ISSN:
Print - 2277 - 0593
Online - 2315 - 7461

Journal of Natural Science, Engineering and Technology

BIOCHEMICAL COMPOSITION OF KENAF (*Hibiscus cannabinus* L.) SEEDS AS INFLUENCED BY STORAGE CONDITION

***[1]T. O. KEHINDE, [1]T. D. ATANDA, [2]J. A. ADETUMBI, [1]M. M. SHITTU, [1]M. A. ADEBISI, [3]Y. O. ALAWODE, [1]W. AZEEZ, [1]A. A. SALAWU**

[1]Department of Plant Breeding and Seed Technology, Federal University of Agriculture, Abeokuta, P. M. B. 2240, Abeokuta, Ogun State, Nigeria
[2]Institute of Agricultural Research and Training, Ibadan, Obafemi Awolowo University, P. M. B 5029, Moor Plantation, Ibadan, Oyo State, Nigeria
[3]Department of Crop and Soil Science, National Open University, Abuja, Nigeria
***Corresponding Author**: kehindeto@funaab.edu.ng **Tel:** 07039317720

ABSTRACT

Kenaf, an annual plant produced for its fibre is known for fast seed deterioration in storage. To address the quick loss of seed viability, the study was carried out to determine the biochemical composition of kenaf seeds with storage temperature in order to ascertain the relationship between biochemical composition and loss of seed viability in kenaf. Eight hundred grammes each of freshly- harvested seeds of four kenaf varieties (Cuba 108, Ifeken 100, Ifeken 400 and Ifeken DI 400) were stored under both cold (19.6 ˚C, RH= ±12%) and ambient environments (23.8 - 28.1 °C, RH = ± 46.0 - 80%) for eight months. The experiment was laid out in a Completely Randomized Design with three replicates. The stored seeds were assessed for biochemical attributes at 120-day intervals for a period of 240 days (0,120 and 240 days). Data collected were subjected to analysis of variance and means separated using Duncan's Multiple Range Test at 5% probability level. There were increments in the p-anisidine (0.20 – 0.57), peroxide (0.27 – 1.06 mEq/kg) and rancidity (0.10 – 0.62 mEq/kg) contents of kenaf seeds under ambient environment with storage up to 240 days which resulted in decline of their quality during storage compared to their values recorded under cold environment (0.2-0.22; 0.27-0.31; 0.10-0.07, respectively). These values were low under cold environment. Ifeken-400 and Cuba-108 varieties had lower values for free fatty acid, p-anisidine, peroxide and rancidity value when stored under cold environment, implying that they did not go rancid when stored under cold environment. Biochemical attributes of oil content, free fatty acid, p-anisidine, peroxide and rancidity of kenaf seeds declined more under ambient environment than cold environment. Storing seeds under cold environment will enhance longer storage life compared to storage under ambient conditions in the humid tropical environment.

Keywords: seed longevity, storage duration, biochemical quality, storage life

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) is a member of the *Malvaceae* family, along with okra (*Abelmoschus esculentus* L. Moench) and cotton (*Gossypium* spp.). Kenaf is believed to have originated in sub-Saharan Africa (Dempsey, 1975). The bast or outer bark fibre and the thick inner core of short, woody fibres are the two different fibre types found in kenaf stems, and both can be utilized to make pulp. It has been reported that kenaf produced 50–60% more fibre per land area than pine and has great potential as a substitute fibre for pine pulp in the production of paper (Kehinde *et al.,* 2015).

The interest of the Nigerian government to diversify the economy has increased the interest of individuals and corporate bodies in agriculture. Some agricultural activities in Nigeria are targeted towards exportation that require the use of bio-degradable bags made from natural fibre which are environmentally- friendly. This has led to increasing demand of kenaf seeds which has been reported to deteriorate rapidly during storage. Kenaf seed is naturally short-lived, due to the oil content (Adetumbi, 2012). The intensity and rate of the seed deterioration process may be directly related to their chemical composition, most especially, the oil content. It is also believed that the deterioration process of the seeds can be reduced when the seeds are kept under certain storage conditions, which limits chemical reactions in the seeds. Consequently, several reports have been documented about rapid deterioration of kenaf seeds during storage due to high oil content which poses a threat to availability of quality seed for sustainable production of the crop (Rababah *et al.,* 2017; Ranganathan and Groot, 2023; Gebregergis *et al.,* 2024). Therefore, adequate knowledge of the biochemical content of kenaf seed and the changes that occur during storage will enhance the prediction and recommendation of the potential seed storage technique for the seedlot of such crop species.

Seed storage is a vital process in agriculture, as it protects seeds for the next season and guarantee sustainable production of such crop. Poor storage conditions greatly affect seed viability and vigour (Heydecker, 1979). Several studies on physical and physiological changes have been conducted on storage of kenaf seed with less emphasis on the biochemical changes (Adjei *et al.,* 2002; Rugut *et al.,* 2010; Rani *et al.,* 2013).

Comprehensive information on biochemical changes in kenaf seeds stored under different storage conditions is however yet to be documented.

In order to reduce seed deterioration of kenaf, it becomes necessary to understand the biochemical changes occurring in kenaf seeds during storage. This will assist seed producers and processors to guide against factors that can cause the seed to deteriorate faster. The objectives of the study were therefore to investigate the rate at which changes occur in the biochemical attributes in kenaf varieties under storage and how storage conditions affect the biochemical content of kenaf seeds in order to enhance the prediction and recommendation of potential seed storage technique for the seedlot of such crop species.

MATERIALS AND METHODS

Seed Materials

Freshly harvested seeds of four kenaf varieties (Ifeken 100, Cuba 108, Ifeken DI 400 and Ifeken 400) were obtained from the Kenaf and Jute Improvement Programme of the Institute of Agricultural Research and Training (IAR&T), Moor Plantation, Ibadan. Ifeken 100, Ifeken DI 400 and Ifeken 400 varieties were locally developed, while Cuba 108 was an imported variety.

Experimental Location, Design and treatments

The storage experiment and the evaluation of biochemical attributes were carried out at the seed testing laboratory of IAR&T, Ibadan. The experiment was a 4 x 2 factorial experiment. Factors evaluated were four kenaf varieties and two storage environments (Ambient and controlled storage). The experiment was arranged in a Completely Randomized Design with three replicates.

Seed Storage

Eight hundred grammes (800 g) of seed of each variety was divided into two (400 g each) using Boerner divider to ensure there was no bias and packaged in polyethylene bag and then sealed. One set of the packaged seedlots of the four varieties were kept under controlled condition (19.6°C, Rh = 12%) in the seed store of the Institute of Agricultural Research and Training (IAR&T), Moor Plantation, Ibadan equipped with a dehumidifier and a thermo hygrometer, while the second seedlots were kept under the ambient conditions (27.5°C, RH = 64.7%) of the seed store. The seedlots were stored for the same period of 240 days (8 months) between August 2019 and April 2020. Average temperature and relative humidity were monitored using a digital thermo-hygrometer (Tf™, Germany) for the period of storage.

Seed Biochemical Evaluation

Samples of the seedlots were drawn before storage to determine the biochemical attributes of the seed. Thereafter, samples were drawn from the stored seed under the two storage environments at an interval of four months (120 days) to determine the biochemical changes that occurred during the storage. The biochemical analyses were conducted on the following:

i) Determination of Total Soluble sugar (AOAC, 2005)
ii) Determination of Crude Protein Content (AOAC, 2005).
iii) Peroxide value (P-V) measurement (AOCS, 2011).
iv) Determination of Linoleic Acid: (AOCS, 2011).
v) Determination of P-Anisidine Value (AOAC, 2005).
vi) Determination of Free Fatty Acid (AOCS, 2011).
vii) Oil Content (percentage): Estimated from the seeds by using NMR (Nuclear Magnetic Resonance technique (Alexander, 1967).
viii) Rancidity (AOAC, 2005).
ix) Moisture content (percentage): Determined using halogen moisture tester.

Statistical Analysis

Data obtained were subjected to analysis of variance using SAS statistical analytical software (SAS, 2002). Significant means were separated using Duncan's Multiple Range Test (DMRT) at 5% probability level (Duncan, 1955).

RESULTS

There was a highly significant ($p \leq 0.01$) difference in the biochemical parameters of kenaf seeds between the storage environments (E) as well as the varieties (V) and the storage duration (P) - Table 1. There were highly significant differences in all the parameters except moisture in E × V and V ×P at the first-degree interactions (E× V, E × P, V × P). There were also significant differences in all the biochemical parameters except moisture content at the second-degree interaction (E × V ×P) – Table 1.

The linoleic acid content (Figure 1) declined in all varieties irrespective of the storage environment, but, Ifeken-400 increased under both environments. With increase in storage duration to 240 DAS, the p-anisidine and peroxide contents in all varieties increased under the ambient environment. Under cold environment, an increase was also observed in the linoleic acid contents of all the varieties except Ifeken-400.

With regards to rancidity, all four varieties had increased values under the ambient environment but a reduction under cold environment storage, except for Cuba-108 (Figure 1).

A gradual and consistent increase was observed in the moisture content of all the varieties regardless of the environment. Ifeken-400 had the highest increment from 10.30 to 12.13% under the ambient environment but had the least increase under cold environment (Figure 2).

There was a reduction in the crude protein contents across all varieties under the ambient environment. However, under cold environment, the crude protein contents of all varieties increased, with the exception of Cuba-108 which decreased as storage progressed to 240 DAS (Figure 2).

For the oil content and total soluble sugar under the ambient environment, there was a decline in the initial values in almost all four varieties. Under the cold environment, there was an increase with storage duration up to 240 DAS for all the varieties except for Ifeken-400 that decreased with increase in storage duration to 240 DAS. Free fatty acid content of Ifeken-100, Ifeken-400 and IfekenDI-400 increased with 0.12, 0.32 and 0.06%, respectively under ambient environment but under cold environment, a reduction in the value was observed with the exception of Ifeken-400 which increased from 2.20 to 2.29% at 240 DAS (Figure 2).

The qualitative rancidity absorbance evaluation on kenaf varieties stored for 240 days across storage environments revealed negative rancidity and yellowish colour for all the varieties at initial storage duration (Table 2). However, at 120 DAS, rancidity for Ifeken-100 and Ifeken-400 tested positive and the colour turned pinkish for storage under ambient environment, while it remained negative but still maintained the yellowish colour under cold storage (Table 2). As storage duration progressed to 240 DAS, rancidity test for all varieties became positive and the colour turned pinkish under ambient. The seeds under cold environment remained negative and the colour was still yellowish.

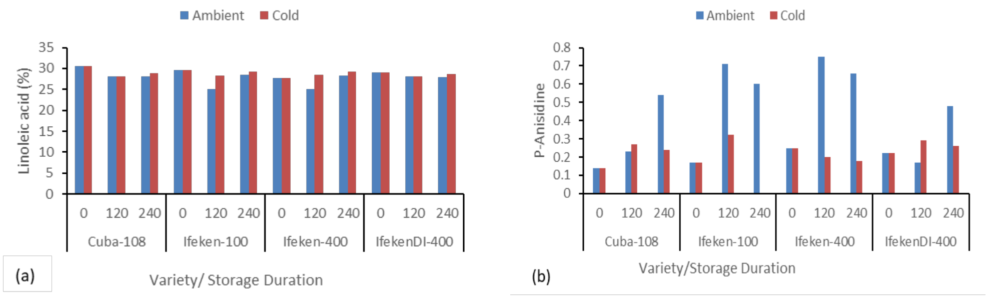
Table 1: Analysis of variance for some biochemical analysis on kenaf seeds

Source of Variation	DF	MC (%)	CP(%)	OC (%)	FFA	TTS (%)	LINO (%)	ANISID	PEROXI	RANCID
Environment (E)	1	2.0335**	22.5750**	5.1534**	0.0123**	5.7397**	26.5432**	0.5941**	35.4903**	1.6200**
Variety (V)	3	4.9313**	10.4333**	4.4418**	0.0917**	1.8755**	10.7669**	0.06901**	8.8878**	0.1005**
Period (P)	2	8.1093**	23.1554**	9.5669**	0.1641**	4.4042**	45.5005**	0.2765**	21.3413**	0.4146**
E×V	3	0.1627	6.0091**	1.7790**	0.0060**	1.7855**	4.9195**	0.0942**	8.8925**	0.1197**
E×P	2	1.0943**	6.7963**	1.8928**	0.2356**	3.8785**	8.9589**	0.1834**	19.9906**	0.4712**
V×P	6	0.2093	3.8705**	1.3589**	0.0704**	1.5849**	5.2856**	0.0396**	8.0705**	0.0633**
E×V×P	6	0.1858	3.3664**	0.8946**	0.0344**	1.5947**	4.0113**	0.0415**	8.0715**	0.0592**
Error	48	0.1955	0.0058	0.0005	0.0004	0.0005	0.0071	0.0001	0.0002	0.0002

*significant at 5% probability level; **significant at 1% probability level
DF: Degree of Freedom CP: Crude Protein, OC: Oil Content, FFA: Free Fatty Acids, TSS: Total Soluble Sugar LINO: Linoleic Acid, ANISID: P-Anisidine value, PEROXI: Peroxide value, Rancid: Rancidity

Table 2: Qualitative rancidity absorbance evaluation on kenaf seeds stored for 240 days.

Variety	Storage Duration (days)	Rancidity colour change		Rancidity colour test	
		Ambient	Cold	Ambient	Cold
Cuba-108	0	Yellowish	Yellowish	Negative	Negative
	120	Yellowish	Yellowish	Negative	Negative
	240	Pinkish	Yellowish	Positive	Negative
Ifeken-100	0	Yellowish	Yellowish	Negative	Negative
	120	Pinkish	Yellowish	Positive	Negative
	240	Pinkish	Yellowish	Positive	Negative
Ifeken-400	0	Yellowish	Yellowish	Negative	Negative
	120	Pinkish	Yellowish	Positive	Negative
	240	Pinkish	Yellowish	Positive	Negative
IfekenDI-400	0	Yellowish	Yellowish	Negative	Negative
	120	Yellowish	Yellowish	Negative	Negative
	240	Pinkish	Yellowish	Positive	Negative



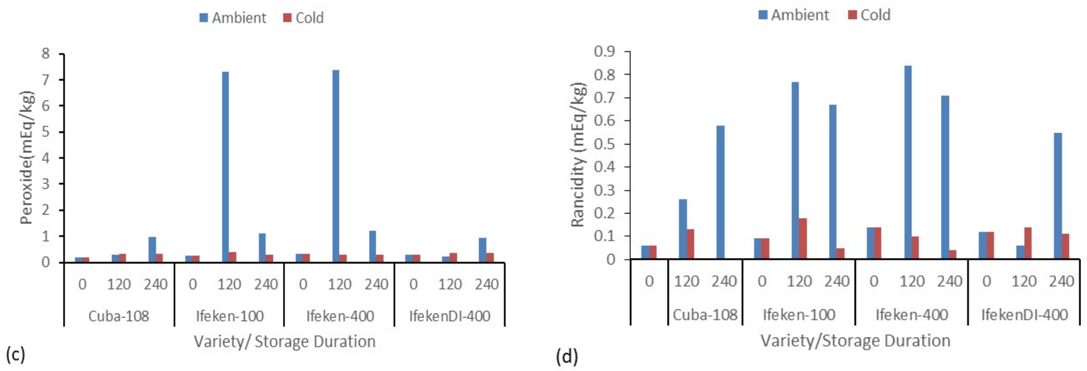
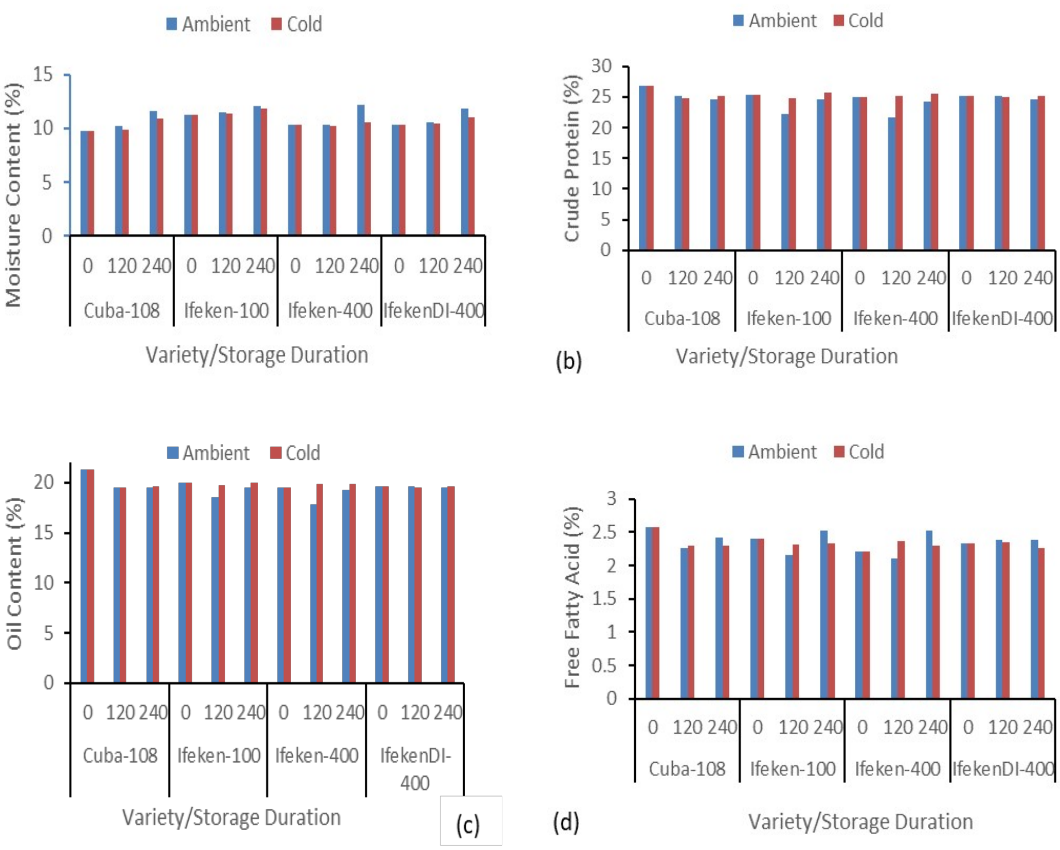


Figure 1(a-d): Interactive effect of varieties and storage duration on some biochemical parameters of kenaf seed stored for 240 days



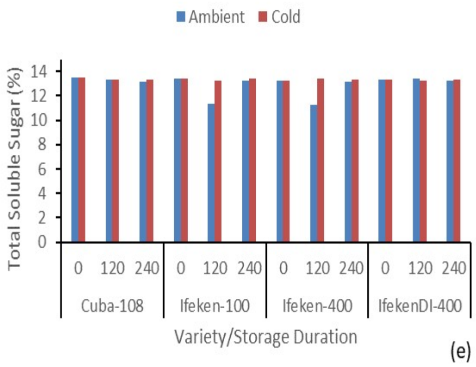


Figure 2 (a-e): Interactive effect of varieties and storage duration on some biochemical parameters of kenaf seed stored for 240 days

DISCUSSION

Biochemical changes occurring in seed during aging are significant as far as seed quality and longevity are concerned and are consequences of the effects of different storage conditions. The combined effects of varietal trait and storage environment were responsible for variations observed during storage in the biochemical parameters considered in this study. Both storage duration and storage environment influenced the biochemical parameters of Kenaf seed. At the end of the 240 days of storage, the higher values of certain biochemical parameters such as crude protein value, oil content, total soluble sugar and linoleic acid value observed under cold environment, when compared to observations under ambient environment, is an implication that the cold environment is able to maintain these parameters better than ambient environment. This is due to reduction in metabolic activities such as respiration, insect and microbial attack which involve the use of nutrient reserves. This supports the findings of Scariot et al. (2017), who reported that the protein content of stored black gram seeds decreased under ambient temperature. The least values for moisture content, free fatty acid, p-anisidine value, peroxide value and rancidity observed from all varieties stored under cold environment supports the findings of Adjei et al. (2022) who reported that biochemical values were lower in seeds of common bean when stored under cold environment.

This study showed variation in the biochemical compounds in the varieties. Ifeken-400 had the highest free fatty acid at 240 DAS when stored under ambient which accounts for the reason why it was positive to rancidity test at both 120 and 240 DAS. This suggests that it will go rancid rapidly when stored under ambient condition. Other studies have reported similar findings with walnut (Fox and Cameron, 1995; Savage et al., 1998; Zwarts et al., 1999). However, when stored under cold environment, it recorded the least value at 240 DAS.

The significant effect of storage duration on oil content of the seed of all varieties in this study is an indication that oil contained in kenaf seed decreases proportionally with the days of storage, regardless of the variety. It also showed that the rate of decrease is higher under ambient than cold environment. These results conform with Sisman (2005), Sisman and Delibas (2004) who reported that during storage (independent from storage conditions) the percentage of seed oil (20%) gradually decreased with increase in storage time. This result is further corroborated by the assertion of Morello et al. (2004) that the development of rancidity is the predominant cause of oil deterioration and reduction during storage, and that in most seed oils, oxygen-dependent deterioration of lipids is known as oxidative rancidity. This rate of oxidation increases with increase in oxygen concentration and the storage duration, implying that the longer the storage duration, the higher the oxygen availability and vice versa. This might be a reason why the percentage of oil of stored seeds tends to reduce during storage. The activities of most of enzymes are partially or wholly requiring the presence of oxygen.

Rancidity is the natural process of degradation of fats and oils, either hydrolysis or oxidation or both. The development of rancidity is accompanied by a marked increase in the acid value of fat, which is tested by using peroxide value and P-anisidine values. Peroxide value measures the extent to which an oil sample has undergone primary oxidation. It is commonly used to determine oxidative rancidity of oils (Satue et al., 1995; Antoun and Tsimidou, 1997), whereas the extent of secondary oxidation may be determined by P-anisidine. P-anisidine, peroxide and rancidity values were high in the seeds under ambient condition. This study shows that rapid increase in the peroxide values of seeds stored under ambient was observed as storage increases, this is in line with reports of Al-Maskri et al. (2003) and Salim and Shereena, 2006. The findings of this study also corroborate the reports of Rababah et al. (2017) who stated that as storage period and temperature increased, the quality of sesame seed oil was affected negatively due to acidity and peroxide increments. In addition, seeds stored under cold environment tested negative which denotes incipient rancidity and then turned yellowish across all storage duration, indicating absence of rancidity when stored under cold condition. On the other hand, a positive result and a pinkish colour were detected across all varieties stored under ambient environment at 240 DAS, indicating incipient rancidity.

CONCLUSIONS

Storage environment and duration influence all biochemical parameters evaluated for the four kenaf varieties.

Biochemical parameters such as moisture content, free fatty acid, p-anisidine, peroxide and rancidity value decline with increase in storage duration under cold storage but increase under ambient environment.

Ifeken-400 and Cuba-108 had lower contents of free fatty acid, p-anisidine, peroxide and rancidity value when stored under cold environment and so, do not go rancid when stored under cold environment.

The rate of decline of the biochemical attributes of kenaf seeds is higher under ambient environment than cold environment.

RECOMMENDATIONS

Ifeken-400 and Cuba-108 have outstanding performance for biochemical attributes under cold environment, and so can be recommended for future seed improvement programme.

Kenaf seeds should be treated as a very vulnerable seed that is highly sensitive to storage environment, hence its storage under cold environment will enhance its storage life compared to storage under ambient conditions.

REFERENCES

Adetumbi, J. A., Adekoya, M. A. Adeyeye O. O. and Ogunbiyi, B. 2012. Seed morphometric studies of some kenaf (*Hibiscus cannabinus*) accessions. *Journal of Research Agriculture* 1: 029-033.

Adjei, E. A., Banful, B. K., Asiedu, E. A., Marnoh, P., Yeboah, S., Agyeman, K., Arthur, M. and Asibuo, J. Y. Interactive effect of moisture content and storage condition on biochemical seed quality of common bean (*Phaseolus vulgaris* L.) in Ghana. *Journal of Stored Products and Postharvest Research* 13(2):6-13.

Alexander, D. E. 1967. Technique of Nuclear and Magnetic Resonance (NMR) *Journal of American Oil Chemistry Society* 44: 546-555.

Al-Maskri, A. Y., Khan, M. M. Khan, I. A and Al-Habsi, K. 2003. Effect of accelerated aging on viability, vigor (RGR), lipid peroxidation and leakage in carrot (*Daucus carota* L.) seeds. *International Journal of Agricultural Biology* 5: 580-584.

American Oil Chemists' Society., 2011. *Official methods and recommended practices of the American Oil Chemists' Society (AOCS)*, Vol. *Cd 8b–90*. Champaign, IL:AOCS Press.

Antoun, N., and Tsimidou, M. 1997. Gourmet olive oils: stability and consumer acceptability studies. *Food Research International* 30(2): 131–136.

Association of Officiating Analytical Chemists (AOAC) 2005. Official method of Analysis. 18th Edition, *Association of Officiating Analytical Chemists,* Washington DC, Method 935.14 and 992.24.

Dempsey, J. M. 1975. Kenaf. Fibre Crops. University of Florida Press. Tallahassee, FL: Rose Printing Company. USA. 102pp

Duncan, D. B. 1955. Multiple Range and Multiple F-tests. *Biometrics II*: 1 – 42.

Fox, B. A. and Cameron, A. G. 1995. Food Science, Nutrition & Health, 6th ed.; Edward Arnold; London, UK.

Gebregergis, Z., Baraki, F. and Fiseseha, D. 2024. Effects of environmental factors and storage periods on sesame seed quality and longevity. *CABI Agriculture and Bioscience* 5:47-58.

Heydecker, W. 1979. Vigour. In: Viability of seed, edited by E. H. Roberts. *Syracuse Univ. Press*. pp. 209-252.

Kehinde, T. O., Adebisi, M. A, Esuruoso, O. A, Akinrinde, G. O and Famakinde, O. 2015. Assessment of seedling vigour characteristics in kenaf (*Hibiscus cannabinus* L.) genotypes. *Applied Tropical Agriculture.* 20 (2): 24-31.

Morello, J. R., Motilva, M. J. Tovar, M. J. Romero, M. P. 2004. Changes in commercial virgin oil (*CV Arbequina*) during storage with special emphasis on the phenolic fraction. *Journal of Food Chemistry* 85: 357-364.

Rababah, T., Al-U'datt, M. U., Al-Mahasneh, M. A., and Odeh, A. 2017. Effect of processing and storage at different temperatures on the physicochemical and minerals content of sesame seeds and tehina. *Bulgarian Journal of Agricultural Science* . 23: 5-8.

Ranganathan, U., and Groot. S. P. C. 2023. Seed longevity and deterioration. In: Dadlani M, Yadava DK, editors. Seed science and technology: biology, production, quality. Singapore: Springer;. p. 91–108.

Rani, P. R., Chelladurai, V., Jayas, D. S., White, N. D. G. and Kavitha-Abirami, C. V. 2013. Storage studies on pinto beans under different moisture contents and temperature regimes. *Journal of Stored Products Research, Manhattan* 52(1):78-85.

Rugut, E., Muasya, R., Gohole, L. 2010. Longevity of bean (*Phaseolus vulgaris*) seeds stored at locations varying in temperature and relative humidity. *Journal of Agriculture, Pure and Applied Science and Technology* 5:60-70.

SAS, Statistical Analysis System, 2002. The SAS System of Windows, Release 9.0. SAS Institute Inc., Cary, NC., USA.

Satue, M. T., Shu-Wen Huang and Frankel, E. N. 1995. Effect of natural antioxidants in virgin olive oil on oxidative stability of refined, bleached, and deodorized oil. *Journal of the American Oil Chemists' Society* 72 (10): 1131-1137.

Savage, G. P., McNeil, D. L. and Dutta, P. C. 1998. Vitamin E content and oxidative stability of fatty acids in walnut oil. *Proceedings of the Nutrition Society of New Zealand* 23: 81- 90.

Salim, N., and Shereena, J. 2006. Chilling tolerance in *Pisum sativum* L. seeds: An ecological adaptation. *Asian Journal of Plant Science* 5: 1047-1050.

Scariot, M. A., Tiburski, G., Júnior, F. W. R., Radünz. L. L., and Meneguzzo, M. R. R. 2017. Moisture content at harvest and drying temperature on bean seed quality. *Pesquisa Agropecuária Tropical* 47:93-101.

Sisman, C. 2005. Quality losses in temporary sunflower stores and influences of storage conditions on quality losses during storage. *Journal of Central European Agriculture* 6: 143-150.

Sisman, C., and Delibas, L. 2004. Storing sunflower seed and quality losses during storage. *Journal of Central European Agriculture* 4: 239-250.

Zwarts, L., Savage, G. P. and McNeil, D. L. 1999. Fatty acid content of New Zealand grown walnuts (*Juglans regia* L.). I*nternational Journal of Food Sciences and Nutrition* 50(3):184-194.

(Manuscript received: 19th July, 2025; accepted: 24th October, 2025).