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Research Article

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Effect of accelerated ageing on variability in oil yield and proximate composition of sesame seed accessions

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ABSTRACT
This study determined the effect of accelerated ageing on variability in oil yield and proximate composition of sesame seed accessions using the standard procedure of the Association of Official Analytical Chemists (AOAC). Sesame seeds were collected from the experimental farm of the National Cereal Research Institute (NCRI), Badeggi, Niger State, Nigeria. Results showed that NCRIBEN203 had the highest oil yield of 54.63±0.44%. Proximate analysis results indicated that NCRIBEN131 had the highest crude protein and crude fat contents of 25.29±0.26% and 52.82±1.44%, respectively, while NCRIBEN201 had the highest crude fibre content of 4.31±0.17%. The study revealed that accelerated ageing does not have a marginal effect on the mineral-rich profile of sesame seed accessions. Therefore, it is recommended that sesame seed accessions that exhibit superior and desirable qualities should be selected and cultivated for purposes of consumption and industrial use. Also, adequate measures such as drying should be employed to reduce the moisture content in sesame seeds before storage to prevent microbial growth and seed deterioration.
Keywords: Sesame Seed, Accelerated Ageing, Oil Yield, Accessions, Crude Fat, Proximate Composition

INTRODUCTION

Sesame (*Sesamum indicum L.*) is one of the world's most important and oldest known oilseed crops (Abou-Gharbia *et al*., 2000). It is grown mostly for the oil extracted from the seed, which is edible and used for industrial and pharmaceutical purposes. The oil is used in the production of perfumes moisturizers, hair creams, bath oil, insecticides, paints, vanishes and drugs (Mohammed and Hamza, 2008). The seed is also consumed throughout the world in condiments and as an essential constituent in different recipes (Alyemeni *et al*., 2016). It is used to add texture and flavour to bread, biscuits, crackers, and salad dressing. Sesame seed has been shown to contain about 35% to 60% of oil (Jimoh *et al*., 2011; Singh *et al.*, 2022).

Nigeria is one of the major producers and exporters of sesame seed and is ranked 6th among world sesame-producing countries and the 2nd largest in Africa (FAO, 2015). The production of sesame in Nigeria is concentrated in the Guinea Savannah zone (Middle Belt). The quantity and quality of the oil contained in the seed have been shown to depend on ecological factors such as climate and soil type, and on cultivars and the maturity of the plant (Rahman *et al*., 2007). Accelerated ageing is recognized as an accurate indicator of seed vigour and storability, as it correlates with field emergence. The seeds that are exposed to accelerated ageing conditions generally show a marked reduction in germination (Hampton *et al*., 2004; McDonough *et al*., 1999). Accelerated ageing also results in an increase in lipid peroxidation and a decrease in the activities of antioxidants and several enzymes which were involved in scavenging free radicals and peroxide (Atici *et al*., 2007).

The impact of accelerated ageing on the oil yield and proximate composition of sesame seed accessions remains poorly understood, especially in the study area. This knowledge gap presents a challenge in optimizing sesame production and its post-harvest management. Understanding the effects of accelerated ageing on sesame seeds can inform storage and handling practices. It can also help farmers, processors, and exporters make informed decisions on how to maintain seed quality throughout the supply chain. In addition, the study's insights can aid in promoting healthier diets by selecting sesame seeds with improved proximate composition, which is particularly relevant in the context of sustainable agriculture and food security.

Sesame (*Sesamum indicum*) is a significant oilseed crop valued for its high oil content and nutritional quality. The stability and quality of sesame seeds during storage are critical factors affecting oil yield and proximate composition, which includes moisture, protein, fat, ash, and carbohydrate content. Accelerated ageing tests have been widely used to simulate the effects of long-term storage and environmental stress on seed quality, providing insights into the deterioration patterns of seeds (ISTA, 2014). Accelerated ageing involves exposing seeds to high temperature and humidity for a short period to mimic natural ageing processes. This method helps to assess seed vigor, viability, and biochemical changes. Studies on various oilseed crops indicate that accelerated ageing leads to significant reductions in oil content and changes in proximate composition, often linked to oxidative degradation and enzymatic activities (Delouche & Baskin, 2021; McDonald, 1999).

In sesame, oil yield is a key quality parameter that can be affected by genetic variability among accessions and environmental factors during storage. Research by Shehu. H *et al*. (2023) demonstrated that accelerated ageing caused a noticeable decline in oil content among different sesame genotypes, with some accessions showing greater tolerance to ageing effects. This variability suggests the potential for selecting and breeding sesame varieties with enhanced storage stability. Proximate composition, including protein and moisture content, also changes under accelerated ageing conditions. Increased moisture and reduced protein levels have been reported after ageing, likely due to metabolic degradation and moisture absorption during the ageing process (Kumar & Singh, 2019). Such changes can adversely affect the nutritional and processing quality of sesame seeds.

Moreover, oxidative rancidity during ageing depletes lipid quality, reducing the oil's nutritional and commercial value. Antioxidant enzyme activity and fatty acid profile alterations have been studied to understand the biochemical basis of these changes (Nisar *et al*., 2022).

Overall, accelerated ageing is a valuable tool for assessing the storage potential and biochemical stability of sesame seed accessions. The variability in response among different accessions underscores the importance of genetic diversity in breeding programs aimed at improving sesame seed quality and shelf life.

MATERIALS AND METHODS

Samples: Sesame seeds were collected from field-grown Nigerian accessions during the 2018 growing season (July – October) at the experimental farm of National Cereal Research Institute (NCRI), Badeggi, Niger State, Nigeria. Approximately 100g of sesame seeds harvested at maturity were collected, properly labelled and sun-dried. And taken to the laboratory for further analysis. Twenty accessions of sesame were characterized for oil yield, and five accessions (NCRIBEN201, NCRIBEN203, NCRIBEN131, NCRIBEN121 and NCRIBEN106) were selected for accelerated ageing in a biochemical incubator at a temperature of 40°C and relative humidity of 80%, respectively, for 0, 3 and 6 days. The aged seeds were then subjected to the various biochemical analyses.

Oil extraction: For Soxhlet extraction, 2g of the milled sample was placed in a paper thimble and fed into a Soxhlet extractor, which was fitted with a 500 mL round-bottom flask and a condenser. After extraction, the extra hexane was distilled off under vacuum in a rotary evaporator at 45°C. The extracted oil was weighed, and the yield was calculated.

Proximate Analysis: A sample of seeds from each accession was taken to the laboratory for proximate analysis for the determination of moisture, protein, fat, carbohydrate, ash and fibre content in the seeds. The method of proximate analyses was according to the standard procedure of AOAC (2009).

Moisture content: This was determined by repeatedly drying a 5-gram sample in an oven at 105°C until a constant weight (W2) was achieved, which indicates the absence of moisture.

$$\%\, mositure = \frac{(W2 - W3)}{(W2 - W1} \, x\, 100$$

Where:

W1 = weight of sample

W2 = weight of petri dish + sample before drying

W3 = weight of petri dish + sample after drying

Crude fibre: The organic residue, remaining after seed extraction with petroleum ether, was utilized for determining crude fibre. The fat-free material was subsequently transferred to a flask or beaker, to which 200 mL of pre-heated 1.25% H_2SO_4 was added. The solution was gently boiled for approximately 30 minutes, while maintaining a constant acid volume by adding hot water. A Buckner flask funnel, pre-heated by pouring hot water into it, was used for filtration under sufficient suction of the hot acid sample mixture. The residue was thoroughly washed with boiling water until it reached a neutral pH, then transferred back to the beaker. Following this, 200 ml of pre-heated 1.25% Na_2SO_4 was added and boiled for an additional 30 minutes. The mixture was filtered under suction, washed thoroughly with hot water, and rinsed twice with ethanol. The residue was dried at 65°C for about 24 hours and weighed. Subsequently, the residue was placed in a crucible and subjected to ashing in a muffle furnace at a temperature range of 400-600°C for 4 hours. Afterwards, it was allowed to cool in a desiccator and weighed.

$$\%\, crude\ fibre = \frac{Dry\ weight\ of\ residue\ before\ ashing - weight\ of\ residue\ after\ ashing}{weight\ of\ sample} \, x\, 100$$

Crude protein: The nitrogen content of the seeds was determined and multiplied by a factor of 6.25 to calculate crude protein, based on the standard that most protein contains 16% nitrogen. The determination of crude protein was carried out using the Kjeldahl method, involving three main steps: digestion, distillation, and titration.

For digestion, approximately 2g of the sample was weighed into a Kjeldahl flask, and it was mixed with 25 ml of concentrated sulfuric acid, 0.5g of copper sulfate, 5g of sodium sulfate, and a trace of selenium tablet. Heat was applied gradually in a fume cupboard to prevent excessive frothing, and the digestion process continued for 45 minutes until the digesta became clear pale green. After cooling, 100ml of distilled water was added, and the flask was rinsed 2-3 times, with the rinsing added to the bulk.

In the distillation step, a Markham distillation apparatus was employed. Approximately 10ml of the digest was added to the apparatus, and 10ml of sodium hydroxide from the measuring cylinder was introduced to prevent the loss of ammonia. Distillation was carried out into 50ml of a 2% boric acid solution containing screened methyl red indicator.

The final step, titration, involved directly titrating the alkaline ammonium borate formed with 0.1N HCl. The volume of acid used was recorded as the titre value and then utilized in the formula below:

$$\%\,Nitrogen = \frac{14\ x\ VA\ x\ 0.1\ x\ w}{1000\ x\ 100}\ x\ 100$$

Where:

VA = volume of acid used; w = weight of sample; % crude protein = %N x 6.25

Ash content: Ash was obtained by burning off the organic matter of the seed at 400-600°C in a muffle furnace for 4 hours. The crucible was pre-heated in the oven for 30 minutes at 105°C, cooled in the desiccator for about 1 hour, and weighed (W1). Two grams of the sample were added to the crucible, and a new weight (W2) was recorded. It was then placed in the muffle furnace for ashing at 550°C for 3 hours until the content turned whitish with no black particles. After removal and cooling in the desiccator, the final weight was noted (W3).

$$\%\,ash = \frac{(W2 - W3)}{(W2 - W1)}\ x\ 100$$

Where:

W1 = weight of crucible

W2 = weight of crucible + sample before ashing

W3 = weight of crucible + sample after ashing

Crude fat: Powdered, moisture-free millet samples were weighed into three different pre-weighed fat-free filter papers. Filter paper free from fat was weighed (W1). Approximately 1 gram of the sample was added to the filter paper, carefully folded and tied to keep the sample intact, and the new weight was noted (W2). A 500ml round-bottom flask was filled up to three-quarters with petroleum ether solvent. The flask was attached to a Soxhlet extractor with a reflux condenser and placed on an electro-mantle heater. Extraction began as the solvent refluxed several times. Extraction continued for approximately 6 hours, after which the condenser was removed, the defatted sample was taken out, and dried in an oven at 105°C for 2 hours until a constant weight was achieved. The difference between the weight of the defatted sample before and after drying was recorded as the weight of fat (W3).

$$Fat\ (\%) = \frac{(W2 - W1)}{W}\ x\ 100$$

Nitrogen Free Extract (NFE): This represents soluble carbohydrates and other digestible and easily utilizable non-nitrogenous substances in seeds. It was determined by subtracting the sum of percentages of all the nutrients already determined from 100.

$$\%\,NFE = 100 - (\%moisture + \%Crude\ Fibre + \%Crude\ Protein + \%Ash + \%Crude\ fat)$$

Data analysis

Data are represented as Mean ± Standard error of mean and were subjected to Analysis of Variance (ANOVA) using the Statistical Tool for Agricultural Research (STAR). Means were compared with Duncan Multiple Range Test (DMRT) analysis at a confidence level of 0.05.

RESULTS AND DISCUSSION

The percentage oil yield of the sesame seeds accession is presented in Table 1. Accessions NCRIBEN203 and NCRIBEN201 had the highest oil yields of 54.63 ± 0.44% and 52.17 ± 0.21%, respectively while NCRIBEN106 had the least percentage oil yield of 28.42 ± 1.35%. In addition, there were significant differences ($p < 0.05$) in oil yield among the sesame accessions.

Table 1. Percentage (%) oil yield of sesame seed accessions

Accessions	% oil yield
NCRIBEN201	52.17 ± 0.21^{d}
NCRIBEN203	54.63 ± 0.44^{e}
NCRIBEN131	49.79 ± 0.29^{c}
NCRIBEN121	37.39 ± 1.21^{b}
NCRIBEN106	28.42 ± 1.35^{a}

Values are mean ± standard error of mean of three determinations.

Values with different superscripts along the column are significantly ($p < 0.05$) different

In the study, the highest oil yields observed for accessions NCRIBEN203 and NCRIBEN201 were consistent with Nadeem *et al*. (2015), who evaluated the physico-chemical properties of sunflower seed oil. Uzun *et al*. (2009) reported that oil content of 103 Turkish sesame cultivars ranged from 41.2 to 62.7%. The variation in oil yield can be attributed to genetic differences and geographical location. Additionally, differences in the extraction protocol and the choice of solvent can affect oil yield. In this study, the use of the Soxhlet extraction method and non-polar solvents appeared to enhance oil recovery, possibly due to the genetic similarity of the sesame accessions. The accession NCRIBEN203, with the highest oil yield, should be given more attention as it holds promise for commercial production for farmers as well as usage by sesame oil-producing industries.

The result of the proximate analysis carried out on the sesame seeds accessions showed considerable and significant variability in the mean moisture, crude protein, crude fibre, crude fat, carbohydrate and ash content among the accessions.

Table 2. Proximate composition of sesame seed accessions

Accession	Moisture	Ash	Crude fat	Crude protein	Crude fibre	CHO
NCRIBEN201	1.86±0.64[d]	6.51±0.24[a]	44.92±2.58[d]	24.02±0.58[a]	4.31±0.17[a]	18.16±2.71[a]
NCRIBEN203	2.73±0.95[c]	6.11±0.34[bc]	47.20±1.22[c]	21.55±0.55[b]	4.09±0.17[ab]	17.08±3.45[a]
NCRIBEN131	3.40±0.41[b]	5.75±0.21[c]	52.82±1.44[a]	25.29±0.26[a]	3.84±0.10[c]	8.94±1.85[c]
NCRIBEN121	2.91±0.83[c]	6.01±0.42[bc]	48.41±1.49[bc]	21.16±3.09[b]	4.01±0.23[bc]	17.27±2.03[a]
NCRIBEN106	3.70±0.91[a]	6.33±0.81[ab]	49.17±1.38[b]	22.56±1.55[b]	4.16±0.51[ab]	14.19±2.97[b]

Values are mean ± standard error of mean of three determinations.
Values with different superscripts along the column are significantly ($p < 0.05$) different

Table 2 shows that the mean moisture content of 3.4% was lower than the mean of 8.5% recorded by Jimoh *et al*. (2016). It has been shown that high moisture content encourages the growth of microorganisms, thereby causing the deterioration of stored seeds (Afolabi, 2018). The high moisture content, therefore, implies that the seeds may not store well, and to avoid this, effort should be made to reduce the moisture content before storage of the seed.

Table 2 also shows that NCRIBEN131 and NCRIBEN121 had the highest and lowest crude protein of 25.29±0.26% and 21.16±3.09%, respectively, which is in line with Borchani *et al*. (2011). In addition, the mean crude fibre content of 4.54% aligned with the reports of Jimoh *et al*. (2011) in all accessions. Fibre in the diet is important as it helps to maintain human health by reducing cholesterol levels in the body (Belury, 2002).

The range of crude fat content, 52.82±1.44% to 44.92±2.58% in accessions NCRIBEN131 and NCRIBEN201, respectively, was considered favourable compared to results obtained by other researchers (Borchani *et al*., 2011; Mohammed and Hamza, 2008). The quantity of oil in sesame seeds is economically significant, and accessions with high crude fat content, like NCRIBEN131, could be preferred for production in the region.

The highest carbohydrate content of 18.16±2.71% recorded for NCRIBEN201 is relatively low when compared with that of other legume seeds, ranging from 23% in groundnut to 66% in bambara groundnut (El Khier *et al*., 2008). The range of ash content (6.51±0.24% to 5.75±0.21%) in accessions NCRIBEN201 and NCRIBEN131, respectively, obtained in this study, is comparable with that reported by Alyemeni *et al*. (2016). A high level of ash makes the oilseed a good source of mineral nutrition to the consumer (Afolabi, 2011).

CONCLUSION

Accession NCRIBEN203 has the highest oil yield, while NCRIBEN131 recorded the highest crude fat and crude protein contents. The study revealed that accelerated ageing does not have a marginal effect on the mineral-rich profile of sesame seed accessions. Therefore, it is recommended that sesame seed accessions that exhibit superior and desirable qualities should be selected and cultivated for purposes of consumption and industrial use. Also, adequate measures such as drying should be employed to reduce the moisture content in sesame seeds before storage to prevent microbial growth and seed deterioration.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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