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Research Article

Effects of processing methods on fatty acid composition of three sesame (*Sesamum indicum* L.) cultivars

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ABSTRACT

Sesame seeds are valued for their high nutritional and medicinal benefits globally. This study investigated the effects of cold and heat processing methods on the fatty acid compositions of sesame seed oil. Three varieties namely: White Benue, Cameroon White, and E8 were cultivated using standard agronomic practices in Ejigbo Campus of Osun State University in 2024. The seeds were evaluated for fatty acids using standard assays. Linoleic acid composition was significantly highest in E8 with a value of 11.81% and significantly lowest in Cameroon White with a value of 11.65%. Linolenic acid, Lauric acid, Capric acid, Myristoleic acid and Palmitic acid compositions were significantly highest in White Benue. Behenic acid composition was 0.03% as there was no significant difference across the cultivars. Linoleic acid had its highest significant value in the cold extracted oil (12.08%) in comparison with its value in the high heat extracted oil (11.22%). Linolenic acid was significantly highest in mild heat extracted oil (11.70%) in comparison with other methods of extraction. Stearic acid was significantly highest in cold extracted oil (13.13%) while high-heat extracted oil had lowest value (11.26%). Palmitic acid had its highest significant value (18.21%) in cold extracted oil and its lowest value (17.15%) in high-heat extracted oil. Cold-pressed oil is richer in nutritional compositions, preserving the essential fatty acids in sesame seeds. However, when heat needs to be applied, it has to be moderate (400C) in order not impair the health-promoting substances in the sesame oil.

Keywords: Sesame; sesame oil; processing methods; Omega 3-fatty acids.

Introduction

Sesame seeds, part of the *Sesamum* genus in the Pedaliaceae family, were the first oilseed cultivated for edible oil. Between 2002 and 2016, sesame seed production expanded significantly, from 2.8 million tons on 6.3 million hectares to 6.2 million tons on 11 million hectares [1]. Most of sesame cultivation occurs in Asia and Africa, with Tanzania, India, and Sudan being the leading producers [2].

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 goods.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 extraction, it is therefore regarded as an unconventional source of protein [3].

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 organs. Its high oil content not only lubricates the intestinal tract,

but also nourishes the internal organs [4]. By soothing minor burns or sunburns and accelerating the healing process, sesame oil can also aid in the healing of burns. In addition, sesame oil has other uses such as a solvent, skin softener, natural UV protection, and oil carrier for pharmaceuticals [5].When applied topically, sesame oil has some analgesic properties. For instance, individuals with chemotherapy-induced phlebitis may find that using sesame oil massage as an adjuvant treatment significantly lessens the intensity of their discomfort [6]. Acute traumatic limb pain can also be effectively relieved by massage with sesame oil [7].

Beni-seeds, as they are commonly called in Nigeria, are a crucial component of the country's agricultural economy as they are one of the most commercially viable crops. The Food and Agriculture Organization (FAO) reports that Nigeria's sesame production has fluctuated throughout time in relation to demand, despite the crop's high viability. Sesame seed oil extracts are used in a variety of ways. It is used in cooking, aerosol manufacture, margarine manufacturing, and medicine to cure burns and ulcers. Additionally, locally produced lubricants, illuminants, and soap paints are made from low-grade sesame oil. Animal feed is made from the by-product of processing sesame seeds [8].

The composition of fatty acids in sesame seeds is determined by different factors including the variety of the seed and the processing methods used [9]. Given the nutritional and health significance of fatty acids, it is crucial to understand how processing affects their composition. Processing methods can degrade or alter the fatty acid composition of sesame oil , thereby impacting the quality and nutritional value of sesame oil [10]. Roasting sesame seeds under high-heat can result into oxidation of unsaturated fatty acids, leading to the formation of trans fats or other undesirable compounds [11]. The response of different varieties of sesame varies, some are more resistant to fatty acids degradation than others [12]. Therefore, it is essential to study the effects of processing on fatty acids of these selected varieties of sesame to optimize processing techniques and ensure the production of high-quality sesame oil. This study assessed the impact of processing methods on the fatty acid of sesame seed oil and compared the fatty acid compositions of three sesame cultivars. This study is important for both consumers and the food industry understanding the changes in fatty acid profiles after processing, it will help the producers to improve their methods and provides consumers with healthier oil options.

Materials and Methods

Field Study

The experiment was carried out at Osun State University, Ejigbo Campus and Redeemer's University, Ede, Osun State. Sesame cultivation, primarily restricted to northern Nigerian states, underwent a recent pilot cultivation at the Federal University of Abeokuta (FUNAAB) in Ogun State. In August 2023, three sesame varieties (white Benue, white Cameroon, and E8) were collected from FUNAAB and cultivated in Osun State University. The 3 varieties of the harvested sesame seeds were processed for oil. The seed were sorted, and cleaned. For oil extraction, 3 methods were used namely: i) cold press i.e. no heat was applied on the seeds before oil extraction; ii) mild heat, roasting of seeds was done at 40-85^{0}C before oil extraction; and iii) high heat, roasting of seeds was done at 180-220^{0}C before oil extraction [13].

Laboratory Analysis

The analysis was to determine the active compound. Composition of fatty acid was determined using method ISO 5508 (1990). Before analysis, fatty acids (FAs) were converted to fatty acid methyl esters (FAMEs) by shaking a solution of 60 mg oil and 3 mL of hexane with 0.3 mL of 2 N methanolic potassium hydroxide. Fatty Acids were analyzed by gas chromatography using a Autosystem-2 version 6,32,0646 chromatograph equipped with an FID. The column used was a CP-Wax 52CB column (30 m 0.25 mm i.d.;autosystem Middelburg, The Netherlands). The carrier gas was helium and the total gas flow rate was 1 mL/min. The initial and final column temperature waere 170^{0}C and 230^{0}C, respectively, and the temperature was increased by steps of 40C/min. The injector and detector temperature was 230^{0}C. Data were processed using a Varian Star Workstation v 6.30 (Varian Inc., Walnut Creek, CA, USA). Results were expressed as the relative percentage of each individual Fatty Acid present in the sample.

Statistical Analysis

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

Results

The Essential fatty and Non-essential acids composition in the three sesame cultivars (Oil)

Table 1 shows the result of the essential fatty acids(stating the reason why they are essential with in-text references). Significant difference at P level of 0.05 was observed among the parameters. Linoleic acid composition was significantly highest in E8 with a value of 11.81% and significantly lowest in Cameroon White with a value of 11.65%. Linolenic acid composition was significantly highest in White Benue and E8 with a value of 11.35% and significantly lowest in Cameroon White with a value of 11.30%.

Table 2 shows the result of the non-essential fatty acids in the three sesame cultivars. Significant difference at P level of 0.05 was observed among the parameters except in Eicosanoic acid, Elaidic acid and Behenic acid. Stearic acid composition was significantly highest in E8 and significantly lowest in Cameroon White 12.09%. Palmitic acid composition was significantly highest in White Benue with a value of 18.10% and significantly lowest in Cameroon White with a value of 17.59%. Palmitoleic acid composition was significantly highest in White Benue with a value of 1.15%, followed by Cameroon White (1.07%),

significantly lowest in E8 with a value of 0.97% Cameroon White is not significantly different from White Benue and E8. Lauric acid composition was highest in White Benue with a value of 2.12%, followed by E8 with a value of 2.06% and significantly lowest in Cameroon White with a value of 1.53%. Capric acid composition was significantly highest in White Benue with a value of 9.58% and significantly lowest in Cameroon White with a value of 9.26%. Caprylic acid composition was significantly highest in E8 with a value of 0.04%, followed by White Benue and Cameroon White with a value of 0.03%. Myristic Acid was significantly highest in E8 with a value of 2.75% and significantly lowest in Cameroon White with a value of 2.52%. Myristoleic acid composition was significantly highest in White Benue with a value of 9.78% and significantly lowest in E8 with a value of 9.74%. Eicosanoic acid composition was with a value of 0.03% as there was no significant difference across the cultivars. Elaidic acid composition was with a value 0.03% as there was no significant difference across the cultivars. Pentadecanoic acid composition was significantly highest in White Benue with a value of 0.05% and significantly lowest in E8 with a value of 0.02%. Heptadecanoic acid composition was significantly highest in E8 with a value of 1.88%, followed by White Benue and Cameroon White with a value of 1.78%. Eruic acid composition was significantly highest in E8 with a value of 0.04% and significantly lowest in Cameroon White and White Benue with a value of 0.03%. Behenic acid composition was with a value of 0.03% as there was no significant difference across the cultivars.

Table 1. Essential Fatty acids composition in the three cultivars seeds

Parameters (%)	White Benue	Cameroon White	E8	LSD
Linoleic acid (Omega 6)	11.76^{b}	11.65^{c}	11.81^{a}	0.0107
Linolenic acid (Omega 3)	11.35^{a}	11.30^{b}	11.35^{a}	0.0107

^{abc} 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.

Table 2. Non-essential Fatty acids composition in the three cultivars seeds

Parameters (%)	White Benue	Cameroon White	E8	LSD
Palmitic acid	18.10^{a}	17.59^{c}	17.82^{b}	0.0201
Stearic acid	12.45^{b}	12.09^{c}	12.46^{a}	0.0087
Palmitoleic acid	1.15^{a}	1.07^{ab}	0.97^{b}	0.1502
Lauric acid	2.12^{a}	1.53^{c}	2.06^{b}	0.0192
Capric acid	9.58^{a}	9.26^{c}	9.41^{b}	0.0495
Caprylic acid	0.03^{b}	0.03^{b}	0.04^{a}	0.0068
Myristic acid	2.71^{b}	2.52^{c}	2.75^{a}	0.0142
Myristoleic acid	9.78^{a}	9.76^{b}	9.74^{c}	0.0136
Eicosanoic acid	0.03^{a}	0.03^{a}	0.03^{a}	0.0086
Elaidic acid	0.03^{a}	0.03^{a}	0.03^{a}	0.0072
Pentadecanoic acid	0.05^{a}	0.04^{b}	0.02^{c}	0.008
Heptadecanoic acid	1.78^{b}	1.78^{b}	1.88^{a}	0.0105
Eruic acid	0.03^{b}	0.03^{b}	0.04^{a}	0.0105
Behenic acid	**0.03^{a}**	**0.03^{a}**	**0.03^{a}**	**0.0051**

^{abc} 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

Influence of processing methods on the Essential and Non-essential fatty acids composition of Sesame Oil.

Table 3 showed the influence of processing methods on the Essential fatty acids composition of Sesame Oil. Significant difference at P level of 0.05 was observed among the parameters. Linoleic acid had its highest significant value in the cold extracted oil (12.08%) and its lowest significant value in the high-heat extracted oil (11.22%). Linolenic acid was significantly highest in mild-heat extracted oil (11.70%) and significantly lowest in high-heat extracted oil (11.13%).

Table 4 showed the influence of processing methods on the Non-essential fatty acids composition of Sesame Oil. Significant difference at P level of 0.05 was observed among the parameters. Stearic acid was significantly highest in cold extracted oil with a value of 13.13% and significantly lowest in high-heat extracted oil with a value of 11.26%. Palmitic acid had its highest significant value of 18.21% in cold extracted oil and its lowest significant value of 17.15% in high-heat extracted oil. Palmitoleic acid was highest in cold extracted oil, 1.14%, followed by mild-heat extracted oil, 1.12% and significantly lowest in high-heat extracted oil, 0.93%. Lauric acid was significantly highest in mild-heat extracted oil, 2.06% and significantly lowest in high-heat extracted oil, 1.78%. Capric acid was significantly highest in cold extracted oil, 9.93% and significantly lowest in high-heat extracted oil, 9.07%. Caprylic acid was significantly highest in cold extracted oil, 0.05% , followed by mild-heat extracted oil, high-heat extracted oil, 0.02%. Myristic acid was significantly highest in cold extracted oil, 2.77% and significantly lowest in high-heat extracted oil, 2.47%. Myristoleic acid was significantly highest in the cold extracted oil, 9.92% and significantly lowest in high-heat extracted oil, 9.56%. Eicosanoic acid was significantly higher in cold extracted oil, mild-heat extracted oil, 0.04% and significantly lower in high-heat extracted oil, 0.02%. Elaidic acid had its highest significant value of 0.04% in cold extracted oil, followed by mild-heat extracted oil, 0.03% and high-heat extracted oil, 0.02%. Pentadecanoic acid was significantly higher in cold extracted oil, 0.05%, significantly lower in mild-heat extracted oil and high-heat extracted oil, 0.03%. Heptadecanoic acid was significantly highest in the cold extracted oil, 2.01% and significantly lowest in mild-heat extracted oil, 1.66%. Eruicacid was significantly higher in the cold extracted oil, 0.05% and significantly lower in mild-heat and high-heat extracted oil, 0.03%. Behenicacid had its highest significant value of 0.04% in cold extracted oil and significantly lower in mild-heat extracted oil and high-heat extracted, 0.02%.

Table 3. Influence of processing methods on the essential fatty acids composition of Sesame Oil.

Parameters (%)	Cold	Mild	High	LSD
Linoleic acid	12.08^{a}	11.92^{b}	11.22^{c}	0.0107
Linolenic acid	11.18^{b}	11.70^{a}	11.13^{c}	0.0107

^{abc} 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.

Table 4. Influence of processing methods on the non-essential fatty acids composition of Sesame Oil.

Parameters (%)	Cold	Mild	High	LSD
Palmitic acid	18.21[a]	18.15[b]	17.15[c]	0.0201
Stearic acid	13.13[a]	12.61[b]	11.26[c]	0.0087
Palmitoleic acid	1.14[a]	1.12[a]	0.93[b]	0.1502
Lauric acid	1.88[b]	2.06[a]	1.78[c]	0.0192
Capric acid	9.93[a]	9.25[b]	9.07[c]	0.0495
Caprylic acid	0.05[a]	0.02[b]	0.02[b]	0.0068
Myristic acid	2.77[a]	2.74[b]	2.47[c]	0.0142
Myristoleic acid	9.92[a]	9.81[b]	9.56[c]	0.0136
Elacosanoic acid	0.04[a]	0.04[a]	0.02[b]	0.0086
Elaidic acid	0.04[a]	0.03[b]	0.02[b]	0.0072
Pentadecanoic acid	0.05[a]	0.03[b]	0.03[b]	0.008
Heptadecanoic acid	2.01[a]	1.66[c]	1.77[b]	0.0105
Eruic acid	0.05[a]	0.03[b]	0.03[b]	0.0105
Behenic acid	0.02[a]	0.02[b]	0.02[b]	0.0051

[abc] 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.

Discussion

The Essential Fatty acids composition of the three sesame cultivars (Oil).

Essential fatty acids are those that the body cannot synthesize and must be obtained from the diet. Linoleic acid is one of such essential fatty acids, it is crucial for maintaining skin health, lowering blood cholesterol levels, and supporting overall cardiovascular function (Goyens, 2014). It is also critical for preserving cellular function, lowering inflammation, and promoting brain health (Simopoulos, 2016).

According to [13], E8 is noted for its higher linoleic acid content, this result also recorded higher level linoleic acid in E8. This result shows that White Benue was with moderate level of linoleic and higher level of linolenic acids and this is in close conformity to [14], they found that White Benue sesame flour generally contains a balanced ratio of linoleic to linolenic acids, often showing a moderate level of linolenic acid. This result shows a lower level of moderate level of linolenic acid in Cameroon White and this is in close conformity to the report of [15], they reported that Cameroon White t ends to have higher levels of linolenic acid compared to other cultivars.

The Non-essential Fatty acids composition of the three sesame cultivars (Oil)

Non-essential fatty acids can be synthesized by human body. This result recorded that E8 has higher level of stearic acid, caprylic acid, myristic acid and more and this in close conformity to the findings of [16], they reported that E8 has higher levels of palmitic acid, stearic acid, moderate levels of palmitoleic acid and myristoleic acids. This result recorded that White Benue has higher level of palmitoleic, lauric, capric, palmitic acids and many more acids and this is in close conformity to the findings of [17], they reported that White Benue often shows a balanced ratio of lauric, capric, and caprylic acids. Additionally, White Benue has been observed to contain lower levels of palmitic acid but higher levels of eicosanoic acid compared to other cultivars. This result recorded that Cameroon White was with higher level of behenic, elaidic, eicosanoic acids, moderate level of eruic, pentadecanoic, heptadecanoic, caprylic, palmitoleic, myristoleic acids and level in the remaining acids and this is close conformity to [18], they found that Cameroon White has higher levels of erucic and behenic acids. Research by [19] highlights that this cultivar tends to have elevated levels of both these long-chain fatty acids, which can affect the oil's texture and stability. It also shows relatively higher levels of pentadecanoic and heptadecanoic acids.

The Effect of Cold extraction on the Essential Fatty acid acids of Sesame Oil

Pressing sesame seeds at temperatures below 40°C is known as "Cold Extraction". This process is well-known for protecting delicate nutrients and retaining the oil's original quality.

Linoleic Acid: Since there is less heat exposure during cold extraction, linoleic acid, an important omega-6 fatty acid, is efficiently preserved [20]. When comparing this process to heat-based extraction techniques, its larger amount is maintained, in this study cold extraction was also observed to preserved the level of linoleic acid in the oil.

Linolenic Acid: Another important omega-3 fatty acid that is well-preserved in cold extraction is linolenic acid. This is because the oxidation and breakdown of this delicate fatty acid are inhibited by cold temperatures [21], this result showed a minimal reduction in the linolenic acid level in the cold extracted oil.

The Effect of Mild-heat and High-heat extraction on the Essential Fatty acids of Sesame Oil

Higher recovery rates of linoleic and linolenic acids without appreciable degradation are possible with mild Soxhlet extraction, which usually uses lower temperatures and may assist maintain the integrity of these fatty acids [22], this result also recorded a minimal loss of linoleic acid and high level of linolenic acid in the mild-heat extracted oil.

By comparison, high-temperature Soxhlet extraction can speed up the extraction process but can cause important fatty acids to be thermally degraded and altered, which could lower their concentrations and bioavailability [23], this result also showed a significant loss of linoleic and linolenic acids in the mild-heat extracted oil.

The Effect of Cold extraction on the Non-essential Fatty acids of Sesame Oil

Palmitic and Stearic Acids: Stearic and palmitic acids are both efficiently preserved by cold extraction. According to [24], these fatty acids do not significantly degrade at low temperatures and are comparatively stable, this result recorded a high level of palmitic acid and stearic acid in the cold extracted oil.

Myristic and palmitoleic acids: Since little heat is needed to oxidize them, palmitoleic and myristic acids also hold up well during cold extraction [25], this result also recorded a high level of myristic and palmitoleic acids in the cold extracted oil.

Caprylic, capric, and lauric acids: Due to decreased thermal degradation, cold extraction helps preserve the quantities of these short-chain fatty acids, despite their decreased prevalence in sesame oil [26], this result also recorded a high level of caprylic, capric, and lauric acids in the cold extracted oil.
Myristoleic Acid and Eicosanoic Acid: Since heat-induced degradation does not occur, these fatty acids are well-preserved under cold extraction conditions [27], this result also recorded a high level of myristoleic and eicosanoic acids in the cold extracted oil.
Elaidic Acid, Pentadecanoic Acid, Heptadecanoic Acid, Erucic Acid, and Behenic Acid: These fatty acids are less affected by cold extraction, maintaining their composition due to low heat exposure [28], this result also recorded a high level of elaidic, pentadecanoic ,heptadecanoic, eruic and behenic acids in the cold extracted oil.

The Effect of Mild-heat extraction on the Non-essential Fatty acids of Sesame Oil

Palmitic and stearic acids:Due to moderate heat exposure, mild-heat extraction results in a modest drop in stearic and palmitic acids; however, their levels remain generally stable when compared to high-heat procedures [29], this result also recorded a minimal loss of palmitic and stearic acids in the mild-heat extracted oil.

Myristic acid and palmitoleicacid:These acids degrade somewhat when extracted at mild temperatures, but not as much as when extracted at high temperatures [30], this result also recorded a minimal loss of myristic and palmitoleic acids in the mild-heat extracted oil.

Lauric Acid, Capric Acid, and CaprylicAcid:Because of their oxidation susceptibility, these fatty acid levels are somewhat lowered at mild heat [31], this result also recorded high level of lauric acid, minimal loss of capric and caprylic acids in the mild-heat extracted oil.

Myristoleic Acid and Eicosanoic Acid: Because moderate heat can alter these fatty acids' stability, mild heat extraction leads in some loss of these fatty acids [32], this result also recorded a minimal loss of myristoleic acid and high level in eicosanoic acid in the mild-heat extracted oil.
Elaidic Acid, Pentadecanoic Acid, Heptadecanoic Acid, Erucic Acid, and Behenic Acid: These fatty acids show moderate reductions under mild-heat extraction due to thermal sensitivity [33], this result also recorded minimal loss of elaidic, pentadecanoic, eruic, behenic acids and significant loss of heptadecanoic acid.

The Effect of High-heat extraction on the Non-essential Fatty acids of Sesame Oil

Stearic Acid and Palmitic Acid: High-heat extraction results in significant reductions in both stearic and palmitic acids due to heat-induced degradation [34], this result also recorded a significant loss of stearic acid palmitic acids in the high-heat extracted oil.
Palmitoleic Acid and Myristic Acid: These fatty acids are prone to substantial degradation under high heat, leading to notable losses [35], this result also recorded a significant loss of palmitoleic and myristic acids in the high-heat extracted oil.

Lauric Acid, Capric Acid, and Caprylic Acid: High-heat conditions lead to severe reductions in these fatty acids due to their susceptibility to oxidation and thermal degradation [31], this result also recorded a significant loss of lauric acid capric acid and minimal loss of caprylic acid in high-heat extracted oil.
Myristoleic Acid and Eicosanoic Acid: These fatty acids toare highly sensitive to high temperatures, resulting in significant loss during high-heat extraction [29], this result also recorded a significant loss of myristoleic and minimal loss of eicosanoic acid in the high-heat extracted oil.

Elaidic Acid, Pentadecanoic Acid, Heptadecanoic Acid, Erucic Acid, and Behenic Acid: According to [38], these fatty acids also experience significant reductions due to their thermal senfsitivity, this result is a little bit contrary to [30] as it recorded a minimal loss of elaidic, pentadecanoic, heptadecanoic, eruic and behenic acids in the high-heat extracted oil.

Conclusion

This research thoroughly examined the effects of various processing methods on the nutritional composition of sesame (*Sesamum indicum* L.) seed oil. Through comprehensive analyses, it was established that processing techniques significantly influence the nutritional profile of sesame oil. It was observed that cold-pressed oil is richer in nutritional compositions, preserving the essential and non-essential fatty acids inherent in sesame seeds. However, when heat needs to be applied, it has be low or moderate temperature to prevent negative influence on the health-promoting substances in the sesame products. All cultivars appear to be unique nutritionally, and they can be selected based on specific nutritional needs or desired health benefits. This diversity offers a wide range of possibilities for the use of sesame in different dietary applications.

By implementing these recommendations, the sesame industry in Nigeria can be significantly enhanced, leading to improved health outcomes for consumers and greater economic benefits for those involved in sesame production and processing. Embracing advanced processing technologies and refining existing methods can create high-quality sesame oil that meet both domestic and international market demands. Moreover, leveraging the unique nutritional profiles of different sesame cultivars can open new avenues for product development and innovation.

Author Contributions

FMO conceptualized the work. Data collection was done by DIT. DIT also wrote the first draft of the manuscript with routine critical reviews by FMO. GGD did the laboratory analysis. All authors have read and approved the final version of the paper and its submission and have given consent for publication.

Declaration of Generative AI and AI-Assisted Technologies in Scientific Writing

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Data Availability Statement

All relevant data are available within the manuscript

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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