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Research Article

Cultivar Selection Effects on the Yield and Nutritional Compositions of Sesame (*Sesamum indicum* L.)

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Sesame plant withstands drought and has great tolerance to different soil types. In addition, its flour and oil are excellent sources of plant-based protein, vitamins, minerals, and healthy fats. The vast utilization of sesame seeds as an alternative to wheat flour and healthy oil is being experienced globally. Three cultivars of the most frequently cultivated sesame in Nigeria, namely White Benue, Cameroon White, and E8, were grown at the Teaching and Research Farm of Osun State University, Ejigbo Campus (a derived savanna) in 2023 using standard agronomic practices. The aim was to evaluate their yield and nutritional performance. Yield was evaluated and the harvested seeds were analyzed for selected nutrients using standard assays. The results of yield (kg/ha) obtained for White Benue, E8 and Cameroun White were 510, 560 and 680, respectively. Iron (%) in White Benue was 4.46, E8 was 4.45 while Cameroon White was 4.34. Calcium (%) in Cameroon White was 0.68, E8 had 0.65 while White Benue had 0.63. Potassium (%) in E8 was 1.17. Cameroon White had 1.16, while White Benue was 1.14. Selenium (%) was 2.04 in E8, Cameroon White had 2.01 while White Benue was 1.99. Flavonoids (%) reached highest value in White Benue 27.48, followed by Cameroon White 10.98 and E8 10.86. Alkaloids reached 5.89 (%) in all the cultivars, while phytic acid ranged between 0.12% and 0.13%. Cameroon White outyielded other cultivars, however, their nutritional values are unique, while all cultivars evaluated have high amounts of important nutrients to contribute to human diet and health.

Keywords: sesame flour, seed yield, wheat bread, iron, food security

1 Introduction

Sesame (*Sesamum indicum* L.) is one of the earliest crops cultivated by humans and belongs to the Pedaliaceae family (Zech-Matterne et al., 2015). It is one of China's four major oil crops, alongside grape, soybean, and peanuts. Originally discovered in ancient Pakistan, sesame has been cultivated for thousands of years and is now widely grown in countries such as Malaysia, China, and India, with the Chinese using sesame seeds for over 5,000 years (Zech-Matterne et al., 2015; Bedigian, 2010; Majdalawieh et al., 2017).

The top global producers of sesame include Tanzania, China, Sudan, India, and Myanmar. Tanzania recently overtook India as the leading sesame producer, contributing 806,000 tons out of the global production of 5.899 million tons in 2017, while China contributed 733,000 tons (Xu et al., 2018). Sesame is highly valued for its mild flavor and rich aroma, making it popular in various culinary applications. Its nutritional and medicinal benefits were officially recognized by the former Chinese Ministry of Health in 2002, with recent comprehensive reviews focusing on its phytochemistry and ethnopharmacology (Mili et al., 2021).

Owing to the rise in sesame seed production over the past several years, customers now place a higher value on sesame seeds and use them in a wider range of nutritious, healthful foods. When compared to other seed proteins, it has significantly more essential and nonessential amino acids, making it a valuable source of protein in terms of nutrition. It also has an abundance of minerals that are necessary for maintaining optimal health (Idowu et al., 2021). Compared to meat (18–25%) and grains (7–13%), sesame seeds have a higher protein content (17–40%) (Bassogog et al., 2020). Edible, creamy, light brown powder, sesame flour has a maximum protein content of 27–32% and an oil content of 10–12%. Furthermore,

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three times as much calcium is present in sesame than in a comparable amount of milk. Additionally, after the oil is extracted, the defatted sesame cake is a great source of high-quality protein and a variety of beneficial phytochemicals, which are plant-based bioactive nutrients that may enhance basic nutrition and lower the risk of serious diseases. Because sesame is mostly used for oil, it is regarded as an unconventional source of protein (Agrahar-Murugkar et al., 2018).

The components of sesame seeds have the potential to offer a person a number of health advantages, both pharmacological and nutraceutical. It has been demonstrated that sesame seeds have cholesterol-lowering, antioxidant, and anticancer effects. Sesame seeds and oil have significant pharmacological benefits and health benefits for the whole body, especially the liver, kidneys, spleen, and stomach. Its high oil content not only lubricates the intestinal tract, but also nourishes the internal organs (Adebisi et al., 2017). It is very important to evaluate the agronomic and nutritional performance of these selected varieties of sesame in order to optimize their values and hence their usage. This work aims at quantifying the yield and evaluating the minerals and phytochemicals of the 3 selected sesame varieties, namely White Benue, Cameroon White, and E8.

2 Materials and Methods

2.1 Field Study

The experiment was conducted at Osun State University, Ejigbo Campus, Osun State (a derived savanna). In August 2023, three sesame varieties (NCRIBEN (white Benue), NCRIBEN 2 (white Cameroon), and E8) were obtained from National Cereals Research Institute Badeggi, Nigeria. The experimental plot size of 9 m^2 was used per cultivar and replicated 4 times, totaling 12 plots. The recommended seeding rate of 9 kg ha^{-1} which amounted to about 8 g plot^{-1} was used. The experiment was a Randomized Complete Block Design (RCBD). The soil sample was collected from a depth of 0–15 cm before planting and was analyzed to determine the soil physical and chemical properties of the soil.

The crop varieties were grown for four months under standard agronomic practices for sesame. White Benue is an extra-early maturing variety; the color of its seed is naturally nearly white. Cameroon White is an early maturity variety; the seed is whitish brown. E8 is also early maturing, with the seed pearly white in color. Seed yield was received after harvesting, while the harvested seeds were sorted, cleaned and then processed into flour. Samples were analyzed for specific minerals and phytochemicals.

2.2 Laboratory Analysis

2.2.1 Methodology for Mineral Determination

Mineral contents of samples were determined by atomic absorption spectrophotometer (AAS) according to the methods of AOAC (2003).

Determination of Heavy metals and minerals by Shimadzu Atomic Absorption Spectrophotometer model AA-6800.

Principle: In this technique, the atoms of an element are vaporized and atomized in the flame. The particle then absorbed the light at a characteristic wavelength. The source of the light is a hollow cathode lamp, which is made up of the same element, which has to be determined. The lamp produces radiation of an appropriate wavelength, which while passing through the flame is absorbed by the free atoms of the sample. The absorbed energy is measured by a photo-detector read-out system.

The amount of energy absorbed is proportional to the concentration of the element in the sample.

2.2.2 Preparation of the Sample

Dry digestion: 0.5 g of the sample was weighed with analytical weighing balance and placed in a carbolite furnace oven. The temperature was raised to 550 °C for 6 hrs until the ash was completed.

The dry digested sample that has been ashed was removed and placed in the desiccators, kept cool and prevented from moisture. Twelve milliliters (12 ml) of 10% HNO_3 was added to the sample with 4.0 ml perchloric acid ($HClO_4$) and mixture was kept for overnight at room temperature. The mixture was then filtered with glass wool and then made up to 20 ml with deionized water.

Procedure: The digested sample was analyzed for mineral contents by Atomic Absorption Spectrophotometer. Different electrode lamps were used for each mineral. The concentrations of minerals recorded in terms of "mg L^{-1}". The final concentration was then calculated by this formula:

$$\textit{reading from the machine} \times \textit{final vol} \big/ \textit{initial weight}$$

2.3 Quantitative Analysis of the Phytochemicals

2.3.1 Determination of Alkaloids

Five (5 g) of the samples were weighed into a beaker of 250 ml. This was preceded by addition of 200 ml of 10% acetic acid in ethanol and allowed to stand for 4 hours. The extract was concentrated on a water bath to one quarter of the original volume after filtration. Precipitation was done by addition of concentrated ammonium hydroxide drop by drop. The precipitate was collected after the whole solution was allowed to settle down and it (precipitate) was then washed with diluted ammonium hydroxide and filtered. The residue obtained is the alkaloids that are dried and weighed.

$$\text{alkaloids} = B - A \times 100/S$$

where: *B* – weight of Whatman filter paper; *A* – weight of Whatman filter paper, after drying; *S* – sample weight

2.3.2 Determination of Tannins Content

The tannins were determined by a slightly modified Folin and Ciocalteu method. Briefly, 0.5 ml of sample extract is added to 3.75 ml of distilled water and 0.25 ml of Folin Phenol reagent, 0.5 ml of 35% sodium carbonate solution. The absorbance was measured at 725 nm. Tannic acid dilutions (0 to 250 mg ml^{-1}) were used as standard solutions. The results of tannins are expressed in terms of tannic acid in mg 100 g^{-1} of extract.

2.3.3 Determination of Saponin Content

Test extract was dissolved in 80% methanol, 2 ml of Vanillin ethanol was added, mixed well and the 2 ml of 72% sulphuric acid solution was added, mixed well and heated on a water bath at 60 °C for 10 min, absorbance was measured at 544 nm against reagent blank.

2.3.4 Determination of Flavonoid Content

Each 0.25 mL filtered sample was added to 4.5 mL of distilled water. 0.3 mL of 5% $NaNO_2$ solution was added and let for 5 minutes. 0.3 mL of 10% of $AlCl_3$ was mixed and incubated for 5 minutes. 2 mL of 1 M NaOH was added, and the entire volume was made to 10 mL with distilled water and mixed well. The absorbance of each sample was measured at 510 nm using a spectrophotometer. Blank was prepared using the above reagents and distilled water instead of sample. A curve chart for each solution was prepared by using absorbance and concentration. The three replicates were prepared for each sample. The flavonoid content was calculated as mg catechin equivalent (mg CAE) per hundred grams of dry matter using the calibration curve.

2.3.5 Determination of Phytate

4 g of grounded sample was weighed and added to 100 mL of 2% HCl. The mixture was shaken constantly for 3 h and thereafter filtered the mixture using Whatman filter paper. 25 mL of the filtrate was poured into a 250 mL conical flask, and thereafter added to 5 mL of 0.3% ammonium thiocyanate (NH_4SCN) and 50 mL of distilled water to achieve the desired acidity. The reaction mixture was titrated against a 0.00195 g mL^{-1} ferric chloride solution (previously poured into a burette) until a persistent brownish yellow coloration was obtained. The phytate content of the sample was calculated using the equation below:

$$\text{phytic acid} = \frac{8.24\, t \times 100}{1{,}000 \times \text{weight of sample (g)}}$$

where: *t* – average titer value

2.4 Statistical Analysis

Data collected were subjected to analysis of variance with the general linear model of SAS, treatment means were compared with the least significant difference at 5% probability level (SAS).

3 Results and Discusion

3.1 Results

Table 1 presents the result of the physical and chemical properties of the soil. The soil is sandy loam with moderate residual soil nutrients. Table 2 and Figure 1 present the climatic conditions of the growing season and location. The average sunshine hours between August and December during the production period was 5.46 hours day^{-1}, it peaked in November (7.9). The average rainfall was 128.82 mm $month^{-1}$, it peaked in October (255.1). The average maximum and minimum temperatures were 31.1 and 21.24 °C, respectively, the maximum temperature peaked in December (34.4 °C), when the relative humidity was lowest (63%).

Table 1 Physical and chemical properties of soil

Properties of soil	Values
Acidity/Alkalinity	7.50 ±0.09
Sand (%)	72.87 ±0.38
Clay (%)	9.23 ±0.07
Silt (%)	15.57 ±0.12
B/D (g cm^{-2})	1.5 ±0.00
Nitrogen (%)	0.02 ±0.00
Temperature (°C)	27.24 ±0.14
Conductivity (μs cm^{-1})	51.42 ±0.65
Potassium (ppm)	6,079.10 ±285.92
Sodium (ppm)	0.13 ±0.02
Magnesium (ppm)	0.55 ±0.02
Phosphorus (ppm)	371.9 ±4.51
Calcium (ppm)	206.2 ±3.49

Table 2 Climate Data of Derived Savanna (Ejigbo) in 2023

Month	Sunshine hours (hour)	Rainfall (mm)	Maximum temp (°C)	Minimum temp (°C)	Relative humidity (%)
January	7	9.1	34.9	19.5	62
February	6.7	14.2	36.3	22.3	64
March	6.7	62.7	34.1	22.5	81
April	7.2	74.2	33.2	23.1	82
May	7.2	214.1	32.8	22.8	82
June	5.4	224.4	30	21.8	88
July	3.9	184.4	29.8	22	90
August	2.6	142.2	28.4	21.5	93
September	3.2	206.1	29.5	21.5	90
October	6.3	255.1	30.9	21.8	87
November	7.9	40.7	32.3	22.2	85
December	7.3	0	34.4	19.2	63

The yield result (Figure 2) shows that Cameroon White produced the highest seed yield (≈ 680 kg ha^{-1}), followed by E8 (≈ 560 kg ha^{-1}) while White Benue produced the lowest yield (≈ 500 kg ha^{-1}). This indicates that under the derived savanna conditions of the study location, Cameroon White had superior agronomic performance and better adaptation for grain production compared to the other cultivars.

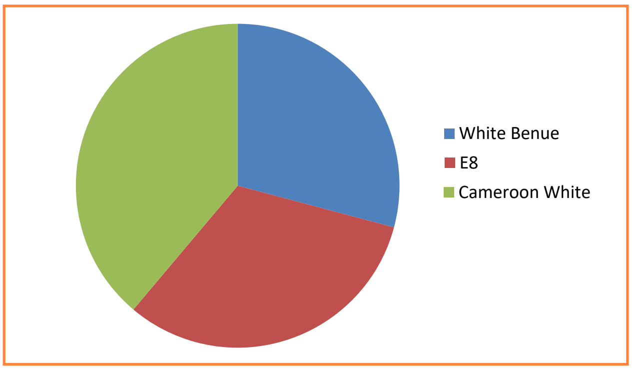

Figure 2 The yield of the three cultivars of sesame

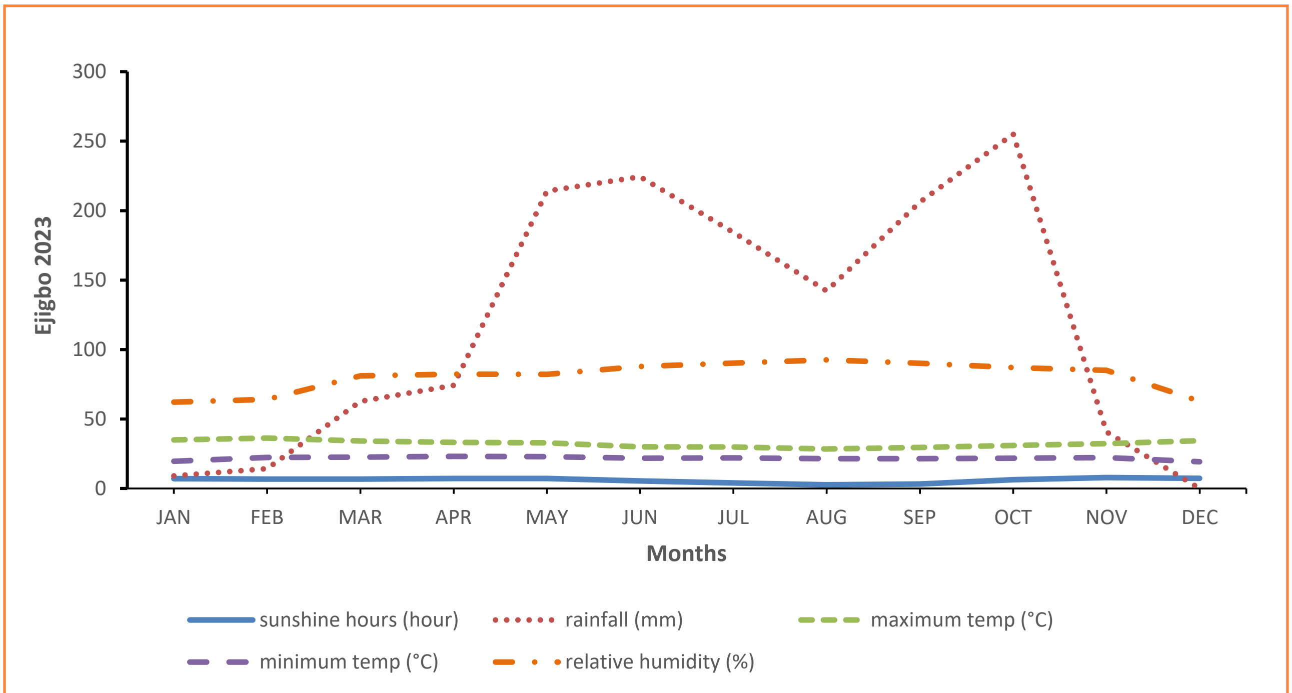

Figure 1 Climate data of derived Savanna in 2023 (Nimeta, 2023)

3.1.1 The Mineral Composition of the Three Cultivars of Sesame Flour

Figure 3 shows the iron content in the three cultivars of sesame. Significant difference at P level of 0.05 was observed in this parameter. Iron was highest in White Benue (4.46%), followed by E8 (4.45%) and significantly lowest in Cameroon White (4.34%). This suggests that White Benue and E8 are better sources of dietary iron than Cameroon White. Figure 4 shows the calcium content in the three cultivars of sesame. Significant difference at P level of 0.05 was observed in this parameter. Calcium was significantly highest in Cameroon White (0.68%), followed by E8 (0.65%) and lowest in White Benue (0.63%). This implies that Cameroon White may be more suitable where dietary calcium improvement is desired. Figure 5 showed the zinc content in the three cultivars of sesame. Significant difference at P level of 0.05 was not observed in the parameter. Zinc value ranges from 2.07% to 2.09%. Zinc concentration did not differ significantly among the three cultivars. This indicates that genotypic differences had little influence on zinc accumulation in the present environment and that all three cultivars provide comparable zinc levels. Figure 6 shows the potassium content in the three cultivars of sesame. Significant difference at P level of 0.05 was observed in the parameter. Potassium was highest in E8 (1.17%), followed by Cameroon White (1.16%) and significantly lowest in White Benue. Figure 7 showed the phosphorus content in the three cultivars of sesame. Significant difference at P level of 0.05 was observed in the parameter. Phosphorus was highest in E8 (0.53%),

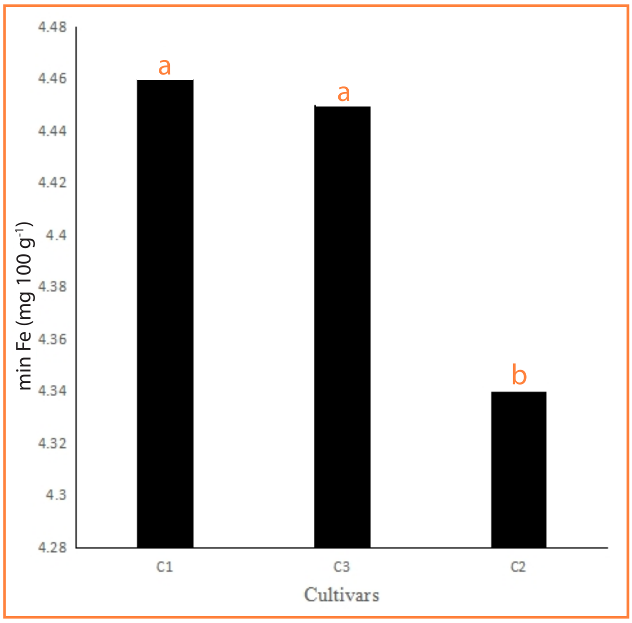

Figure 3 The iron content in the three cultivars of sesame flour
C1 – white benue, C2 – cameroon white, C3 – E8

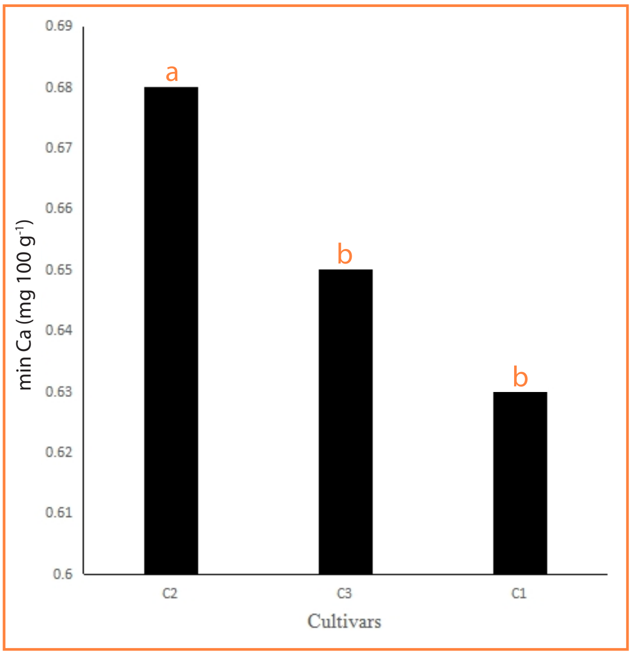

Figure 4 The calcium content in the three cultivars of sesame flour
C1 – white benue, C2 – cameroon white, C3 – E8

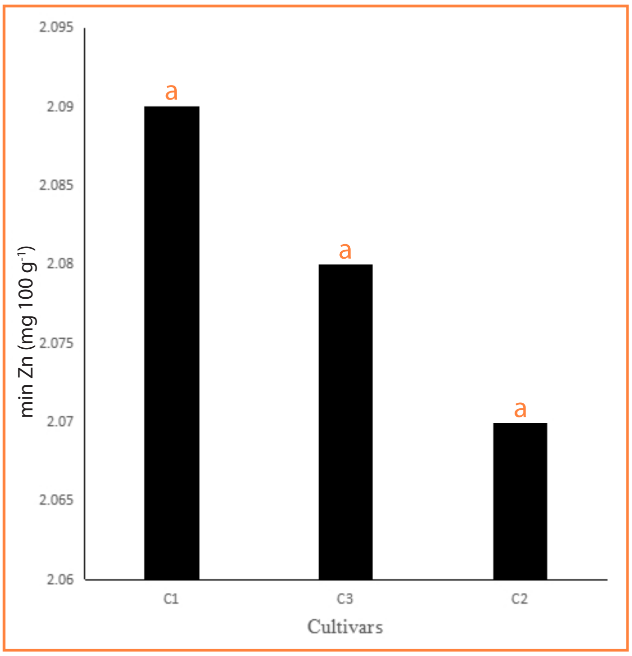

Figure 5 The zinc content in the three cultivars of sesame flour
C1 – white benue, C2 – cameroon white, C3 – E8

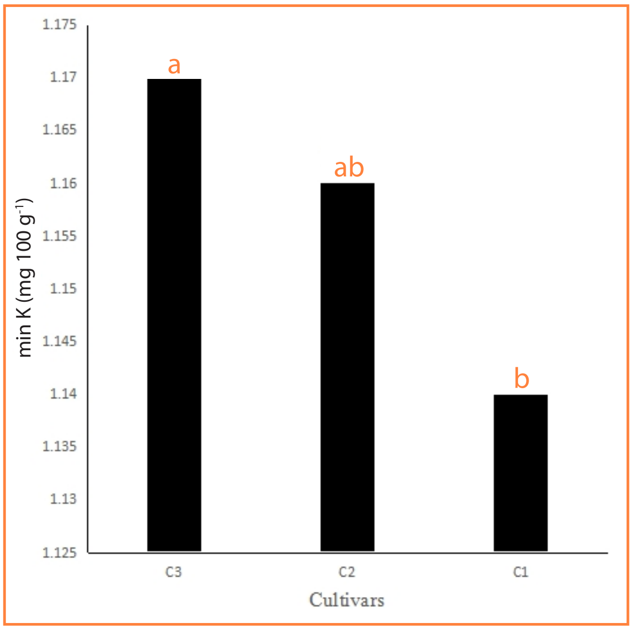

Figure 6 The potassium content in the three cultivars of sesame flour
C1 – white benue, C2 – cameroon white, C3 – E8

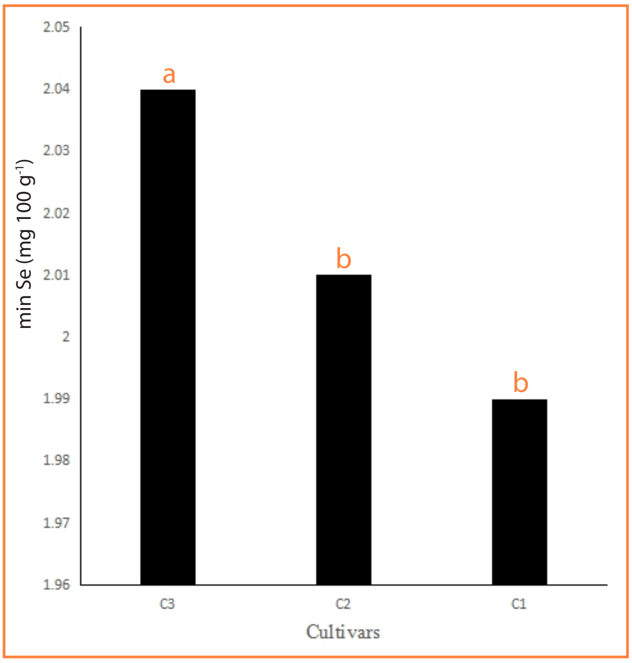

Figure 8 The selenium content in the three cultivars of sesame flour
C1 – white benue, C2 – cameroon white, C3 – E8

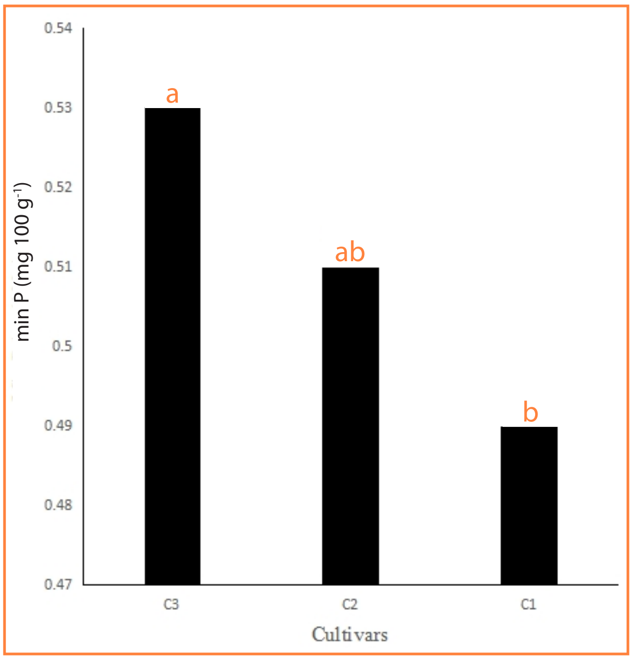

Figure 7 The phosphorus content in the three cultivars of sesame flour
C1 – white benue, C2 – cameroon white, C3 – E8

followed by Cameroon White (0.51%), and lowest in White Benue (0.49%). Figure 8 showed the selenium content in the three cultivars of sesame. Significant difference at P level of 0.05 was observed in the parameter. Selenium was significantly highest in E8 with a value of 2.04%, followed by Cameroon White with a value of 2.01% and low in White Benue with a value of 1.99%. This suggests that E8 has superior selenium concentration, which is important for antioxidant-related nutritional benefits.

3.1.2 The Phytochemicals Composition in the Three Cultivars of Sesame Flour

Table 3 shows the result of phytochemicals composition in the three cultivars of sesame. Significant difference at P level of 0.05 was observed among the parameters except in alkaloids and phytic acid. Alkaloids value was 5.87% across the cultivars. Tannins were highest in E8 with a value of 1.94% followed by the White Benue with a value of 1.93% although it was not significantly different from E8 and was significantly low in Cameroon White. There was no significant difference in phytic acid across the cultivars but it was higher in White Benue and E8 (0.13%) and lower in Cameroon White (0.12%). Flavonoid ranges from 10.86% to 27.48% as there was no significant difference statistically, across the cultivars.

Alkaloids and phytic acid did not differ significantly among the cultivars, indicating similar levels of these compounds. Tannins differed significantly, with E8 and White Benue having higher values than Cameroon White. Flavonoids were highest in White Benue, although

Table 3 The Phytochemicals composition in the three sesame cultivars (flour)

Parameters (%)	White benue	Cameroon white	E8	LSD
Alkaloids	5.89[a]	5.89[a]	5.89[a]	0.0232
Tannins	1.93[a]	1.86[b]	1.94[a]	0.0376
Phytic acid	0.13[a]	0.12[a]	0.13[a]	0.016
Flavonoids	27.48[a]	10.98[a]	10.86[a]	29.40

a, b – means on the same row with different superscript are significantly different ($P < 0.05$) according to Duncan's multiple range test; LSD means Least Significant Difference

the large variation resulted in no statistical difference among cultivars.

The very high flavonoid level observed in White Benue indicates that this cultivar possesses stronger antioxidant potential compared with the others

3.2 Discussion

Olowe et al. (2024) found that E8 and Cameroon White grain yield was 1.2 t ha^{-1} each, while White Benue grain yield was 1.3 t ha^{-1} in 2020. Yields obtained within the work under this paper were lower compared to the reported. This variation might be due to differences in nutrient source, soil type and location/environment and climatic condition. Zinc is crucial for immunity, protein synthesis, and cell growth. Zinc was not significantly different across the cultivars, but Cameroon White was with the highest value. This was contrary to the observation of Nguyen et al. (2021), they reported that E8 has a higher zinc composition compared to White Benue and Cameroon White. The variation might be based on soil mineral composition and environment. Selenium is an essential trace element that plays a critical role in antioxidant defense. Selenium content can be influenced by soil conditions and cultivar differences; the cultivar's ability to take up selenium from the soil. E8 has higher selenium levels compared to the other cultivars (Smith et al., 2022), this study corroborates that report, E8 has the highest value also in this study.

Iron is vital for oxygen transport and energy production. E8 exhibits higher iron levels (Chen et al., 2019), this result also recorded the highest level of iron in E8. This implies that E8 consumption will help in blood boosting or synthesis and can be helpful in combating anemia in pregnant women and nursing mothers including the aged. Phosphorus is essential for bone health and energy metabolism. Phosphorus levels are relatively stable among cultivars but can vary slightly. E8 generally has higher phosphorus content (Lee et al., 2020). This difference is influenced by the cultivar's ability to accumulate phosphorus. E8 generally has higher phosphorus content (Lee et al., 2020), this result also recorded the highest value of phosphorus in E8. Potassium is crucial for maintaining fluid balance and cell function. Potassium content may vary, with E8 generally having slightly higher levels (Nguyen et al., 2021). Differences are related to the cultivar's ability to uptake potassium from the soil, this result also conforms to it, as E8 was with the highest value. Calcium is essential for bone health and various cellular functions. Calcium content is often higher in E8 compared to the other cultivars (Chen et al., 2019), this result is slightly different from Chen et al., (2019) as Cameroon White had the highest value in this study.

Alkanoids are compounds that occur normally in plants that mostly have potent biological activities, and their concentrations may differ significantly across the cultivars. According to Nguyen et al. (2021), E8 has about 0.15% of alkaloids, while White Benue and Cameroon White had 0.12% and 0.10%, respectively, this result shows the three cultivars has same alkaloids content. Tannins are polyphenolic compounds which are recognized for their antioxidant properties and their ability to bind and precipitate proteins. Lee et al. (2020) found that White Benue contained approximately 0.45% tannins, while E8 and Cameroon White had 0.40% and 0.38%, respectively, this study corroborates these findings. Phytic acid is a form of phosphorus that acts as an anti-nutrient by binding minerals and reducing their bioavailability. Chen et al., (2019) reported that Cameroon White has higher phytic acid content compared to E8 and White Benue. This study deviates from the report of Chen et al., (2019), the location and climatic conditions may be the factors. Flavonoids represent a group of polyphenolic compounds which has antioxidant properties; scavenging free radicals, reducing inflammation and providing cardiovarscular protection (Panche et al., 2016). Flavonoid content, which contributes to antioxidant activity, can vary among cultivars. E8 generally has a higher flavonoid content compared to White Benue and Cameroon White, this study reports a slightly higher flavonoid content in White Benue compared to E8 and Cameroon White which is contrary Chen et al., (2019) report. This implies that White Benue will be an important food ingredient for people who need to improve their intake of antioxidants diet.

4 Conclusions

Cultivar selection significantly influenced both yield and nutritional composition of sesame grown under the derived savanna. Cameroon White produced the highest seed yield under the derived savanna conditions of the study area, indicating its superior agronomic performance. However, White Benue and E8 exhibited distinct advantages in mineral and phytochemical compositions, particularly in iron, selenium and flavonoid contents. Although all three cultivars showed strong potential to contribute to human nutrition and food security, further multi-season and multi-location evaluations are recommended to validate the stability of these performance trends. Overall, the three cultivars possess complementary agronomic and nutritional attributes, and all can contribute meaningfully to food and nutritional security.

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