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Comparative Chlrorophyll and Carotenoid Analysis of Six Sesame (*Sesamum indicum* L.) Varieties Cultivated in Katsina State.

Buah, J. D.*[1], Musa, D. D.[1], Omotoso, A. A.[3], Anakaa, T. M.[1], Kutawa, A. B.[1], Kankia, I. D.[1], Adejumo, A. G.[2], and Animasaun, D. A.[2]

[1]Department of Plant Science and Biotechnology, Federal University Dustin-Ma.
[2]Department of Plant Biology, University of Ilorin.
[3]Department of Agricultural Extension, University of Ilorin.

*Corresponding Author: jbuah@fudutsinma.edu.ng

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Abstract

Sesamum indicum L. is a valuable oil crop and grain. The aim of this study is to analyze the chlorophyll and carotenoid content of six sesame varieties. Three seeds of each accession (Igboho Black, 02M, E8, Exsudan, Kenan 4 and Bogoro Local) were sown in sandy loamy soil at 0-15cm depth in perforated polythene bags, replicated three times, and arranged in a Randomized Complete Block Design (RCBD). Leaf samples were analyzed for pigment concentrations at two weeks interval for fourteen weeks. The data was analyzed using ANOVA at a probability value of $p \leq 0.05$. The chlorophyll and carotenoid concentration of each accession increased from seedling to maturity with slight fluctuations. At two weeks, Bogoro Local had the highest total chlorophyll ($4.27 \pm 2.21 mgL^{-1}$) and carotenoid (1.06 ± 1.11 mgL^{-1}). The total chlorophyll of Bogoro Local (4.27 ± 2.21 mgL^{-1}) was not significantly different from Kenan 4 (4.16 ± 2.22 mgL^{-1}), but different from other accessions, while the carotenoid of Bogoro Local ($1.06 \pm 1.11 mgL^{-1}$) was significantly different from the other accessions. At four weeks, Exsudan had the highest total chlorophyll ($6.32 \pm 2.11 mgL^{-1}$) and carotenoid ($1.21 \pm 2.32 mgL^{-1}$), significantly different from other accessions and E8 with the least. At maturity, Exsudan had the highest total chlorophyll (12.87 ± 2.30), followed by 02M (7.28 ± 2.41 mgL^{-1}) and Igboho Black (7.26 ± 2.10 mgL^{-1}). The total carotenoid was highest in Exsudan (1.53 ± 0.10 mgL^{-1}), but not significantly different from Bogoro Local (1.51 ± 0.10 mgL^{-1}) and Kenan 4 (1.01 ± 0.10 mgL^{-1}), while Igboho Black had the least (0.88 ± 1.10 mgL^{-1}). The accessions Exsudan, Bogoro Local and Kenan 4 consistently exhibited higher pigments concentrations, while E8 and Igboho Black had the lowest. These could be linked to genetic variation and environmental influences which is important in understanding the physiological process in sesame leaves for agronomic selection and cultivation.

Introduction

Sesame is a valuable oil producing crop that is appreciated for its oil-rich seeds, used in cooking, cosmetics, and traditional medicine (Sajid et al., 2024). Sesame belongs to the family pedaliaceae and is esteemed for its resilience to varying climates, impressive oil content, and exceptional antioxidant properties (Darika et al., 2021). Sesame is one of the oldest crops in the world, cultivated in Asia for several years. The crop has its origins in East Africa and in India, the world's largest producers of sesame are India and China, followed by Myanmar, Sudan, Uganda, Nigeria, Pakistan, Tanzania, Ethiopia, Guatemala and Turkey (Pham et al., 2010). Sesame serves as a vital source of premium-quality edible oil in the range of 50–60% and approximately 19–25% of protein (Buah, et al., 2026). The oil of sesame boasts a significant proportion of natural antioxidants, such as sesamolin, sesamin, and sesamol; these antioxidants contribute to the extended shelf life and stability of sesame oil (Muez et al., 2024)

Moreover, sesame seeds are abundant in essential minerals like iron, magnesium, copper, and calcium, along with vitamins B1 and E, as well as phytosterols; these nutritional components were reported to play a role in reducing blood cholesterol levels (Ahmad et al., 2018). Additionally, sesame contains essential nutritional elements such as carbohydrates, protein, moisture, crude fibre, fat and oil, further enhancing their value (Buah, et al., 2026). Sesame therefore is a versatile and nutritious crop with immense potential for various applications, from culinary to health-enhancing products (Buah, et al., 2026).

The green pigment found in plant leaves called chlorophyll, plays a fundamental role in the process by which plants convert light energy into chemical energy, ultimately sustaining life on Earth a process referred as photosynthesis (Muez et al., 2024). It serves as a crucial indicator of a plant's photosynthetic vitality and overall health (Muez et al., 2024).

Carotenoids are terpenoid pigments that serve as light-harvesting accessory molecules and as quenchers of singlet oxygen in photosynthetic tissues, but they also accumulate in seeds where they contribute colour, antioxidant capacity and pro-vitamin A activity (Sebastian et al., 2025)

Chlorophyll predominantly absorbs light within the red (650–700 nm) and blue-violet (400–500 nm) regions of the visible spectrum and, interestingly, it exhibits a unique property of reflecting green light (~550 nm), which imparts the characteristic green coloration to chlorophyll (Pal et al., 2020). The primary differentiation between these two chlorophyll types is the presence of a methyl group in chlorophyll a, which is replaced by a formyl group in chlorophyll b (Muez et al., 2024).

In higher plants, chlorophyll manifests primarily as chlorophyll a (Chla), serving as the principal pigment, and chlorophyll b (Chlb), operating as a supplementary pigment. These chlorophyll variants coexist in a typical chlorophyll ratio (Chla/b) of roughly 3 to 1, although this proportion can be subject to fluctuations influenced by growth conditions and environmental factors (Muez et al., 2024).

Sesame is mainly prized for its oil, the determination of the chlorophyll and carotenoid content of sesame leaves has received far less scientific attention than its lipid or lignan components (Sebastian, et al., 2025). Unlike the well-characterised carotenoid profiles of some crops, sesame carotenoids have been documented in only a handful of cultivar-by-environment combinations, leaving a gap that limits both nutritional-quality breeding and food-industry applications (Sebastian, et al., 2025).

Measuring chlorophyll and carotenoid concentration of sesame plant is crucial in assessing the plant's photosynthetic efficiency, overall health, and response to environmental stressor. Thus, provides relevant information for breeders, agronomist, and farmers to monitor and manage the health and growth of sesame crops, leading to increased yields and sustainable agricultural practices. Therefore, this research is designed to determine the chlorophyll and carotenoid accumulation of six sesame (Sesamum indicum L.) accession cultivated in Katsina State.

Materials and Methods

Planting material

Seeds of *Sesamum indicum* L. bought from agro stores outlet licensed by the National Agricultural Seeds Council (NASC) Funtua, Katsina state. The six varieties collected are Igboho Black, 02M, E8, Exsudan, Kenan 4, and Bogoro Local.

Soil: Sandy loamy soil from 0-15cm soil depth taken from the Biological garden, Federal University of Dutsin-Ma.

Planting of the seeds: The seeds (three each) were planted in perforated polythene bags containing 10kg of garden sandy loamy soil replicated three times arranged in a complete randomized design (CRD).

Management practice*:* Watering was done twice daily and weeding carried out at regular interval manually.

Sample collection

The leaves of each sesame variety were collected from two weeks after planting to fourteen weeks after planting (fully matured) at an interval of two weeks for chlorophyll and carotenoid concentration analysis.

Chlorophyll and Carotenoids Determination

Experimental procedure:

Chlorophyll extraction and determination was carried out as described by Porra et al. (1989). Fresh leaves of the samples were collected from the pots in the field early in the morning and taken to the laboratory for analysis. The leaves (12.5mg) of each accession were dipped into sample bottles containing 3.5ml of acetone in three replicates. The set-up was left for a period of 72 hours in a dark cupboard at room temperature for the extraction of the chlorophyll contents of the leaves. After 72 hours the samples were shaken vigorously, the bleached leaves were removed leaving behind the leaf homogenates in the sample bottles.

A clean cuvette from the spectrophotometer was obtained and filled two-thirds full with 80% acetone (this is the control), it was wiped with a tissue and put it into the spectrophotometer, the wavelength was then set to 470nm and the cuvette chamber was covered then set to zero (0) absorbance with the control in place. It was later removed (control) and kept for the next measurement. The first sample (A) was gently swirled into the second cuvette two-third full then wiped clean, inserted into the spectrophotometer then the hatch was closed and the readout gives the absorbance at 470nm which was recorded.

The wavelength was changed to 646 nm, the control cuvette was reinserted and the spectrophotometer was re-zeroed for the new wavelength which was later remove and a cuvette containing sample (A) was inserted, then the readings were recorded down. This was repeated for the other extracts of each sample. The wavelength was changed to 663 nm, the control cuvette was reinserted and the spectrophotometer was re-zeroed for the new wavelength which was later remove and a cuvette containing sample (A) was inserted, then the readings were recorded down. This was repeated for the other extracts of each sample.

Using the Porra et al. (1989) equation (below)

Chlorophyll a (mg/ml) = $[(12.21 \times A663) - (2.81 \times A646)]$

Chlorophyll b (mg/ml) = $[(20.13 \times A646) - (5.03 \times A663)]$

Total Chlorophyll = Chlorophyll a + Chlorophyll b.

Carotenoids = $[(1000 \times A470) – (3.27 \times chl.a) – (104 \times chl.b)] / 198$

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using SPSS version 24 (2019), and means were separated using Duncan's Multiple Range Test (DMRT). A probability value of $p \leq 0.05$ was used as the benchmark for statistical significance.

Results

The results obtained from the chlorophyll and carotenoid analysis of the leaves of each accession are presented in Table 1-7.

Two weeks after sowing, the accession Bogoro Local had the highest chlorophyll a, chlorophyll b, total chlorophyll and total carotenoid content of 3.25±1.42mgL^{-1}, 1.01±1.22mgL^{-1}, 4.27±2.21mgL^{-1} and

1.06±1.11 mgL^{-1} respectively. The chlorophyll a of Bogoro Local (3.25±1.42mgL^{-1}) is not significantly different from Kenan 4 (3.18±2.12mgL^{-1}) and Exsudan (3.00±1.32mgL^{-1}), while the accession E8 had the lowest chlorophyll a (1.68±3.20mgL^{-1}). The chlorophyll b and total chlorophyll of Bogoro Local (1.01±1.22mgL^{-1} and 4.27±2.21mgL^{-1} respectively) is not significantly different from Kenan 4 (0.98±1.42mgL^{-1} and 4.16±2.22 mgL^{-1} respectively) but different from the other accessions with the least chlorophyll b and total chlorophyll in E8 (0.48±3.12 mgL^{-1} and 2.16±1.22 mgL^{-1} respectively).

The carotenoid of Bogoro Local (1.06±1.11mgL^{-1}) is significantly different from all the other accessions with the least in E8 (0.54±3.32 mgL^{-1}) as presented in Table 1. At four weeks after sowing, the accession Exsudan had the highest chlorophyll a, chlorophyll b, total chlorophyll and total carotenoid of 4.78±3.11mgL^{-1}, 1.54±2.22mgL^{-1}, 6.32±2.11mgL^{-1}, and 1.21±2.32mgL^{-1} respectively. The chlorophyll b and carotenoid of Exsudan (1.54±2.22mgL^{-1} and 1.21±2.32mgL^{-1} respectively) is not significantly different from Bogoro Local (1.15±1.12mgL^{-1} and 1.07±2.10mgL^{-1} respectively) but different from all other accessions with the least observed in E8 (0.61±2.10mgL^{-1} and 0.57±1.32 mgL^{-1} respectively). The accession E8 had the lowest chlorophyll a (2.23±2.32 mgL^{-1}) but not significantly different from Igboho Black (2.50±1.42mgL^{-1}), and the lowest total chlorophyll (2.83±3.14mgL^{-1}) and the lowest total carotenoid (0.57±1.32mgL^{-1}) but not significantly different from Igboho Black (0.62±2.42mgL^{-1}) at four weeks after sowing (Table 2).

Six weeks after sowing, Exsudan had the highest chlorophyll a, chlorophyll b, total chlorophyll and total carotenoid content of 6.53±1.32mgL^{-1}, 3.09±2.11mgL^{-1}, 9.62±2.22mgL^{-1} and 1.26±2.10mgL^{-1} respectively that is significantly different from the other accessions while the accession E8 had the lowest chlorophyll a (2.51±3.13mgL^{-1}), chlorophyll b (0.57±1.10mgL^{-1}), total chlorophyll (3.08±3.32mgL^{-1}) and total carotenoid (0.68±1.11mgL^{-1}) as presented in Table 3. At eight weeks after planting the lowest chlorophyll a was highest in Exsudan (7.75±4.10mgL^{-1}), followed by Igboho Black (4.54±1.00mgL^{-1}) which is not significantly different from Bogoro Local (4.39±1.10mgL^{-}) and the least was observed in E8 (3.93±2.11mgL^{-1}) which is not significantly different from kenan 4 (3.77±2.11mgL^{-1}).

The highest chlorophyll b was observed in Exsudan (3.82±2.11mgL^{-1}) followed by Igboho Black (2.07±1.20mgL^{-1}) and the least were observed in E8 (0.36±3.10mgL^{-1}). Exsudan had the highest total chlorophyll (11.53±2.12mgL^{-1}) and carotenoid (1.58±2.10 mgL^{-1}) as presented in Table 4. The accession Exsudan at ten weeks after sowing had the highest chlorophyll a (8.04±3.32 mgL^{-1}), while Kenan 4 (3.94±1.40 mgL^{-1}) had the lowest. The accession Exsudan had the highest chlorophyll b (4.29±2.12mgL^{-1}), and total chlorophyll (12.33±1.32mgL^{-1}) which is significantly different from the other accessions.

Exsudan also had the highest carotenoid (1.52±3.10mgL^{-1}) but not significantly different from Bogoro Local (1.43±3.11mgL^{-1}) as presented in Table 5. The accession with the highest chlorophyll a at twelve weeks after sowing was Exsudan (8.37±0.12 mgL^{-1}), followed by Igboho Black (4.78±1.12 mgL^{-1}) which is not significantly different from Bogoro Local (4.25±1.10mgL^{-1}), and 02M (4.32±2.22mgL^{-1}). Chlorophyll b was highest in Exsudan (4.35±2.22 mgL^{-1}), and least in E8 (1.20±1.12 mgL^{-1}) which is not significantly different from Kenan 4 (1.81±1.10mgL^{-1}) and Bogoro Local (1.56±2.12mgL^{-1}), while total chlorophyll and total carotenoids was highest in Exsudan (12.72±3.12mgL^{-1} and 1.63±2.11mgL^{-1} respectively) as presented in Table 6. At fourteen weeks after sowing, the accession Exsudan had the highest chlorophyll a (8.31±1.20mgL^{-1}), followed by Igboho Black (4.85±1.20mgL^{-1}) which is not significantly different from 02M (4.62±1.30mgL^{-1}).

Chlorophyll b was highest in Exsudan (4.56±1.20 mgL^{-1}) and E8 had the least (1.08±2.22 mgL^{-1}) which is not significantly different from Bogoro Local (1.32±1.30 mgL^{-1}). The total chlorophyll was highest in Exsudan (12.87±2.30), followed by 02M (7.28±2.41 mgL^{-1}) and Igboho Black (7.26±2.10 mgL^{-1}). The total carotenoid was highest in Exsudan (1.53±0.10 mgL^{-1}) but not significantly different from Bogoro Local (1.51±0.10 mgL^{-1}) and Kenan 4(1.01±0.10 mgL^{-1}). The accession with the least total carotenoid was Igboho Black (0.88±1.10 mgL^{-1}) as presented in Table 7.

Discussion

The chlorophyll and carotenoids content of Sesamum indicum L. leaves increased from seedling stage to full maturity varied and significantly amongst the six accessions.

The accession Bogoro Local had the highest chlorophyll a, chlorophyll b, total chlorophyll and carotenoid content (3.25±1.42mgL^{-1}, 1.01±1.22mgL^{-1}, 4.27±2.21mgL^{-1} and 1.06±1.11 mgL^{-1} respectively) at two weeks after sowing with the least chlorophyll a, chlorophyll b, total chlorophyll and carotenoid observed in E8 (1.68±3.20mgL^{-1}, 0.48±3.12 mgL^{-1}, 2.16±1.22 mgL^{-1} and 0.54±3.32 mgL^{-1} respectively). These variations in chlorophyll and carotenoid concentration amongst the six sesame accessions at seedling stage may likely stem from the genetic differences influencing chlorophyll and carotenoid production and synthesis pathways in the leaves. This finding is corroborated by the report of Muez et al. (2024) who identified significant variations in chlorophyll content of sesame cultivated in China, assessed through spectral vegetation indices (SVI) and the chlorophyll and carotenoid concentrations per leaf area, evaluated across diverse factors such as genotype diversity, greenness categories, and leaf disk positions varied significantly. Muez et al. (2024) reported a strong association between SVI, chlorophyll ratios, total chlorophyll, carotenoid concentrations, and genotype variation, indicating distinct sesame genotypes with varying chlorophyll levels. Sebastian et al. (2205) also reported 19.7% mean increase in carotenoids of sesame with biofertilizer treatment and in carrot and tomato where phosphate-solubilising bacteria improved carotenoid content by 12 to 22% through enhanced phosphorus uptake and possibly through production of plant-growth-promoting substances. As the sesame plant development progressed with time, at four weeks the accession Exsudan had the highest chlorophyll a, chlorophyll b, total chlorophyll and total carotenoid of 4.78±3.11mgL^{-1}, 1.54±2.22mgL^{-1}, 6.32±2.11mgL^{-1}, and 1.21±2.32mgL^{-1} respectively. Although the chlorophyll b and total carotenoid of Exsudan (1.54±2.22mgL^{-1} and 1.21±2.32mgL^{-1} respectively) is not significantly different from the accession Bogoro Local (1.15±1.12mgL^{-1} and 1.07±2.10mgL^{-1} respectively) but different from all other accessions with the least observed in E8 (0.61±2.10mgL^{-1} and 0.57±1.32 mgL^{-1} respectively). This highlights a closely linked relationship between the chlorophylls, and carotenoids density of sesame leaves from Exsudan and Bogoro LocaL, a likely indicator of the plant adaptation to the environment, but significantly different from 02M, Kenan 4 and E8. This is in alignment with Rajalakshmi and Banu (2015), who reported that chloroplast density and pigment-producing structures influences variation in chlorophyll and carotenoid content, high chlorophyll concentration is mostly found around the tips of leaf and 75% localization along the sesame leaf blade consistently yields increased chlorophyll content..

Table 1: Chlorophyll and Carotenoids analysis of sesame (*Sesamum indicum* L.) leaves two weeks after sowing

Accession	Chlorophyll a (mgL^{-1})	Chlorophyll b (mgL^{-1})	Total chlorophyll (mgL^{-1})	Total Carotenoids (mgL^{-1})
Igboho Black	2.03±1.11^{c}	0.62±2.11^{c}	2.65±2.12^{c}	0.79±2.12^{b}
02M	2.19±2.10^{c}	0.58±2.10^{c}	2.77±3.20^{c}	0.71±2.11^{bc}
E8	1.68±3.20^{d}	0.48±3.12^{d}	2.16±1.22^{d}	0.54±3.32^{d}
Exsudan	3.00±1.32^{ab}	0.84±2.14^{b}	3.84±2.22^{b}	0.70±1.41^{c}
Kenan 4	3.18±2.12^{a}	0.98±1.42^{a}	4.16±2.22^{a}	0.79±2.32^{b}
Bogoro Local	3.25±1.42^{a}	1.01±1.22^{a}	4.27±2.21^{a}	1.06±1.11^{a}
P – Value	0.02	0.02	0.02	0.03

Values with same letter (s) along a column are not significantly different at $p \geq 0.05$

Table 2: Chlorophyll and Carotenoids analysis of sesame (*Sesamum indicum* L.) leaves four weeks after sowing

Accession	Chlorophyll a (mgL^{-1})	Chlorophyll b (mgL^{-1})	Total Chlorophyll (mgL^{-1})	Total Carotenoids (mgL^{-1})
Igboho Black	$2.50{\pm}1.42^{de}$	$1.01{\pm}3.42^{b}$	$3.51{\pm}2.12^{c}$	$0.62{\pm}2.42^{de}$
02M	$3.10{\pm}2.10^{bc}$	$1.03{\pm}2.14^{b}$	$4.12{\pm}3.11^{bc}$	$0.86{\pm}4.12^{cd}$
E8	$2.23{\pm}2.32^{e}$	$0.61{\pm}2.10^{c}$	$2.83{\pm}3.14^{e}$	$0.57{\pm}1.32^{e}$
Exsudan	$4.78{\pm}3.11^{a}$	$1.54{\pm}2.22^{a}$	$6.32{\pm}2.11^{a}$	$1.21{\pm}2.32^{a}$
Kenan 4	$2.64{\pm}2.11^{d}$	$0.76{\pm}1.12^{c}$	$3.39{\pm}3.10^{cd}$	$0.88{\pm}2.22^{bc}$
Bogoro Local	$3.54{\pm}4.10^{b}$	$1.15{\pm}1.12^{ab}$	$4.69{\pm}1.11^{b}$	$1.07{\pm}2.10^{ab}$
P – value	0.03	0.02	0.02	0.03

Values with same letter(s) along a column are not significantly different at $p \geq 0.05$

Table 3: Chlorophyll and Carotenoids analysis of sesame (*Sesamum indicum* L.) leaves six weeks after sowing

Accession	Chlorophyll a (mgL^{-1})	Chlorophyll b (mgL^{-1})	Total Chlorophyll (mgL^{-1})	Total Carotenoids (mgL^{-1})
Igboho Black	$3.36{\pm}1.11^{cd}$	$1.82{\pm}2.42^{b}$	$5.18{\pm}2.12^{b}$	$0.66{\pm}4.12^{d}$
02M	$3.50{\pm}2.12^{c}$	$1.64{\pm}3.32^{bc}$	$5.14{\pm}1.42^{b}$	$0.99{\pm}3.10^{d}$
E8	$2.51{\pm}3.13^{e}$	$0.57{\pm}1.10^{d}$	$3.08{\pm}3.32^{d}$	$0.68{\pm}1.11^{e}$
Exsudan	$6.53{\pm}1.32^{a}$	$3.09{\pm}2.11^{a}$	$9.62{\pm}2.22^{a}$	$1.26{\pm}2.10^{a}$
Kenan 4	$3.45{\pm}2.10^{c}$	$1.06{\pm}2.10^{cd}$	$4.51{\pm}1.22^{bc}$	$1.08{\pm}3.22^{bc}$
Bogoro Local	$4.38{\pm}1.41^{b}$	$0.63{\pm}1.12^{d}$	$5.01{\pm}2.20^{b}$	$1.51{\pm}1.10^{ab}$
P – value	0.02	0.02	0.01	0.02

Values with same letter(s) along a column are not significantly different at $p \geq 0.05$

Table 4: Chlorophyll and Carotenoids analysis of sesame (*Sesamum indicum* L.) leaves eight weeks after sowing

Accession	Chlorophyll a (mgL^{-1})	Chlorophyll b (mgL^{-1})	Total Chlorophyll (mgL^{-1})	Total Carotenoids (mgL^{-1})
Igboho Black	$4.54{\pm}1.00^{b}$	$2.07{\pm}1.20^{b}$	$6.61{\pm}1.11^{b}$	$0.93{\pm}1.12^{cd}$
02M	$4.00{\pm}1.10^{c}$	$1.90{\pm}2.11^{c}$	$5.90{\pm}2.12^{c}$	$1.00{\pm}3.32^{c}$
E8	$3.93{\pm}2.11^{d}$	$0.36{\pm}3.10^{e}$	$4.29{\pm}1.10^{d}$	$0.90{\pm}1.22^{d}$
Exsudan	$7.75{\pm}4.10^{a}$	$3.82{\pm}2.11^{a}$	$11.53{\pm}2.12^{a}$	$1.58{\pm}2.10^{a}$
Kenan 4	$3.77{\pm}2.11^{d}$	$1.19{\pm}0.12^{d}$	$5.00{\pm}3.13^{c}$	$1.23{\pm}3.11^{bc}$
Bogoro Local	$4.39{\pm}1.10^{bc}$	$1.85{\pm}1.12^{cd}$	$6.23{\pm}2.14^{b}$	$1.44{\pm}2.10^{ab}$
P – value	0.02	0.02	0.02	0.01

Values with same letter(s) along a column are not significantly different at $p \geq 0.05$

Table 5: Chlorophyll and Carotenoids analysis of sesame (*Sesamum indicum* L.) leaves ten weeks after sowing

Accession	Chlorophyll a (mgL^{-1})	Chlorophyll b (mgL^{-1})	Total Chlorophyll (mgL^{-1})	Total Carotenoids (mgL^{-1})
Igboho Black	4.59 ± 2.10^{b}	2.15 ± 1.10^{b}	6.74 ± 1.41^{b}	0.93 ± 3.12^{d}
02M	4.24 ± 1.21^{b}	2.29 ± 2.22^{b}	6.53 ± 1.12^{b}	1.04 ± 1.14^{cd}
E8	4.17 ± 0.10^{bc}	0.50 ± 3.20^{d}	4.68 ± 2.10^{d}	1.18 ± 2.32^{c}
Exsudan	8.04 ± 3.32^{a}	4.29 ± 2.12^{a}	12.33 ± 1.32^{a}	1.52 ± 3.10^{a}
Kenan 4	3.94 ± 1.40^{c}	1.43 ± 2.31^{c}	5.37 ± 2.12^{c}	1.26 ± 2.20^{bc}
Bogoro Local	4.34 ± 1.10^{b}	1.87 ± 1.12^{c}	6.21 ± 1.12^{b}	1.43 ± 3.11^{ab}
P – value	0.01	0.02	0.02	0.03

Values with same letter(s) along a column are not significantly different at $p \geq 0.05$

Table 6: Chlorophyll and Carotenoids analysis of sesame (*Sesamum indicum* L.) leaves twelve weeks after sowing

Accession	Chlorophyll a (mgL^{-1})	Chlorophyll b (mgL^{-1})	Total Chlorophyll (mgL^{-1})	Total Carotenoids (mgL^{-1})
Igboho Black	4.78 ± 1.12^{b}	2.28 ± 1.10^{b}	7.06 ± 2.10^{b}	0.93 ± 1.11^{d}
02M	4.32 ± 2.22^{b}	2.76 ± 2.12^{b}	7.09 ± 1.12^{b}	0.86 ± 3.10^{de}
E8	4.08 ± 2.10^{c}	1.20 ± 1.12^{cd}	5.28 ± 2.21^{d}	0.88 ± 1.20^{e}
Exsudan	8.37 ± 0.12^{a}	4.35 ± 2.22^{a}	12.72 ± 3.12^{a}	1.63 ± 2.11^{a}
Kenan 4	4.07 ± 2.12^{c}	1.81 ± 1.10^{c}	5.88 ± 1.10^{c}	1.10 ± 1.40^{c}
Bogoro Local	4.25 ± 1.10^{b}	1.56 ± 2.12^{c}	5.80 ± 1.11^{cd}	1.46 ± 2.11^{ab}
P – value	0.02	0.02	0.02	0.02

Values with same letter(s) along a column are not significantly different at $p \geq 0.05$

Table 7: Chlorophyll and Carotenoids analysis of sesame (*Sesamum indicum* L.) leaves fourteen weeks after sowing

Accession	Chlorophyll a (mgL^{-1})	Chlorophyll b (mgL^{-1})	Total Chlorophyll (mgL-1)	Total Carotenoids (mgL-1)
Igboho Black	4.85 ± 1.20^{b}	2.41 ± 1.10^{bc}	7.26 ± 2.10^{b}	0.88 ± 1.10^{cd}
02M	4.62 ± 1.30^{b}	2.66 ± 2.30^{b}	7.28 ± 2.41^{b}	0.97 ± 0.11^{c}
E8	4.08 ± 2.21^{d}	1.08 ± 2.22^{de}	5.16 ± 1.12^{de}	0.94 ± 2.30^{c}
Exsudan	8.31 ± 1.20^{a}	4.56 ± 1.20^{a}	12.87 ± 2.30^{a}	1.53 ± 0.10^{a}
Kenan 4	4.12 ± 1.40^{cd}	2.00 ± 1.13^{c}	6.12 ± 1.21^{c}	1.01 ± 0.10^{ab}
Bogoro Local	4.22 ± 0.11^{c}	1.32 ± 1.30^{d}	5.54 ± 2.10^{d}	1.51 ± 0.10^{a}
P – value	0.02	0.02	0.02	0.03

Values with same letter(s) along a column are not significantly different at $p \geq 0.05$

Muez et al. (2024) also reported that Chlorophyll variants coexist in a typical chlorophyll ratio (Chla/b) of roughly 3 to 1, although this proportion can be subject to fluctuations influenced by growth stages, conditions and environmental factors. Six weeks after sowing, Exsudan had the highest chlorophyll a, chlorophyll b, total chlorophyll and total carotenoid content of $6.53\pm1.32mgL^{-1}$, $3.09\pm2.11mgL^{-1}$, $9.62\pm2.22mgL^{-1}$ and $1.26\pm2.10mgL^{-1}$ respectively that is significantly different from the other accessions while the accession E8 had the lowest chlorophyll a ($2.51\pm3.13mgL^{-1}$), chlorophyll b ($0.57\pm1.10mgL^{-1}$), total chlorophyll ($3.08\pm3.32mgL^{-1}$) and total carotenoid ($0.68\pm1.11mgL^{-1}$). The chlorophyll (Chlorophyll a, b and total chlorophyll) and carotenoid content of Exsudan improved as the plant develops towards maturity and had the highest values while E8 accession had the least chlorophyll concentrations. At maturity (14 weeks after sowing), the accession Exsudan had the highest chlorophyll a (8.31±1.20mgL^{-1}), followed by Igboho Black (4.85±1.20mgL^{-1}). The chlorophyll b was highest in Exsudan (4.56±1.20 mgL^{-1}) and E8 had the least (1.08±2.22 mgL^{-1}) which is not significantly different from Bogoro Local (1.32±1.30 mgL^{-1}).

The total chlorophyll was highest in Exsudan (12.87±2.30), followed by 02M (7.28±2.41 mgL^{-1}) and Igboho Black (7.26±2.10 mgL^{-1}). The total carotenoid was highest in Exsudan (1.53±0.10 mgL^{-1}) but not significantly different from Bogoro Local (1.51±0.10 mgL^{-1}) and Kenan 4 (1.01±0.10 mgL^{-1}). The accession with the least total carotenoid was Igboho Black (0.88±1.10 mgL^{-1}). The low chlorophyll content and carotenoid in E8 and Igboho Black could be attributed to ecological influence and their genetic constituents which also significantly impede one of the most important physiological process (Photosynthesis) that support the development and growth of plants. This is in alignment with Pengfei et al. (2024) who reported that at low temperatures the chlorophyll content of the albino tea plant reduces, whereas the chlorophyll content of other varieties were affected by both high and low temperatures with symptomatic altered leaf colors and form. Similarly, Ritonga et al. (2021) reported that low temperature had a greater effect on the carotenoid content of the tea plant cultivars, and that photosynthetic pigment content is significantly reduced under cold stress conditions. This may also be linked to the suppression of chlorophyll and carotenoid synthesizing genes of sesame influenced by environmental factors since the ratio of Chlorophyll a, b, total chlorophyll, and carotenoid varied at different developmental stages of the sesame accessions.

The accession Igboho Black had a high chlorophyll concentration (7.26±2.10 mgL^{-1}) with very low carotenoid concentration (0.88±1.10 mgL^{-1}), this could be likely due to the secondary role of carotenoid in light absorption and this aligns with the report of Pengfei et al. (2024) who reported that carotenoid serves as supplementary pigments for trapping light in the chloroplast to drive photosynthesis but can be inhibited by a strong wavelength of light which influences the biosynthesis of carotenoids in tea plants. Jiang et al. (2020) reported that shading treatment increased by 30% the accumulation of carotenoids in albino leaves of 'Huangjinju', which turn the leaf to green.

The high carotenoid concentration in Exsudan (1.53±0.10 mgL^{-1}), Bogoro Local (1.51±0.10 mgL^{-1}) and Kenan 4 (1.01±0.10 mgL^{-1}), is significant in enhancing photosynthetic activities, better physiological response to environmental stress and improving the nutritional value of the sesame varieties. This is in tandem with Udeme and Collins, (2025) who reported a 9.8 μ/g carotenoid concentration in sesame and its significance in combating oxidative stress, lower inflammation and reduce the risk of several chronic diseases, including cardiovascular and neurological disorders, type 2 diabetes, and different types of cancer. Seabstian et al. (2025) reported that carotenoids concentration within the sesame plant varies between the leaves and seed, which could inform milling and dehulling strategies that maximise pigment retention. Similarly, Gulcin, (2025) reported that carotenoid anti-inflammatory properties have been associated with improving cardiovascular health, reducing inflammation which helps to protect against heart diseases and prevents arterial walls from being blocked.

The chlorophyll and carotenoid presence extended across a varied spectrum amongst the different sesame varieties and the Chlorophyll and carotenoid concentration in this sesame accession provides crucial data that can be used in the physiological assessment of the plant's photosynthetic efficiency, pathological assays of the plants overall health, and response to environmental stressors for agronomic and breeding purpose.

Conclusion

The results obtained from the chlorophyll and carotenoid analysis of the six sesame accessions showed significantly higher concentration of Chla, Chlb, total chlorophyll and carotenoid content in Exsudan, Bogoro Local and Kenan 4. These distinctions underscore the influence of genetic variations amongst the different accessions and the role of ecological factors on the physiological process associated with their development and their likely effect on the size, form, and green coloration of the leaves.

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Contribution:

Study design**:** Buah, J.D., Animasaun, D.A. and Musa, D.D. Data Collection: Buah, J.D., Anakaa, T. M., Adejumo, G.A. Analysis and result interpretation: Buah, J.D, Omotoso, A. A, Kutawa, A.B, & Kankia, I.D. Draft manuscript: Buah, J.D and Omotoso, A. A and Musa, D.D.

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