 2022). In contrast, air-dried Phyllanthus amarus at a young age displayed the lowest magnesium level, underlining the influence of both plant species and drying methods on mineral content (Omoregie et al., 2020). Hence, this study provides valuable insights into how maturity stages and drying methods affect the nutritional and antioxidant properties of selected plant species. The findings underscore the importance of considering these factors when assessing the potential health benefits of these plants and highlight the need for further research to explore the complex interactions between plant species, growth stages, and drying techniques in greater detail.

Table 9: Effect of Maturity Stages and Drying Methods on the Minerals of *Phyllanthus Amarus*

Sample	Potassium (mg/100g)	Calcium (mg/100g)	Magnesium (mg/100g)
C1N²)	278.41±2.30)ᵇ	222.73±1.84ᵈ	125.24±1.03ᵈ
C2N	597.89±2.30ᵃ	478.31±1.84ᵃ	268.96±1.03ᵃ
C1O	474.09±2.30ᶜ	379.27±1.84ᶜ	213.27±1.03ᶜ
C2O	495.39±2.30ᵇ	396.31±1.84ᵇ	222.85±1.03ᵇ

Mean value with the same alphabets along the column shows no statistically significance difference at p>0.05.
Keys:
C1N = *Phyllatus amarus* air dried at young age
C2N = *Phyllatus amarus* air dried at mature age
C1O = *Phyllatus amarus* at young age oven dried at 50^0C
C2O = *Phyllatus amarus* at mature age oven dried at 50^0C

Correlation Loading of the Effect Interactions between the Drying Process and Maturity Stages on the Selected Vegetables and Herb

Table 10 reveals the correlation loading of the interactions between the drying process and maturity stages of the selected plants and their effects on their antioxidative potentials, minerals and vitamins. The result implies that the principal component 1 (PC1) was in positive correlation with vitamin D, potassium, calcium and magnesium, but correlated in a negative way with the antioxidant properties, vitamin B1 and vitamin C. The PCA biplot, as presented in Figure 2 allowed us to differentiate the samples based on their antioxidant properties, minerals and vitamins. The result revealed a data variance of about 69.42 %, with PC1 making up to 51.83 % and PC2 contributing 17.59%. The B1N, CIN, C2N and C20 were in the same quadrant with vitamin B1, vitamin C and FRAP. Similarly, A1O and C1O were in the same quadrant with TPC, TFC, TAC and DPPH. Interestingly, sample A1N and A2N were in the quadrant with vitamin D, potassium, calcium and magnesium. Conclusively, the preference for the samples A1O of Ocimum gratissimum and C1O of phyllantus amarus might be attributed to their high antioxidant capacities retention, while sample B1N of Lactuca taraxacifolia might also be considered because of its richness in vitamin B1, vitamin C and FRAP.

Table 10: Correlation Loading of Selected Vegetables and Herb Quality Determinants

	F1	F2	F3	F4	F5
DPPH	-0.611	-0.548	-0.082	0.538	0.094
TAC	-0.733	-0.578	-0.115	0.030	0.290
TFC	-0.490	-0.630	0.469	-0.044	-0.275
FRAP	-0.519	0.490	0.157	0.601	-0.267
TPC	-0.854	-0.143	0.319	-0.164	0.238
Vitamin C	-0.454	0.701	0.249	0.159	0.398
Vitamin D	0.832	-0.321	-0.028	0.314	0.081
Vitamin B1	-0.180	0.069	0.948	-0.094	-0.051

	F1	F2	F3	F4	F5
Potassium	0.935	-0.120	0.270	0.105	0.108
Calcium	0.935	-0.120	0.270	0.105	0.108
Magnesium	0.935	-0.120	0.270	0.105	0.108

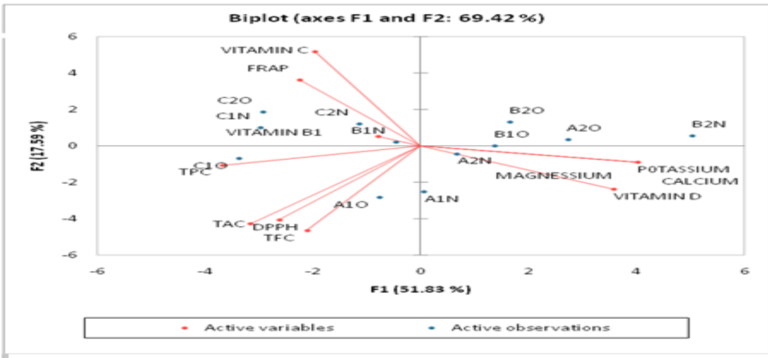

Figure 2: Principal component biplot of the selected vegetables and herb quality determinants

CONCLUSION

The results showed that the drying methods and maturity stages of the selected plants significantly influenced their antioxidative potentials, minerals and vitamins. For the correlation loading results, the predominant principal component exhibited positive correlations with vitamin D, potassium, calcium and magnesium, but negatively correlated with the antioxidant properties, vitamin B1 and vitamin C. However, the preferences for samples A1O of Ocimum gratissimum and C1O of phyllantus amarus might be attributed to their high antioxidant capacities retention, while sample B1N of Lactuca taraxacifolia might also be considered because of its richness in vitamin B1, vitamin C and FRAP.

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