AJFAND Since 2001
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 25 No. 9
October 2025
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2025; 25(9): 27818-27841 https://doi.org/10.18697/ajfand.146.25745

Date	Submitted	Accepted	Published
	23rd January 2025	13th October 2025	6th November 2025

PHYSICOCHEMICAL PROPERTIES OF SEEDS AND OIL FROM DIFFERENT VARIETIES AND CULTIVARS OF EDIBLE SUNFLOWER (*HELIOTHUS ANNUS* L.) SEEDS

Guissou AWDB[1], Oboulbiga EB[1]*, Semdé Z[1], Ramde R[1] and C Parkouda[1]

Wendsipagnangdé Déogracias Bénédicte Aimée Guissou

*Corresponding author email: obouled@yahoo.fr
ORCID: https://orcid.org/0000-0002-4871-3742 - Guissou AWDB
ORCID: https://orcid.org/0000-0003-1845-8936 - Oboulbiga EB
ORCID: https://orcid.org/0009-0009-1920-0241 - Semdé Z
ORCID: https://orcid.org/0000-0003-4989-0027 - Parkouda C

[1]Food Technology Department (DTA), Institute for Research in Applied Sciences and Technologies (IRSAT), National Center for Scientific and Technological Research (CNRST), 03 BP 7047 Ouagadougou 03, Burkina Faso

Since 2001 ajfand AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 25 No. 9
October 2025
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

ABSTRACT

Satisfying food oil needs in quantity and quality requires diversification of crop sources. Besides cotton, sunflower is one of the best plants that makes a significant contribution to this issue. This study was conducted to determine the physical and physicochemical characteristics of sunflower cultivars and varieties that contribute to the selection of better varieties for oil producing factories. A total of 16 cultivars and 12 varieties of sunflower seeds obtained from plant breeding research were used as plant materials for experimental treatments. Physical and physicochemical parameters were determined by standard analytical methods. Analysis of the physical parameters of cultivar/variety seeds reveals an average of 1000 seeds weight ranging from 39.39 ± 0.00 g to 79.98 ± 0.07 g, a length of 9.27 ± 0.53 to 12.00 ± 1.07 mm, a girth of 5.04 ± 0.40 to 7.83 ± 0.66 mm and girth of the diameter of 3.04 ± 0.30 to 5.10 ± 0.56 mm. Physicochemical parameters of whole sunflower seed samples showed a water content in the range of 3.48 ± 0.17 to 4.96 ± 0.31%, an average total ash content in the range of 3.27 ± 0.09 to 6.34 ± 0.28%, a fat content of 37.10 ± 0.09 to 45.66 ± 1.16%, and an acid value of 1.24 ± 0.15 to 6.70 ± 0.07 mg KOH/g. The kernel analysis gave an acid value of 1.65 ± 0.03 to 4.87 ± 0.08 mg KOH/g and a lipid fraction of 39.80 ± 0.07% to 52.24 ± 0.24%. Oils extracted from whole seeds and kernels have an iodine index of 96.16 ± 0.15 to 118.31 ± 0.02 mg I_2/100 g and a saponification index of 186.16 ± 0.98 to 196.48 ± 2.40 mg KOH/g. At the end of this study, six cultivars (C28, C34, C39, C87, C98, C99) and four varieties (V1, V13, V14, V15) had interesting physicochemical characteristics and could be retained for varietal selection. These varieties meet a sustained demand for oils in terms of both quantity and quality, which makes it possible to further enhance the value of production and improve the profitability of farmers' operations.

Key words: Sunflower, seeds, oil, physicochemical properties, cultivar, variety, Burkina Faso

Citation: Guissou AWDB, Oboulbiga EB, Semdé Z, Ramde R and C Parkouda Physicochemical Properties of Seeds and oil from Different Varieties and Cultivars of Edible Sunflower (*Heliothus annus* L.) Seeds. *Afr. J. Food Agric. Nutr. Dev.* 2025; **25(9):** 27818-27841. https://doi.org/10.18697/ajfand.146.25745

Since 2001 ajfand AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 25 No. 9
October 2025
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

INTRODUCTION

Originally a North American native plant, sunflower (*Helianthus annuus* L.) has become one of the most important oilseed crops in the world today along with crops like soya (soybeans), rapeseed, oil palm, cotton and peanuts. Over the past decade, global production of sunflower seeds has increased from 43,458,887 tons in 2013 to 54,285,948 tons in 2022 [1]. The main producing countries in 2022 were Russia, Ukraine, Argentina, Turkey, Bulgaria, Romania, France, Kazakhstan and Hungary. Africa accounts for 4.9% of total world production [1].

Sunflower is generally cultivated for its seed, which is very rich in oil of great nutritional value and for its meal, a food very appreciated by livestock [2]. The sunflower seed is also characterized by its high protein content, which also classifies it in the category of oleo-protein crops. Sunflower seeds contain 20 to 33.85% protein, 40.33 to 65.42% fat and 18 mineral elements [3, 4]. In the non-food sector, sunflower oil can be used as a lubricant (biofuel) and as a bio-solvent for its oleic acid content in paints, and cosmetic or pharmaceutical products for its phytosterols or certain saturated fatty acids.

Like other oilseeds, sunflower seeds are rich in polyunsaturated fatty acids, which are effective in preventing cardiovascular diseases, and in minerals, which are useful in fighting bad cholesterol (LDL). Sunflower seeds are also rich in vitamin E, a powerful antioxidant that protects cells against free radicals, and strengthens the immune system [5, 6]. Sunflower oil is a highly appreciated oil for its richness in monounsaturated fatty acids, omega 6 and omega 9 fatty acids [7]. Its richness in linoleic acid (omega 6) and its fairly neutral flavor have contributed to making sunflower oil an attractive oil for food use. Furthermore, the oleic acid (omega 9) contained in sunflower oil has nutritional qualities sought after in human food. Depending on their oleic acid content, sunflowers are classified as oleic sunflowers or linoleic or conventional sunflowers. Oleic sunflower has a modified fatty acid composition to achieve a high oleic acid content, close to 82%, and linoleic sunflower is characterized by a higher linoleic acid (omega-6) content [7].

The production of edible oils in Burkina Faso is insufficient and does not meet the needs of oil consumers. Local demand for edible oil in Burkina Faso is estimated at nearly 100,000 tons with a growth rate of 4% per year. The supply of local oil is between 30,000 to 40,000 tons per year, reflecting the vulnerability of the domestic market to the international market environment [8]. This shortfall is mainly filled by imports of palm oil from West Africa (Ivory Coast and Togo) and Asia (Malaysia and Indonesia). The edible oil produced in Burkina Faso is made mainly from cotton, but this raw material is not sufficient to meet the needs of oil processors. It is therefore imperative to look for other oilseed crops capable of supplying raw material in sufficient quantity, at accessible and profitable costs. Thus, several oilseed crops such as sunflower, soybeans, sesame, peanuts (groundnuts), and tiger nut are produced in Burkina Faso and could meet the processing needs of national oil mills. Sunflower cultivation in Burkina Faso could contribute to making the raw material available and further guarantee a very good quality edible oil that is easy to process. Sunflower was introduced in Burkina Faso in 1951 by the Oilseed Oil Research Institute at the Niangoloko experimental station [9]. The average production of sunflower in Burkina Faso from 2009 to 2020 is estimated at nearly 212.8 tons per year in the high production area, with 132 ha of planted area, and nearly 470 tons per year in the average production area with 315 hectares of planted area [9].

The Burkinabe government is therefore committed through the Ministry in charge of Research and Innovation, and that in charge of agriculture and food security, to promoting sunflower cultivation in Burkina Faso. The National Institute of the Environment and Agricultural Research (INERA) was commissioned to experiment with the cultivation of different varieties and cultivars of sunflower in Burkina Faso.

The objective of this study was to determine the physicochemical characteristics of the seeds of different sunflower varieties and cultivars to contribute to the selection of better sunflower varieties for the agro-industry of Burkina Faso.

MATERIALS AND METHODS

Plant material

The plant material used in this study consisted of seeds from 12 varieties and 16 cultivars of sunflower obtained from the Institut de l'Environnement et de Recherches Agricoles (INERA) of Centre National de Recherche Scientifique et Technologique (CNRST) of Burkina Faso. The seeds of the 12 varieties and 16 cultivars were authenticated by a botanist. The cultivars were C99 AMMHT 235 (C99), C98 AMMHT 232 (C98), C93 AMMHT 224 (C93), C88 AMMHT 204 (C88), C87 AMMHT 201 (C87), C81 AMMHT 176 (C81), C62 AMMHT 130 (C62), C59 AMMHT 126 (C59), C56 AMMHT 121 (C56), C41 AMMHT 81 (C41), C39 AMMHT 76 (C39), C34 AMMHT 63 (C34), C3 AMMHT 07 (C3), C28 AMMHT 48 (C28), C24 AMMHT 39 (C24), C15 AMM HT 29 (C15). The varieties were the V13 BOSPHORA F (V13), V14 NEOMA F1 (V14), V15 NEOMA F2 (V15), V17 NK ADAGIO F2 (V17), V18 INAYA F1 (V18), V1 CETIOM 265 (V1), V3 AMSOL (V3), V4 PEREDOVICK S (V4), V5 MIRAMAR (V5), V6 CABURE (V6), V7 GUYACAN (V7), V8 HAVANA F1 (V8).

Physical analysis of seeds

Determination of the weight of a thousand (1000) seeds.

The specific weight of sunflower seeds was determined by weighing a test portion of 20 seeds using a precision analytical balance (OHAUS Analytical plus, Rice Lake Weighing Systems, Rice Lake, WI 54868).

The total weight of 1000 seeds were calculated using the following equation:

$$\mathrm{PMG} = \frac{1000 \times m}{20}$$

where:

PMG is the weight of thousand (1000) seeds
M is the weight of 20 seeds

Seed Sizing
The measurement of the seeds (length, girth and girth of the diameter) was determined according to the method described by Aydın and Özcan [10] and Polat *et al*. [11]. The flattening index was determined according to the formula: Girth of the diameter /diameter. A random test portion of 20 seeds from each sample was measured with a *Castorama* (LR44, Germany) electronic digital caliper (precision of 0.02). Length was assessed from both ends and diameter at the middle portion of each seed.

Physicochemical analysis of seeds and extracted oil

Sample treatments
Sunflower seeds from different varieties and cultivars were removed from the shells and the kernels crushed using a SEAAN brand electronic seed and grain grinder and preserved for physicochemical analyses. They were kept refrigerated at a temperature of 5°C.

Determination of water content, total ashes and fats
Moisture, ashes and crude fat contents of sunflower seed samples were determined according to the AOAC [12]. The sample moisture content was determined by drying seeds in an oven at 105˚C overnight. The percent moisture content of the seed sample was expressed as the quotient of the difference in the wet and dry weights and the fresh weight of the sample multiplied by 100, or [(Sample fresh weight - Sample dry weight)/Sample fresh weight) x100]. Ashes was determined by incinerating 5 g of sample in a muffle furnace (Nabertherm) at 550°C for 4 hours. Crude fats content was determined using Soxhlet method with hexane as solvent.

Determination of the acid content of whole seeds and kernels
The acid content of the seeds was determined by titration following the fatty acidity method of the French standardization Association (AFNOR) standard [13]**.** The principle of the method is based on an acid-base titration. The free fatty acids present

https://doi.org/10.18697/ajfand.146.25745

in the solution are determined by titrating with a 0.1 M potassium hydroxide (KOH) solution.

Determination of the saponification index

The saponification index was determined according to AFNOR standards [13]. The method consists of weighing 1.5 g of oil in an Erlenmeyer flask. Then 10 ml of 1M alcoholic potassium hydroxide (KOH) are added. The mixture is then heated for 30 minutes under magnetic stirring. The resulting mixture is cooled and 2 to 3 drops of phenolphthalein are added. The excess potash after saponification is titrated with 1M hydrochloric acid (HCl) until a persistent discoloration is obtained for a few seconds.

Determination of the iodine index

The iodine index was determined according to the standard [14]. The method consists of weighing 0.2 g of oil in an Erlenmeyer flask to which 20 ml of chloroform (CHCl3) and 25 ml of Wijs reagent are added. The mixture is stirred, then placed in the dark for 1 hour. After the reaction time, 20 ml of 10% potassium iodide is added and stirred. Then, the mixture is titrated with the standard solution of sodium thiosulfate (0.1 M) until the yellow color due to iodine has almost disappeared; a few drops of the 1% starch solution are added and the titration is continued until the blue color disappears after vigorous stirring.

Statistical analysis

All physicochemical analyses were conducted in triplicate. Data were processed to derive means and relative standard deviation. An analysis of variance (ANOVA) followed by Fisher's test was carried out to determine statistical differences between samples with a confidence interval of 95% ($p < 0.05$), using the XLSTAT software, version 2016. A Principal Component Analysis (PCA) was performed using the FactoMinR package with the RStudio software, version 1.1.463, to visualize the grouping of samples with regard to physicochemical parameters. Hierarchical Ascending Classification was used with the software.

RESULTS AND DISCUSSION

Physical characteristics of whole seeds

The physical parameters of whole sunflower seeds are reported in Table 1.

The weight of 1000 seeds (PMG) is an indicator of technological performance in primary processing industries. The average 1000 seed weight of cultivars/varieties varies between 39.39 ±0.00 g (V18 INAYA F1) to 79.98 ± 0.07 g (C87 AMMHT 201). Statistical analysis showed a significant difference at $p \leq 0.05$. These values are similar to those found by Ruzdik *et al.* [2] and Muttagi and Joshi [15], who obtained minimum and maximum values for 1000 seeds of 56.67 and 87.83 g and 38.1 and

ajfand Since 2001 AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 25 No. 9
October 2025
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

51.3 g, respectively. The values obtained are lower than those obtained by Makliak and Korkodola [16] with an average 1000 seed weight of 122.30 and 118.3 g with the SPK variety grown with moldboard plowing and tillage without moldboard, respectively. Awoke and Anteneh [17] showed that there was no statistical difference between the tested varieties for average 1000 seed weight, with values of 75.5 g for the Red Black variety and 68.81 for the Local variety. Variability in average 1000 seeds weight can be influenced by growing environment and variety /cultivar. Vrataric and Sudaric [18] and Velimir *et al.* [19] had shown that the variability in the weight of 1000 seeds is characteristic of the genotypes.

The seed size distribution reveals lengths, which vary between 10.30 ± 0.87 to 12.00 ± 0.07 mm for the cultivars and between 9.27 ± 0.53 to 11.21 ± 0.87 mm for the varieties. The highest length value was recorded by the C87 AMMHT 201 cultivar and the lowest by the V15NEOMA F2 variety. These values are higher than those of Evon and Philippe [20] (3 and 7.79 mm) but similar to those reported by Gupta and Das (9.52 mm) [21].

The girth varied from 6.07 ± 0.34 to 7.83 ± 0.66 mm for cultivars and from 5.04 ± 0.40 to 6.49 ± 00 mm for varieties. The highest girth was recorded by the cultivar C87 AMMHT 201 and the lowest by the variety V18 INAYA F1. The values obtained for the cultivars and varieties are similar to those reported by Gupta and Das [21] (5 to 12 mm).

The girth of the diameter for their part varied from 4.06 ± 00 to 5.10 ± 0.56 mm for the cultivars and from 3.04 ± 0.30 to 4.38 ± 00 mm for the varieties. The highest girth of the diameter was recorded by the cultivar C87 AMMHT 201 and the lowest by the variety V18 INAYA F1. These values are close to those reported by Gupta and Das [21] and Esref and Nazmi [22] with values of 3.27 and 4.19 to 6.30 mm, respectively. Flattening index varied from 0.37±0.09 mm for the V7 GUYACAN to 4.89±0.48 mm for the C99 AMMHT 235 cultivar. Statistical analyses showed a significant difference at $p \leq 0.05$ for girth, length, girth of the diameter and Flattening index.

Physicochemical characteristics of whole seeds

The physicochemical parameters of the cultivar and variety samples such as water content, total ash, fat and acid value (I_a) of whole seeds are presented in Table 2.

The water content of samples of cultivars and varieties varied between 3.48 ± 0.17 (V15 NEOMA F2) to 4.96 ± 0.31 (C87 AMMHT 201). Statistical analyses of the samples show a significant difference at $p \leq 0.05$. The values obtained are similar to those (5.50%) obtained by Muttagi and Joshi [2]. These results are significantly lower than those of Srilatha and Krishnakumari [3], Evon and Philippe [20] and Petraru *et al*. [23], with values of 7.49, 5.50 and 6.16 %, respectively.

The determination of the water content is very important, especially since it is an essential factor in the conservation of seeds. All samples of the cultivars and varieties analyzed had a low water content. From a conservation point of view, the seeds of the different cultivars and varieties analyzed can be stored well without the grains deteriorating. Additionally, this allows the almond to be better separated from its shell during shelling for oil extraction.

The average total ashes content of seed samples of cultivars and varieties varied from 3.27 ±0.09 for the V15 NEOMA F2 variety to 6.34 ±0.28 for the V18 INAYA F1 variety. The statistical analysis indicates a significant difference in ash contents between samples of different varieties and cultivars at $p \leq 0.05$. Studies conducted by Srilatha and Krishnakumari [20] and Evon and Philippe [23], yielded average sunflower seed ashes contents of 3.11 and 3.49%, respectively. The ash values obtained are higher than those reported by Petraru *et al.* [3] (2,73%). These differences observed in comparison with other studies could be attributed to the type of cultivar or variety used.

Furthermore, the expression of genetic potential will be conditioned by the context of the crop, namely the environmental conditions (soil, water regime, climatic sequence), cultivation practices (sowing date, irrigation) [24, 25]. The differences in ash content have been attributed to growing conditions, genetic factors and geographic variation [26]. Minerals are of crucial importance in the diet, even though they represent only 4 to 6 percent of the human body and the health benefits [27] .

Analysis of whole sunflower seeds revealed that the lipid fraction of cultivars and varieties varied from 37.10 ±0.09 to 45.66 ±1.16%. The C98 AMMHT 232 cultivar had the highest fat content and the V18 INAYA F1 variety the lowest. Statistical analysis shows that the fat contents of the samples were significantly different at $p \leq 0.05$. The sunflower seed essentially accumulates two types of reserve substances, proteins and lipids, representing approximately 20 and 50% of the dry matter of the seed, respectively [28]. The values obtained are similar to that (37.47%) reported by Evon and Philippe [23]. They are lower than those (49.70% and 51%) obtained by Srilatha [20] and Krishnakumari [28], respectively in whole sunflower seeds.

Studies carried out by Ayerdi Gotor *et al.* [29] also give fat contents varying between 40 to 55%. However, these values remain higher than those found by Lambert *et al.* [30] in cotton and soybeans (soya), 20% and 16-18%, respectively. According to Lambert *et al.*[28], cultivation practices and agronomic criteria (temperature, sowing

Since 2001 ajfand AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 25 No. 9
October 2025
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

date, water availability, genotype) can have an impact on the oil content of sunflower seeds.

Analysis of whole sunflower seeds indicates an acid value varying from 2.31 ± 0.13 (C39 AMMHT 76) to 6.70 ± 0.07 mg KOH/g (C87 AMMHT 201) for cultivars and from 1.24 ±0.15 (V6 CABURE) to 3.38 ±0.18 mg KOH/g (V5 MIRAMAR) for varieties. Varieties had lower acid values than cultivars. The statistical analysis showed that the acid content of the cultivars and varieties was significantly different at the probability threshold $p \leq 0.05$.

The strong variation in the acid content of seeds could be linked to harvesting or storage conditions. However, it is estimated that the acid content could be reduced to an acceptable level during the refining process.

Biochemical characteristics of kernels

The physicochemical parameters of sunflower kernels studied were acid and fat contents (Figure 1). The analysis of sunflower kernels showed that the cultivars studied had an acid content in the range of 1.76 ± 0.02 and 4.87 ± 0.08 mg KOH/g. For varieties, it varied between 1.65 ± 0.03 and 3.95 ± 0.03 mg KOH/g. These results are lower than those of whole seeds; this would indicate that the seed hulls have a strong impact on the acid content of the whole sunflower seed. Following the analysis of variance, there were significant differences between varieties and cultivars. Also, unlike the others, the acid contents of the kernels of samples C98 AMMHT232, C99 AMMHT235, V6 CABURE and V8 INAYA F1 were slightly higher. This could be related to how long the kernels last after shelling.

In this study, the fat content of kernels ranged between 47.60 ± 0.00 to 52.13 ± 0.00% for the cultivars and from 39.80± 0.00 to 52.24 ± 0.00% for varieties. More than 80% of the samples had 45% or more fats. The values obtained are close to those of Muttagi and Joshi [2] with values of 40.33% for kernels of the KBSH 44 variety and 54.06% for that of KBSH 41. These results are lower than those of Muttagi [20] and Joshi [23] with respective values of 62.35 and 66.60%. The fat values are comparable to those of peanuts with 43.32% [2]. The lipid fraction from the kernel is 90% [20] and constitutes the most sought-after part. Results revealed that cultivars contained more lipids than varieties. This is therefore reasonable, especially since they are “cultivated varieties” having undergone improvement or selection methods. Sunflower seed oil contains fatty acids such as oleic acid (C18:1), linoleic acid (C18:2), stearic acid (C18:0) and palmitic acid (C16:0) [31] . Unsaturated fatty acids are the most dominant and vary depending on the variety. Essential fatty acids, C18:1 and C18:2, have beneficial effects on the body [31].

ajfand Since 2001 AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 25 No. 9
October 2025
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

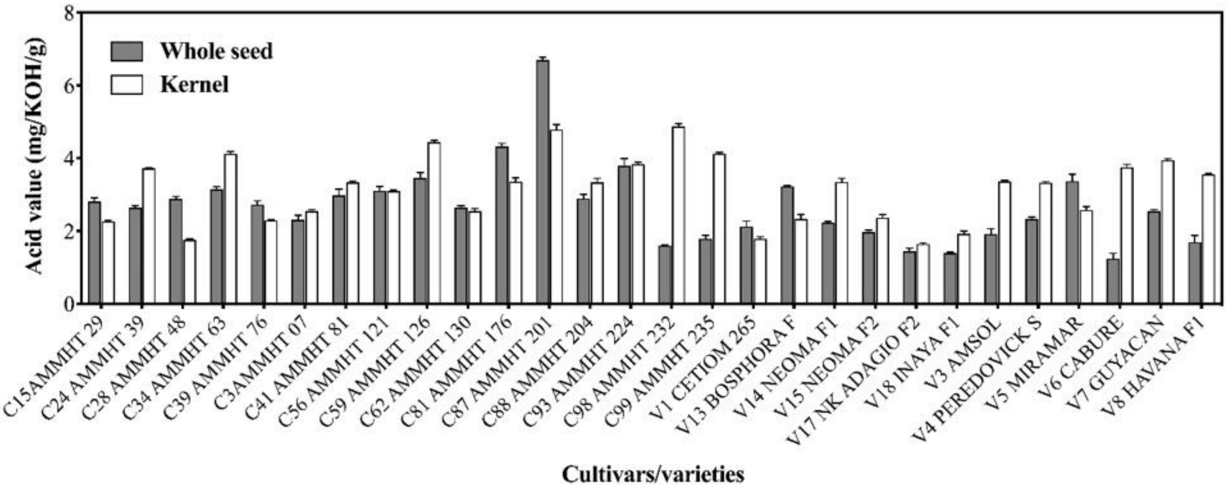

Figure 1: Comparison of the acidity value of kernels and whole seeds of sunflower cultivars and varieties

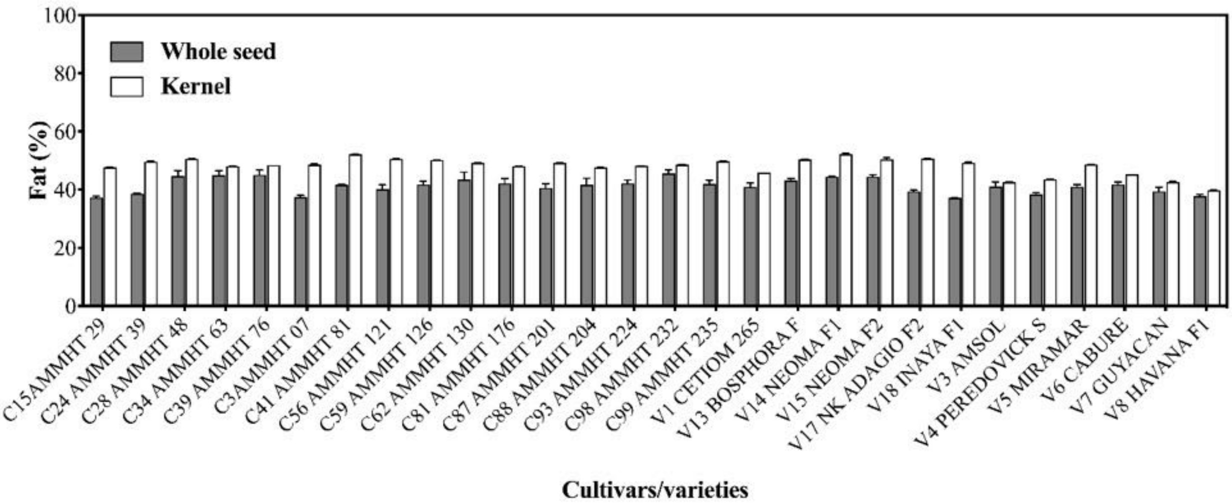

Figure 2: Comparison of fat contents of kernels and whole seeds of sunflower cultivars and varieties

Iodine index and saponification index of oils extracted from seeds

The iodine number is an index of the degree of unsaturation, which influences solubility, hardness and oxidation resistance. The iodine index and the saponification index of oils extracted from sunflower seeds are presented in Table 3.

The analysis of the oils reveals that the cultivars had an iodine index between 101.70 ± 0.05 and 118.31 ± 0.02 mg I_2 / 100g. Concerning the varieties, it varied from 96.16 ± 0.15 to 117.43 ± 0.26 mg I_2 / 100 g. The values obtained are lower than those reported by Subila [32] with a value of 133 mg I_2 / 100 g. Muttagi and Joshi [2] found in sunflower kernels an acid content value of 127.36 to 184.90 I_2 / 100 g. Statistical analysis showed that the iodine index of the samples was significantly different at $p \leq 0.05$. The interest of the iodine index is to be able to characterize the different sunflower oils according to their fatty acid nature. This helps determine which type of fatty acid predominates in these oils. According to the standard [33] for crude vegetable oils with a specific name, crude oils of sunflower, high oleic sunflower, medium oleic sunflower should have values between 118-141, and 78-90 and 94-122 mg I_2/100 g as iodine value, respectively. This makes it possible to classify the present oils in the category of sunflower oils with medium oleic acid content because the results agree with the specifications of said category (Table 4). Sample C99 AMMHT 235 is not in medium. In this category, the content of oleic acid (C18:1), which is a monounsaturated fatty acid can reach 43.1-71.8% depending on the standard [33].

The analysis of the saponification index showed that the oils of cultivars had an index varying from 185.79± 2.99 to 195.16 ±4.20 mg KOH/g of oil and the varieties of 188.07 ±1.46 to 197.40 ± 1.64mg KOH/g of oil. The values obtained are higher than that reported by Subila [32] with a value of 144 mg KOH/ g. Muttagi and Joshi [2] found in sunflower kernels an acid content value of 130.00 to 180.9 mg KOH/ g. The statistical analysis showed that the saponification index of the samples was significantly different at $p \leq 0.05$. According to the specifications of the standard [33], crude sunflower oils with medium oleic acid content must have a saponification index between 190-191 mg KOH/ g of oil. Only approximately 18% of the oils studied meet the requirements of this standard. On the other hand, the indices found are closer to that of sesame oil (186-195) peanut oils (187-196) and soybean oils (189-195) [33]. These oils can be used in soap factories.

The varieties and cultivars having a saponification index in compliance with the standard (CODEX STAN 210-1999, 2015) are V8 HAVANA F1, C15 AMMHT29, V14 NEOMA F1, C41 AMMHT81, C59 AMMHT126.

Principal component analysis (PCA)

There is a dispersion of cultivars and varieties around the studied parameters. Figure 3 illustrates the Principal Component Analysis (PCA) of the physicochemical parameters of whole seeds and kernels of sunflower cultivars and varieties. The main axes Dim1 and Dim2 represent 51.6% of the total inertia, with 31.00% and 20.6%, respectively.

A good representativeness of the AW-WS, W-100 Seeds, AI-A, II-FWS, AC-WS, SI-FWS in relation to the main axis Dim1 was observed. Compared to the main axis Dim2, FC-WS, FA, WC-WS are more represented. It makes it possible to distinguish three groups of samples between the two axes.

The cultivars C28, C34, C39, C41, C56, C88, C59, C62, C98, C99 and the varieties V13, V14, V15 are marked by their proximity to the axis of the fat variables of whole seeds (FC_WS) and kernel (F_A). Which means that these samples are richer in fat. The oil content being the most targeted characteristic in this study, these species will be more recommended in the varietal choice.

The varieties V1, V3, V4, V7, V8, V17, V18 and the cultivars C3, C15 are closer to the axis of the variable's ashes (AC_WS), Acid value (II_FWS) and Saponification index (SI_FWS). This means that these samples are mainly rich in minerals (especially C3, V1, C15 and V18). Additionally, the overall analysis of the iodine index of the extracted oils indicated that all cultivars and varieties (except V4) had an index between 100-150. Thus, these oils can be listed in the category of semi-drying oils according to the traditional classification of vegetable oils according to their iodine index. This possibly reflects their richness in unsaturated fatty acids.

The cultivars C24, C81, C87, C88, C93 and the varieties V5, V6 were mainly characterized by the variable's weight of 1000 seeds (W-1000 seeds), water content (WC_WS) and whole seed acidity value (AI_A) and kernel acid value (AI_A). This strongly reflects the size and density of their achenes (seeds). Furthermore, these samples are more humid and with high acidity (except V6) than the others. However, the water content of all the samples studied is moderately acceptable.

The identification of varieties and cultivars was done on the basis of principal component analysis with particular attention to certain quality parameters (%FC, %AS, II, weight of 1000 seeds). The PCA was carried out and retained following a multivariate analysis, that is to say several combinations of the different parameters studied. After analyses, the cultivars C28, C34, C39, C87, C98, C99 and the varieties V1, V13, V14, V15 were observed as species presenting satisfactory nutritional potential.

Since 2001 ajfand
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 25 No. 9
October 2025
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

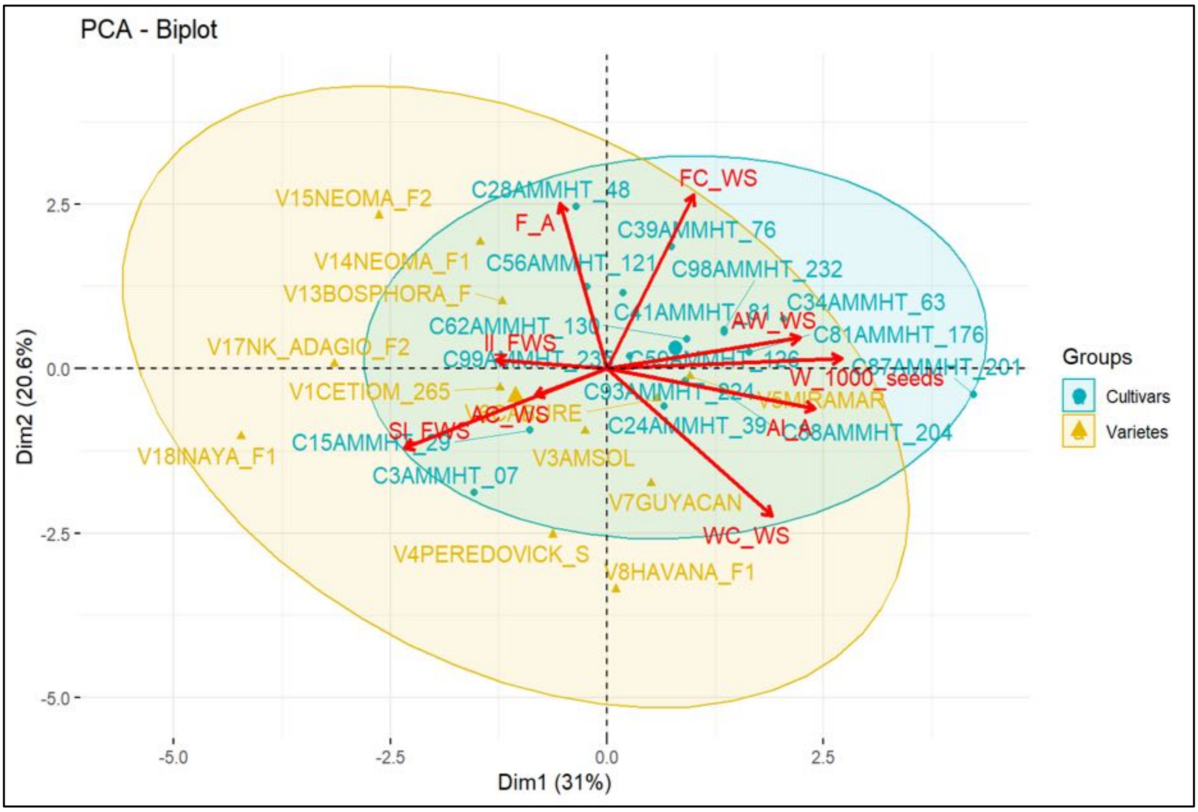

Figure 3: PCA biplot of physicochemical parameters of whole seeds and kernels of sunflower cultivars and varieties

FC_WS: whole seed fat; F_A: Kernel fat; AC_WS: Ashes; II_FWS: Acid value; SI_FWS: Saponification Index; W-1000 seeds: weight of 1000 seeds; WC_WS: water content; AI_A: whole seed acidity index; AI_A: acid value of kernels

Hierarchical Ascending Classification of physicochemical parameters of whole seeds and kernels of sunflower cultivars and varieties

Figure 4 shows the dendrogram of physicochemical parameters of whole seeds and kernels of sunflower cultivars and varieties. Class 1 consists of the cultivars C28, C34, C39, C41, C56, C88, C59, C62, C98, C99 and the varieties V13, V14, V15. These are lower varieties of lycopene and β-carotene. Class 2 consists of the varieties V1, V3, V4, V7, V8, V17, V18 and the cultivars C3, C15. These varieties are the richest in minerals. Class 3 consists of cultivars C24, C81, C87, C88, C93 and the varieties V5, V6. This is the group with a 1000 grain weight, higher moisture content and acidity value.

Since 2001 ajfand AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 25 No. 9
October 2025
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

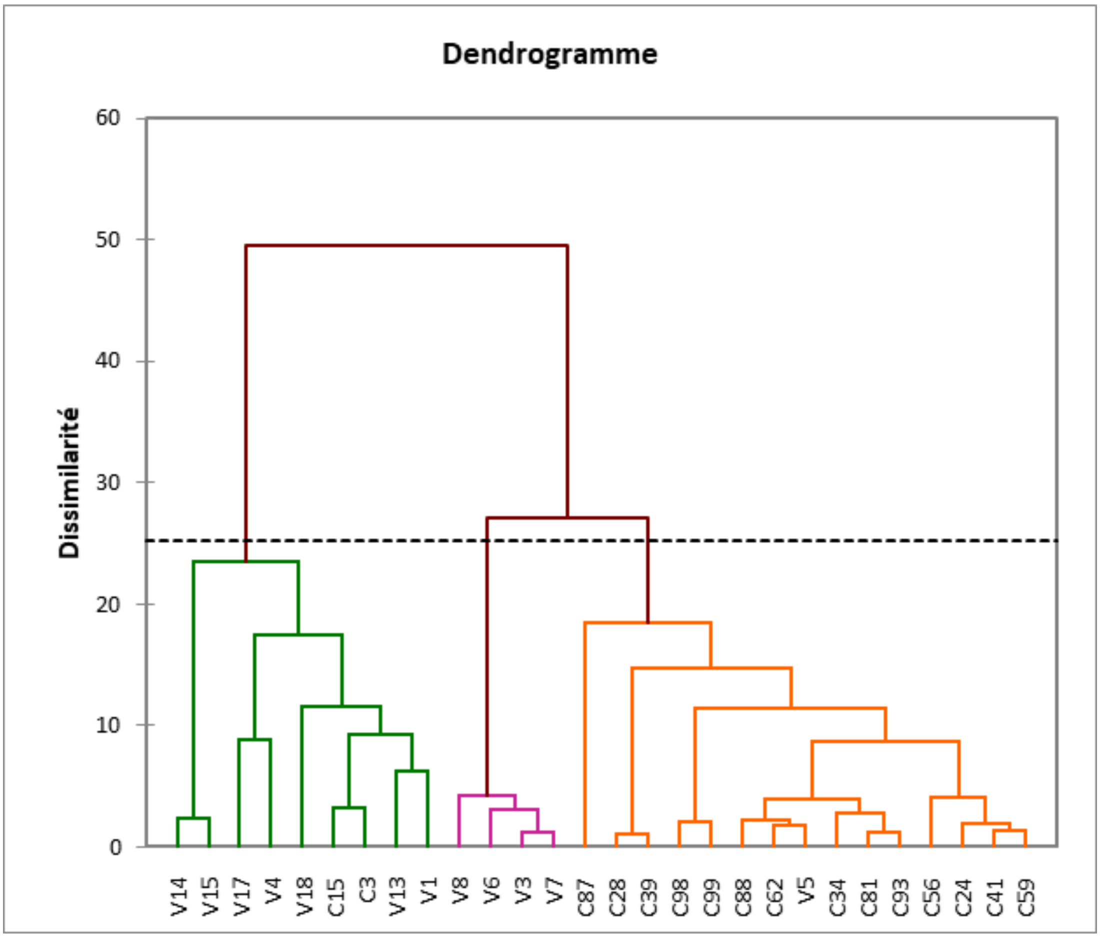

Figure 4: Hierarchical Ascending Classification of physicochemical parameters of whole seeds and kernels of sunflower cultivars and varieties

C99: C99 AMMHT 235, C98: C98 AMMHT 232, C93: C93 AMMHT 224, C88: C88 AMMHT 204, C87: C87 AMMHT 201, (C81): C81 AMMHT 176, C62: C62 AMMHT 130, C59; C59 AMMHT 126, C56: C56 AMMHT 121, C41: C41 AMMHT 81, C39: C39 AMMHT 76, C34: C34 AMMHT 63, C3: C3 AMMHT 07, C28: C28 AMMHT 48, C24: C24 AMMHT 39, C15: C15 AMM HT 29, V13: V13 BOSPHORA F, V14: V14 NEOMA F1, V15: V15 NEOMA F2, V17: V17 NK ADAGIO F2, V18: V18 INAYA F1, V1: V1 CETIOM 265, V3: V3 AMSOL, V4: V4 PEREDOVICK S, V5: V5 MIRAMAR, V6: V6 CABURE, V7: V7 GUYACAN, V8: V8 HAVANA F1

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

As part of the search for new resources for oilseed products in Burkina Faso, the sunflower (*Helianthus annuus* L.) represents one of the plants of choice due to the richness of its seeds in fatty substances. For all cultivars and varieties studied, the results showed a considerable range of variations in the parameters studied. The results obtained during this study indicate that the seeds presented acceptable physical qualities. Cultivars C28, C34, C39, C41, C56, C88, C59, C62, C98, C99 and varieties V13, V14, V15 were higher in fat. Cultivars C24, C81, C87, C88, C93 and varieties V5, V6 were characterized by the variables high 1000 seed weight with high water content and acid value (except V6) than the others. These analyses made it possible to classify the cultivars and varieties in the category of sunflowers with medium oleic acid content following the determination of the iodine index of the extracted oils.

The cultivars C28, C34, C39, C87, C98, C99 and the varieties V1, V13, V14, V15 were selected as having better physicochemical and biochemical characteristics. These new varieties can be popularized among producers. The introduction of new oil-rich sunflower varieties with high 1000-seed weights in the study area is crucial for farmers because it will increase yields, improve their incomes, diversify agriculture, meet growing market demand for high-quality oils, and strengthen the resilience of farms to climatic and economic hazards. These varieties offer significant agronomic and economic advantages, providing varied outlets and better value for crops.

ACKNOWLEDGEMENTS

The authors are grateful to the Ministry of Higher Education, Research and Innovation (MESRI) in Burkina Faso who funded this work. The authors also thank Dr SANOU Jacob for providing samples of the different sunflower varieties and cultivars for this study.

Conflict of interest

The authors declare no conflict of interest.

https://doi.org/10.18697/ajfand.146.25745

ajfand Since 2001
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 25 No. 9
October 2025
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 1: Physical parameters of cultivars and varieties of sunflower seeds

Samples	Weight of 1000 seeds (g)	Length (mm)	Girth (mm)	Girth of the diameter (mm)	Flattening index (mm)
CULTIVARS					
C99 AMMHT 235	68.48±0.12^{ijk}	10.57±0.58^{a}	6.91±0.38^{bcd}	4.89±0.48^{gh}	0.46±0.02^{c}
C98 AMMHT 232	71.35±0.07^{jk}	10.80±0.54^{bcd}	6.53±0.045^{abc}	4.57±0.42^{efg}	0.42± 0.03^{b}
C93 AMMHT 224	64.15±0.05^{efghi}	10.88±0.94^{bcd}	6.29±0.86^{a}	4.44±0.50^{def}	0.41±0.01^{c}
C88 AMMHT 204	72.17±0.09^{jk}	11.81±0.83^{bcd}	7.08±0.63^{a}	4.35±0.44^{def}	0.37± 0.05^{a}
C87 AMMHT 201	79.98±0.07	11.43± 0.80^{a}	7.83±0.66^{bcd}	5.10± 0.56^{a}	0.45±0.08^{c}
C81 AMMHT 176	66.49±0.03^{ghijk}	11.18±0.80^{ab}	6.67±0.50^{abc}	4.51±0.50^{efg}	0.41±0.08^{b}
C62 AMMHT 130	65.95±0.05^{fghij}	10.81±0.72^{bcd}	6.59±0.47^{abc}	4.54±0.42^{efg}	0.42± 0.01^{b}
C59 AMMHT 126	68.76±0.19^{ijk}	11.21±0.76^{bc}	6.73±0.72^{bcd}	4.60±0.46^{efg}	0.41±0.02^{b}
C56 AMMHT 121	60.36±0.09^{efgh}	11.16±0.68^{ab}	6.34±0.40^{b}	4.48±0.47^{def}	0.40± 0.03^{b}
C41 AMMHT 81	68.96±0.03^{ijk}	12.00±1.07^{ab}	6.94±1.03^{cds}	4.53±0.73^{efg}	0.38± 0.03^{a}
C39 AMMHT 76	72.41±0.09^{jk}	10.93±0.63^{bcd}	6.64±0.67^{abc}	4.42±0.31^{def}	0.41± 0.04^{b}
C34 AMMHT 63	65.91±0.06^{fghij}	11.01±0.93^{ab}	6.36±0.81^{ab}	4.34±0.62^{bcd}	0.40± 0.05^{b}
C3 AMMHT 07	59.50±0.06^{efg}	10.56± $^{0.12a}$	6.65±0.58^{abc}	4.27±0.40^{bcd}	0.41± 0.02^{b}
C28 AMMHT 48	66.94±0.03^{hijk}	10.86±0.74^{bcd}	6.10±0.38^{a}	4.06± 0.52^{a}	0.38± 0.04^{a}
C24 AMMHT 39	68.85±0.08^{ijk}	10.30±0.87 ^{b}	6.64±0.63^{abc}	4.38±0.31^{bcd}	0.43± 0.02^{b}
C15AMM HT 29	57.92±0.08^{cd}	10.70±0.61^{bc}	6.07± 0.34^{a}	4.16±0.45 ^{ab}	0.39± 0.03^{a}
VARIETES					
V13 BOSPHORA F	51.36±0.14^{bc}	11.14±0.65^{ab}	6.39±0.6^{bc}	4.23±0.58^{ab}	0.38± 0.04^{a}
V14 NEOMA F1	45.63±0.02^{ab}	10.26±0.61^{ab}	5.96±0.48^{abcde}	4.06± 0.49^{a}	0.40± 0.05^{b}
V15 NEOMA F2	46.99± 0.05^{b}	9.27±0.53^{ab}	5.56±0.37^{abc}	4.10± 0.39^{a}	0.44±0.03^{bc}
V17 NK ADAGIO F2	52.03±0.07^{bcd}	10.37± 0.73^{b}	5.64±0.41^{abcd}	3.90±0.39^{ghi}	0.38± 0.12^{a}
V18 INAYA F1	39.39±0.00^{a}	10.45± 0.12 ^{a}	5.04± 0.40 ^{a}	3.04± 0.30^{a}	0.29± 0.02^{c}
V1 CETIOM 265	72.21±0.02^{k}	11.21±1.15 ^{ab}	6.40±0.43^{abc}	4.30±0.44^{bcd}	0.39± 0.02^{a}
V3 AMSOL	58.22±0.11^{of}	10.41± 0.74 ^{a}	6.36±0.76^{bc}	4.15±0.47^{ab}	0.40±0.05^{b}
V4 PEREDOVICK S	48.74±0.03^{b}	10.98±0.61^{bcde}	6.41±0.57^{bc}	4.21±0.63^{ab}	0.39± 0.05^{a}
V5 MIRAMAR	69.99±0.09^{ijk}	11.07±0.85^{ab}	6.49±0.62^{bc}	4.20±0.54^{ab}	0.38±0.03^{a}

ajfand Since 2001 AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 25 No. 9
October 2025
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

V6 CABURE	72.69±0.06^{k}	10.69±0.42^{bcd}	6.23± 0.27^{a}	4.38±0.38^{bcd}	0.41±0.06^{b}
V7 GUYACAN	59.93±0.10^{efg}	11.06±0.78^{ab}	6.43±0.44^{bc}	4.06± 0.043^{a}	0.37±0.09^{a}
V8 HAVANA F1	64.21±0.07^{efghi}	10.65±0.59^{bcd}	6.17± 0.36^{a}	4.37±0.36^{bcd}	0.41±0.01^{b}
P-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Numbers with the same superscript letters (a, b, c) in the same column are not significantly different at the probability threshold $p \leq 0.05$.

Table 2: Physicochemical characteristics of whole seeds of sunflower cultivars/varieties

Samples	Water Content (%)	Ash Content (%)	Fat Content (%)	Acid Value (mg KOH/g)
CULTIVARS				
C15 AMM HT 29	4.51 ±0.15^{a}	4.35±0.03^{jklm}	37.31±0.42^{a}	2.82±0.10^{mno}
C24 AMMHT 39	4.48±0.18^{ghijkl}	4.13±0.02^{jklm}	38.57±0.27^{ij}	2.64±0.06^{kl}
C28 AMMHT 48	3.74±0.07^{ab}	4.19±0.03^{jhi}	44.65±1.93^{ij}	2.89±0.06^{no}
C34 AMMHT 63	4.61±0.42^{hijklm}	3.94±0.0^{of}	44.98±1.50^{ij}	3.15±0.07^{pq}
C39 AMMHT 76	4.02±0.43^{cdef}	4.22±0.03^{hijk}	45.15±1.57^{days}	2.73±0.10^{ef}
C3 AMMHT 07	4.81±0.24^{lmn}	4.60±0.06^{n}	37.41±0.69^{ab}	2.31±0.13^{days}
C41 AMMHT 81	4.12±0.25^{abcd}	4.26±0.03^{hijkl}	41.63±0.25^{cdefghij}	2.98± 0.17^{op}
C56 AMMHT 121	3.87±0.57^{bc}	3.94±0.02^{of}	40.09±1.59^{abcdef}	3.11±0.12^{pq}
C59 AMMHT 126	4.27±0.14^{defghi}	4.36±0.02^{lm}	41.77±1.17^{cdefghij}	3.46±0.15^{s}
C62 AMMHT 130	4.81±0.10^{lmn}	4.22±0.04^{hij}	43.46±2.60^{fghij}	2.65±0.05^{klm}
C81 AMMHT 176	4.59±0.25^{hijklmn}	4.40±0.04^{m}	42.19±1.64^{defghij}	4.32±0.09^{u}
C87 AMMHT 201	4.96± 0.31^{n}	4.37±0.01^{lm}	40.6±1.44a^{bcdefg}	6.70± 0.07^{v}
C88 AMMHT 204	4.85±0.24^{lmn}	4.35±0.02^{klm}	41.74±2.21^{cdefghij}	2.90±0.11^{no}
C93 AMMHT 224	4.61± 0.13^{ijklmn}	4.55±0.02^{n}	42.15±1.22^{gh}	3.79±0.20^{t}
C98 AMMHT 232	4.61±0.13^{ijklmn}	4.31±0.01^{jklm}	45.66±1.16^{days}	1.60±0.02^{cd}
C99 AMMHT 235	4.50±0.08^{ghijkl}	4.02±0.01^{ef}	41.87±1.36^{defghij}	1.79±0.09^{ef}
VARIETIES				
V1 CETIOM 265	4.35±0.24^{efghij}	5.53±0.12^{p}	40.99±1.29^{abcdefgh}	2.13±0.15^{hi}
V13 BOSPHORA F	4.24±0.16^{bcdef}	5.38±0.14^{o}	43.20±0.68^{efghij}	3.23±0.02^{qr}
V14 NEOMA F1	3.98±0.21^{bcde}	3.80±0.18^{c}	44.52±0.05^{ghij}	2.23±0.04^{ij}

V15 NEOMA F2	3.48±0.17[ghijklm]	3.27±0.09[a]	44.50±0.65[ghij]	1.97±0.06[gh]
V17 NK ADAGIO F2	3.96±0.11[bcd]	3.54±0.04[b]	39.39±0.45[abcde]	1.45±0.08[bc]
V18 INAYA F1	4.13±0.19[cdefg]	6.34±0.28[q]	37.10±0.09[a]	1.40±0.03[ab]
V3 AMSOL	4.23±0.15[cdefgh]	4.07±0.10[efg]	41.12±1.55[bcdefghi]	1.92±0.14[fg]
V4 PEREDOVICK S	4.68±0.08[jklmn]	3.84±0.02 [d]	38.41±0.54[abcd]	2.34± 0.05[k]
V5 MIRAMAR	4.76±0.10[kmn]	3.59±0.05[b]	41.00±0.70a[bcdefgh]	3.38±0.18[rs]
V6 CABURE	4.41±0.11[fghijk]	3.59±0.02[b]	41.79±0.75[cdfghij]	1.24±0.15[a]
V7 GUYACAN	4.53±0.27[height]	3.58±0.03[b]	39.47±1.41[abcde]	2.54±0.05[k]
V8 HAVANA F1	4.88±0.12[mins]	4.14 ±0.04[fgh]	37.86±0.5[abc]	1.70±0.18[of]
P-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Numbers with the same superscript letters (a, b, c) in the same column are not significantly different at the probability threshold $p \leq 0.05$.

Table 3: Iodine index and saponification index of sunflower oils

Samples	Iodine index (mg I_2 / 100g)	Saponification index (mg KOH/g)
CULTIVARS		
C93 AMMHT 224	109.88±0.68[hrs]	189.66±0.27[defg]
C15AMM HT 29	114.62± 0.72[n]	187.87±1.41[gh]
C24 AMMHT 39	103.26±0.80[bcde]	189.28±0.73[abcdef]
C28 AMMHT 48	102.61±2.92[bcd]	187.62±0.28[abcde]
C3AMMHT 07	112.13±0.46[jkl]	195.16±4.20[jk]
C34 AMMHT 63	103.30±0.43[bcef]	185.79± 2.99[a]
C39 AMMHT 76	102.14±0.4[bc]	185.83± 2.7[a]
C41 AMMHT 81	106.69±0.09[fg]	189.64±1.04[defg]
C56 AMMHT 121	111.07±0.86[ijkl]	185.83± 0.97[a]
C59 AMMHT 126	104.23±0.46[cd]	188.51±1.28[bc]
C62 AMMHT 130	104.39±1.04[of]	186.42±1.58[abc]
C81 AMMHT 176	105.36±0.57[ef]	186.40±0.13[abc]
C87 AMMHT 201	101.41±0.44[b]	186.86±1.00[abcd]
C88 AMMHT 204	112.99±0.60[km]	186.12±0.24[ab]
C98 AMMHT 232	113.62±0.70[lm]	187.70±1.83[abcde]

C99 AMMHT 235	117.99±0.69[o]	188.58±1.38[abcdef]
VARIETIES		
V13 BOSPHORA F	109.88±2.36[hi]	189.41±0.91[cdefg]
V14 NEOMA F1	112.97±0.31[km]	190.38±0.95[efgh]
V15 NEOMA F2	116.31±0.23[no]	192.13±0.85[ghi]
V17 NK ADAGIO F2	105.48±2.12[ef]	197.40± 1.64[k]
V18 INAYA F1	117.32±0.56[o]	193.04±1.09[ij]
V1 CETIOM 265	102.83±0.81[bcd]	196.12±5.96[jk]
V3 AMSOL	108.61±1.01[gh]	188.55±1.04[abcdef]
V4 PEREDOVICK SOUROU	95.93±0.42[a]	194.80±1.82[ijk]
V5 MIRAMAR	108.48±4.33[gh]	188.17±1.67[abcdef]
V6 CABURE	112.07±1.46[ijkl]	188.07±1.46[abcdef]
V7 GUYACAN	108.48±1.98[gh]	189.50±1.08[cdefg]
V8 HAVANA F1	109.91±0.56[hij]	191.21±2.09[gh]
P-value	< 0.0001	< 0.0001

Numbers with the same superscript letters (a, b, c) in the same column are not significantly different at the probability threshold $p \leq 0.05$

Table 4: Classification of varieties and cultivars according to the CODEX STAN 210-1999 standard for the iodine index

	Iodine index		
	Sunflower oil	**Sunflower oil medium oleic acid**	**Sunflower oil high in oleic acid**
Reference sample	**118-141 mg I_2/100 g**	**94-122 mg I_2/100 g**	**78-90 mg I_2/100 g**
CULTIVARS			
C3 AMMHT 07	-	+	-
C15 AMMHT 29	-	+	-
C24 AMMHT 39	-	+	-
C28 AMMHT 48	-	+	-
C34 AMMHT 63	-	+	-
C39 AMMHT 76	-	+	-
C4 1 AMMHT 81	-	+	-

C56 AMMHT 121	-	+	-
C59 AMMHT 126	-	+	-
C62 AMMHT 130	-	+	-
C81 AMMHT 176	-	+	-
C87 AMMHT 201	-	+	-
C88 AMMHT 204	-	+	-
C93 AMMHT 224	-	+	-
C98 AMMHT 232	-	+	-
C99 AMMHT 235	+	+	-
VARIETIES			
V1 CETIOM 265	-	+	-
V3 AMSOL	-	+	-
C4 PEREDOVICK SOUROU	-	+	-
V5 MIRAMAR	-	+	-
V6 CABURE	-	+	-
V7 GUYACAN	-	+	-
V8 HAVANA	-	+	-
V13 BOSPHORA F	-	+	-
V14 NEOMA F1	-	+	-
V15 NEOMA F2	-	+	-
V17 NK ADAGIO F2	-	+	-
V18 INAYA F1	-	+	-

The sign (+) designates that the iodine value of the variety or cultivar is within the indicated range; The sign (-) indicates that the iodine value of the variety or cultivar is not included in the indicated range

REFERENCES

1. **FAOSTAT.** Food and Agriculture of the United Nation Statistical database. In: 2024. https://www.fao.org/faostat/fr/#data/QCL *Accessed November 2024.*

2. **Muttagi GC and N Joshi** Physico-chemical composition of selected sunflower seed cultivars. *Int J Chem Stud.* 2020; **8(4):** 2095-2100. https://doi.org/10.22271/chemi.2020.v8.i4w.9936

3. **Petraru A, Ursachi F and S Amariei** Nutritional characteristics assessment of sunflower seeds, oil and cake. Perspective of using sunflower oilcakes as a functional ingredient. *Plants*. 2021; **10(11).**

4. **Puttha R, Venkatachalam K, Srean P and S Hanpakdeesakul** Exploring the Potential of Sunflowers: Agronomy, Applications, and Opportunities within Bio-Circular-Green Economy. *Horticulturae*. 2023; **9(10).** https://doi.org/10.3390/horticulturae9101079

5. **Adeleke BS and OO Babalola** Oilseed crop sunflower (*Helianthus annuus* L.) as a source of food: Nutritional and health benefits. *Food Sci Nutr.* 2020; **8(9):** 4666-4684. https://doi.org/10.1002/fsn3.1783

6. **De Giada MLR** Antioxidant capacity of the striped sunflower seed (*Helianthus annuus* L.) aqueous extract. *European Journal of Lipid Science and Technology.* 2008; **110(3):** 284-290. https://doi.org/10.1002/ejlt.200600303

7. **Duru M and MB Magrini** Alimentation Animale et Santé Humaine: Quels Défis Pour l'agronomie? Vol 7. *Environnement and Sociétés*. 2017.

8. **Ouedraogo M** Reconquête Du Marché de l'huile Au Burkina Faso. CFSI. 2016. https://www.alimenterre.org/reconquete-du-marche-de-l-huile-au-burkina-faso *Accessed November 2024.*

9. **Thio IG, Traore A and H Bama** RAPPORT FINAL Étude de Recherche et Développement d'huile à Base de Tournesol, Pour Combler La Production d'huile de Coton Au Profit de La Chambre de Commerce et d'Industrie Du Burkina Faso (CCI-BF). 2021.

10. **Aydın C and MM Özcan** Determination of nutritional and physical properties of myrtle (*Myrtus communis* L.) fruits growing wild in Turkey. 2005; **79(6):** 453-458. https://doi.org/10.1016/j.jfoodeng.2006.02.008

11. **Polat MY, Özcan A, Uygun S and O Aydın** Measurement of Projected Areas in Some Confectionery Sunflowers (*Helianthus annuus* L.) Seeds by Image Processing Technique. *Selcuk Journal of Agricultural and Food Sciences*. 2023. https://doi.org/10.15316/SJAFS.2023.015

12. **AOAC.** Official Methods of Analysis of AOAC International. 18th Editi.; 2005.

13. **NF EN ISO 3657**. Corps Gras d'origines Animale et Végétale - Détermination de l'indice de Saponification.; 2020.

14. **ISO 3961.** Corps Gras d'origines Animale et Végétale Détermination de l'indice d'iode. 2018.

15. **Ruzdik NM, Karov I, Mitrev S, Gjorgjieva B, Kovacevik B and E Kostadinovska** Evaluation of sunflower (*Helianthus annuus* L.) hybrids using multivariate statistical analysis. *Helia*. 2015; **38(63):** 175-187. https://doi.org/10.1515/helia-2015-0007

16. **Makliak K and M Korkodola** Evaluation of seed yield and thousand seed weight of confectionery sunflower (*Helianthus annuus* L.) varieties grown by different farming techniques in the northern steppe of Ukraine. *AgroLife Scientific Journal.* 2023; **12(2):** 107-115. http://dx.doi.org/10.17930/AGL2023215

17. **Awoke T and T Anteneh** Evaluation of Sunflower (*Helianthus annuus* L.) Varieties for Growth, Yield and Yield Components under Irrigation at Lowland Area of South Omo Zone, Southern Ethiopia. *Journal of Agriculture and Aquaculture*. 2022; **4(2)**.

18. **Velimir R, Jelena M, Milan J, Petar C, Aleksandra D and J Sinisa** Sunflower 1000-seed weight as affected by year and genotype. *Ratarstvo i povrtarstvo*. 2013; **50(1):** 1-7. https://doi.org/10.5937/ratpov50-3214

19. **Vrataric M and A Sudaric** Oplemenjivanje I genetika suncokreta. In Suncokret *Helianthus annuus* L. Vratarić (ed.). Poljoprivredni institut Osijek Hrvatska. 2004; **34(1):** 69-162.

20. **Evon MP** Nouveau Procédé de Bioraffinage Du Tournesol Plante Entière Par Fractionnement Thermo- Écano-Chimique En Extrudeur Bi-Vis: Étude de l'extraction Aqueuse Des Lipides et de La Mise En Forme Du Raffinat En Agromatériaux Par Thermomoulage. 2005.

21. **Gupta RK and SK Das** Physical Properties of Sunflower Seeds. *Journal of Agricultural Engineering Research*. 1997; **66(1):** 1-8. https://doi.org/10.1006/jaer.1996.0111

22. **Esref I and Nazmi** Physical Properties of Sunflower Seed (*Helianthus annuus* L.). *International Journal of Agricultural Research.* 2007. **2(8):** 677-686. https://doi.org/10.3923/ijar.2007.677.686

23. **Srilatha K and K Krishnakumari** Proximate Composition and Protein Quality Evaluation of Recipes Containing Sunflower Cake. *Plant Foods Hum Nutr*. 2003; **58:** 1–11. https://doi.org/10.1023/B:QUAL.0000041139.37434.5c

24. **Mahmood T, Ahmed T and R Trethowan** Genotype x Environment x Management (GEM) Reciprocity and Crop Productivity. *Frontiers in Agronomy*. 2022; **4**. https://doi.org/10.3389/fagro.2022.800365

25. **Collins NC, Tardieu F and R Tuberosa** Quantitative trait loci and crop performance under abiotic stress: Where do we stand? *Plant Physiol.* 2008; **147(2):** 469-486. https://doi.org/10.1104/pp.108.118117

26. **Özcan MM** Determination of the mineral compositions of some. *GRASAS Y ACEITES*. 2006; **57(2):** 211-218.

27. **Marcovecchio JE, De Marco SG, Buzzi NS, Botté SE, Labudia AC, Noelia La Colla and MDF Severini** Handbook of Mineral Elements in Food. 2015. Book Editor(s): Miguel de la Guardia, Salvador Garrigues. https://doi.org/10.1002/9781118654316.ch27

28. **Roche J** Composition de La Graine de Tournesol (*Helianthus Annuus* L.) Sous l'effet Conjugué Des Contraintes Agri-Environnementales et Des Potentiels Variétaux. 2005.

29. **Ayerdi Gotor A, Berger M, Labalette F, Centis S, Dayde J and A Calmon** Variabilité des teneurs et compositions des composés mineurs dans l'huile de tournesol au cours du développement du capitule: Partie I - Tocophérols. OCL - Oleagineux Corps Gras Lipides. 2006; **13(2-3):** 206-212. https://doi.org/10.1684/ocl.2006.0014

30. **Lambert KN, Bekal S, Domier LL, Niblack TL, Noel GR and CA Smyth** Selection of Heterodera glycines chorismate mutase-1 alleles on nematode-resistant soybean. *Molecular Plant-Microbe Interactions*. 2005; **18(6):** 593-601. https://doi.org/10.1094/MPMI-18-0593

31. **Anushree S, André M, Guillaume D and F Frédéric** Stearic sunflower oil as a sustainable and healthy alternative to palm oil. A review. *Agron Sustain Dev*. 2017; **37(3).** https://doi.org/10.1007/s13593-017-0426-x

32. **Subila S** Determination of Saponification and Iodine Value of Sunflower Oil. *International Journal of Innovative Research and Advanced Studies* (IJIRAS). 2016; **3(13).**

33. **CODEX STAN 210-1999.** Norme Pour Les Huiles Végétales Portant Un Nom Spécifique. 2015.