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Physicochemical Properties of Oil of *Polygala multiflora* Poir. Grown in Burkina Faso

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Abstract

Polygala multiflora is an important source of oil that needs to be valorized. This study aimed to investigate the potential of *P. multiflora* as an oleaginous plant. The physical and chemical properties of oil extracted from *P. multiflora* seeds were analyzed according to standard methods. The main physical parameters were yield of oil (43.25 ± 2.3%), relative density (0.912 ± 0.031), melting point (2.42 ±0.6 °C), and refraction index (1.45 ±0.02), yellow light color. Chemical characteristics were: free fatty acids (1.97 ±0.2 % ac. Oleic), acidity index (6.93 ±0.14 mg KOH/g), saponification index (186.3 ±9.31mg KOH/g), iodine index (40.37 ±0.5 gI_2/100g), and peroxide index (1.58 ±0.05 Meq O_2/kg). Overall, *P. multiflora* seed oil has shown properties in line with standards for food, cosmetic and pharmaceutical use.

Keywords: *Polygala multiflora*, oil, physicochemical characteristics, Burkina Faso

1. Introduction

Edible fats include oils and fats of animal or vegetable origin. Dietary fats include oils and fats of animal or vegetable origin. Vegetable oils represent a large and varied group of fats of different origins, compositions, qualities, and tastes. In addition to their importance in the diet (they help to build structures, provide energy (approx. 9 kcal/g) and essential fatty acids and fat-soluble vitamins), fats are also important in various sectors, including cosmetics and pharmaceuticals **(**Lecerf, 2011). As the world's population grows, the demand for oilseed food crops is increasing dramatically. It is estimated that oilseed crops need to increase by 133 million tons to 282 million tonnes to meet demand. Yet only four oilseed crops (oil palm, soybean, rapeseed, and sunflower) account for 83% of global production (FAO, 2012). The main oilseed production areas are in temperate zones. America and Europe together account for over 60% of the world's oilseed production, while much less (<5%) comes from tropical areas such as Africa, Malaysia, and Indonesia (Sharma et al., 2012). The main tropical oilseed crops are coconut, oil palm, peanut, and cotton.

However, many other traditional oilseed in tropical Africa are under-exploited, as their nutritional and economic values are poorly understood. These oils come from numerous botanical families, including the *Anacardiaceae* in West Africa. The great diversity of oil seed resources potentially makes a wide variety of fats available to the various application areas. In plants, lipids including oils are mostly present in the endosperm of grains along with carbohydrates and proteins where they jointly nourish the embryo (Oyeyiola **,** 1993**)**.

Extracted oils are used in a variety of ways, *i.e.* food texturing, baking, frying and also industrially applications in the manufacture of soap, detergent, cosmetics, and oil paints **(**Sarwar et al., 2013).

In Burkina Faso, widely produced and consumed oils extracted from cottonseed, groundnut, sesame, and shea kernel oil. Approximately 86 000 tons of edible vegetable oils are produced each year. Annual demand for edible oils is estimated at 150000 tons, with a growth rate of 4% (Tietiambou**,** 2018**)**. The shortfall in vegetable oils is made up of imports, mainly palm oil from Cote d'Ivoire and Asia **(**MARAH, 2021). Every year, Burkina Faso imports an average of 75000 tons of edible oils worth more than 14.6 billion FCFA **(**MARAH, 2021)**.** However, other important sources of available vegetable oils unknown or not yet exploited (Ndjouenkeu &Ngassoum, 2002)**.**

There are high-potential but under-utilized local vegetable oil species whose promotion can help generate substantial income for rural and urban communities (Tietiambou**,** 2018**)**. In many African countries, including Burkina Faso, oil- and fat-producing plants in particular have great potential (Sama et al., 2022). Natural oil sources generally contain stabilizing compounds, which can be used, complemented by various antioxidants to extend their storage or use life. The need to find new sources of oilseeds and natural oil preservatives has led to research being launched in indigenous areas, particularly in Africa. Nutritional and industrial processes have increased the demands for oils and this in turn has led to the search for oils from different types of seeds (Sama et al., 2022).

Previous investigations on oilseeds from Burkina Faso had revealed that *P. multiflora* exhibited an important source of oil that can be explored for nutritional, cosmetic and pharmaceutical assessment. Also, the utilization of oil for various applications are largely determined by the yield, composition, physical and chemical properties of the oil (Abeer et al., 2020). It is a plant species in the milkwort family (*Polygalaceae*) and native to Western Africa Lebrun and Stork, 1991). However, according to current literature, the physicochemical properties of *P. multiflora* seed and oil have not been investigated and no knowledge was recorded. However, knowledge of the properties of the oil could make it possible to envisage the valorization of the species as a source of vegetable oil for food, cosmetic and pharmaceutical use, and as an additional source of income for local populations. The present study aims to examine the physicochemical properties of *P. multiflora* seed oil to provide useful information for effective use.

2. Materials and Methods

2.1 Sample Collection

Polygala multiflora seeds were collected in Sassema located 11 km from Tenkodogo (10°24'26.2"N; 4°33'44.7"W) in central-eastern of Burkina Faso. After sorting to eliminate defective organs and foreign bodies. They were dried in the laboratory at 25 °C using a Prolab dryer. After drying and sorting to remove defective organs and foreign matter, the dried samples were ground with a blender (MICROTRON®MB800) to pass a screen of 0.5 mm and the powder particles low to 0.3mm were collected for analysis. The powder obtained was kept in an amber glass bottle and stored for fat extraction.

2.2 Oil Extraction Process

The fat was extracted from a mass of *P. multiflora* seeds powder via Soxhlet by using n-hexane and mild extraction temperature was chosen to avoid thermal degradation following the method NF V03-924 (AFNOR, 1993). A sufficient amount of absolute n-hexane was added into the flask and the top part of the Soxhlet was fitted with a condenser. Constant heat was applied through the heating mantle and the extraction was conducted for a minimum extraction of 6 h to make sure the maximum oil was extracted. After complete extraction and cooling, the obtained oil was filtered through filter paper. The solvent was evaporated via a rotary evaporator and further dried under open air in a dark area. The yield of the oil was calculated and stored in hermetically closed dark bottles and kept in a refrigerator for further physicochemical study.

2.3 Determination of Physical Parameters of Extracted Oil

The extraction yield was determined as a ratio between the mass of the oil and that of the seeds. The color of the extracted oil was determined using the ISO 27608 (2016) method. Hunter *L* (lightness), $a*$ (green/red) and $b*$ (blue/yellow) color values of oils were determined using a tristimulus colorimeter (METTLER TOLEDO) according to the "CIE-LAB" colorimetric system. The moisture content of the samples and volatile matter (VM) at 105 °C of the fats were determined using the ISO 662 (1998) method. The density of the oil was evaluated following standard NF T60-214 (AFNOR, 1993). The perfectly clean and dry pycnometer was weighed and then filled with distilled water. Dynamic viscosity (h) expressed in milli-Pascal/seconds (mPa.s^{-1}.) was determined using a Stresstech Rheometer viscometer by ISO 3104 (2020). The melting point was measured according to ISO

6321 (2002).

2.4 Determination of Chemical Parameters of Extracted Oil

The refractive index of seed oil was determined following standard NF T60-212 (AFNOR, 1993). The free fatty acid value was determined by the NF T 60-205 (AFNOR, 1993) method. The oxidative stability was determined following the AOAC recommended methods 935.14 and 992.24. (AOAC, 2005).

The acid, saponification, peroxide, and iodine indices were analyzed following AFNOR standards NF VO3-903, NF T60-204, and NF T60-220 (AFNOR, 1993).

2.5 Statistical Analyses

All assays were carried out in triplicate and the means and standard deviations are reported. Differences in mean performance for each composition among samples standard deviation were calculated using SPSS 29.0. software (2020).

3. Results and Discussion

3.1 Physical Characteristics of Extracted Oil

The yield of extracted oil from *Polygala multiflora* seeds was 43.25±2.3% (Table 1). Oil samples showed values of parameter *a** (-4.20±0.05) and b* (51.2±0.07) with the L* mean of 91.40±0.02. The obtained values for some physical parameters such as relative density and dynamic viscosity were 0.86 ±0.01 g/ml and 22.5 ±1.5 mPa.S respectively. Moisture, volatile matters, and melting registered 1.33± 0.4%, 0.13 ± 0.02% and 2.42±0.6 ℃, respectively.

Table 1. Physical parameters of extracted oil

Parameters		**Values**
Extraction yield (% m/m)		43.25 ±2.3
Color	***L******	91.40±0.02
Yellow light	***a******	-4.20±0.05
	b***	51.2±0.07
Relative density (g/ml)		0.912 ±0.031
Dynamic Viscosity (mPa/s)		22.5 ±1.5
Moisture (% m/m)		1.33±0.4
Volatile matter (% m/m)		0.13 ±0.02
Melting point (℃)		2.42±0.6

Although the oil content of *P. multiflora* seeds has not been previously reported in the literature, it should be noted that the content obtained is comparable to that of other oilseed species, confirming the oleaginous potential of the species. Indeed, the yield obtained is higher than those reported by Segura-Campos et al. (2014) in grape seeds such as chia (27.3%). The yield of oil found in *P. multiflora* seeds was higher than those reported by Segura-Campos et al. (2014) in grapes seeds like chia (27.3%). It is also higher than that found in cottonseed (16-28%) and groundnuts (40%) (Kapseu and Parmentier, 1997). Compared to solvent-extracted oil yields from *Nigella* seeds from different countries our finding was higher than 30% of Akram Khan et al. (1999), 37% of Gharby et al. (1999a)**,** and 40% of Cheikh-Rouhou et al. (2011). It was assumed that the difference in the yield of oil could result in seed variety and variation of extraction method used **(**Al-Kayssi et al. 2011). The seeds of *P. mutiflora* and their extracted oil are consumed in central eastern Burkina Faso (Nadembega, 2015).

Moreover, phenological events such as water stress or saline conditions, and eventually cool temperatures can contribute to reducing the yield of oil in plant seeds.

Oil content in *P. multiflora* seeds gave a positive value of parameter b* and a negative value of parameter *a** showing that the oil samples have yellow light color. Similar characteristics of oil color were reported by Poulli et al. (2009).

The relative density of extracted oil (0.912 ±0.031 g/ml) was close to that reported by Uzunova et al. (2016) in chia seeds oil from Argentina (0.928). The high value of relative density is related to high unsaturation content in the fatty acids of oil according to Alvarado and Aguilera (2001).

The viscosity of *P. multiflora* seeds oil at 25℃ was 22.5±1.5 mPa.s^{-1}, a value lower than conventional and non-conventional oils. This result is in line with the low iodine value of oil, as viscosity decreases with unsaturation. Indeed, there is a clear correlation between fatty acid chain length and viscosity (Gelle and

Goodrum, 2000).

Interestingly, moisture content (1.33 ± 0.4 %) was found to be particularly low compared to *Nigella* seeds oil registered by Gharby et al. (2015) (8.1–11.6%) and Alrashidi, et al. (2020) (1.97%).

The low moisture content of the seed (<10%) shows that it can resist microbial growth, and hence has a longer shelf life. The difference in moisture content values could be due to the maturity index of the seed, drying method, and climatic conditions **(**Koubaa et al., 2016).

The volatile matter measured (0.13 ± 0.02 %) of the oil sample, was higher than those obtained by Aïssi et al. (2009) and was also in line with the codex standards for oils, which should be less than 0.2% m/m **(**FAO/WHO, 2001). According to Edris (2001) and Ramadan *et al.* (2003) content in volatile matters or in other minor components such as polyphenols or tocopherols could explain such induction time variability of oil.

3.2 Chemical Characteristics of Extracted Oil

Extracted oil showed mean values of 1.45 ±0.02 at 25˚C, 2.11 ±0.03 h, and 1.97 ±0.2 % for refraction index, oxidative stability, and free fatty acid, respectively (Table 2).

The results indicate that the acid value which is an index of free fatty acid content due to enzymatic activity in the samples was 6.93 ±0.14 mg/KOH.

The iodine value is a measurement of the degree of unsaturation of vegetable oils and an indicator of their exposure to oxidation. The iodine value of *P. multiflora* was found to be 40.37 ±0.5 as iodine/100 g oil. The saponification value obtained from this work indicated that the oil contains 186.3 ±9.31mg KOH/g. The peroxide value is an indicator of the extent of primary oxidation products and oxidative stability in the oil product. The peroxide value of extracted oil was found to be 40.37 ±0.5 gI_2/100g.

Table 2. Chemical parameters of extracted oil

Parameters	**Value**
Refraction indice (at 20 °C)	1.45 ±0.02
Oxidative stability (h)	2.11 ±0.03
Free fatty acid (as oleic %)	1.97 ±0.2
Acid value (mgKOH/g)	6.93 ±0.14
Iodine value (gI_2/100g)	40.37 ±0.5
Saponification value (mgKOH/g)	186.3 ±9.31
Peroxide value (Meq O_2/kg)	1.58 ±0.05

Polygala multiflora oil exhibited a refraction index (1.45 ±0.02) value close to that obtained from Mexico chia seeds oil (1.4761) by Segura-Campos et al. (2014), *Griffonia simplicifolia* oil (1.47153 ± 0.00112) by Novidzro et al. (2019) at same temperature from cottonseed oil (1.470-1.473) by Aïssi et al. (2009). However, the index value was within the range established by *Codex Alimentarius* (2001).

A previous study reported that the refraction index depends on the analysis temperature and unsaturation contents of the fatty acids **(**Segura-Campos et al., 2014). The authors established that high analysis temperatures showed lower refraction index values and high unsaturation content is related to high refraction index values. The refractive index is considered to be a criterion of an oil's purity. This index is proportional to the molecular weight of the fatty acids and their degree of unsaturation.

For oxidative stability, an induction time of 2.11 ±0.03 h was found for solvent-extracted seeds oil to be close to the value of tested oil of chia seeds (2.4 h) reported by Meléndez-Martínez *et al.* (2007).

The value registered in this study was lower than those of Gharby et al. (2015) who found induction time of 13 and 9 h for cold press and solvent-extracted *Nigella* seed oils, respectively. Cheikh-Rouhou et al. (2007) have reported a higher induction time of 12 h for *Nigella* seed oil from Tunisia. Oxidative stability is an important parameter to estimate vegetable oil susceptibility to oxidation, and consequently, its shelf life **(**Ramadan and J.-T. Morsel, 2002).

The oxidative stability of oil is dependent on the composition, concentrations, and activity of reaction substrates and antioxidants. To minimize the use of food additives, oxidative stability can be potentially improved by preserving or enhancing the endogenous oxidation control systems of foods (Uzunova et al., 2016).

The free fatty acid content in oil was determined to be 1.97 ±0.2 % reflating endogenous enzymatic triacylglyceride hydrolysis. Our result was lower than those reported by Gharby et al. (2015) for solvent-extracted Nigella seed oil (2.3%) from Morocco. Enzymatic triacyl-glyceride hydrolysis and saponification reactions are responsible for free fatty acid (FFA) formation in vegetable oils **(**Sultan et al., 2009). FFA determination is particularly important for industrial purposes since this component can modify the oil's organoleptic or physicochemical properties.

The iodine value was 40.37±0.5 gI_2/100g. Compared with other common oils, it was lower than that of soybean oil (120-143), sesame oil (118-120), and groundnut oil (85-90) **(**Karleskind, 1992).

It is lower than the iodine value in linseed oil (187 gI2/100 g oil) **(**Decker, 1998). The lipid with a low iodine index demonstrates a low unsaturated fatty acid structure and higher oil stability.

The iodine value of the oil obtained from *P. multiflora* seeds attests to the dietary potential of this fat. However, further studies will be needed to assess its anti-nutrient content.

The acidity value of 6.93±0.14 mg/KOH of the *P. multiflora* seeds oil sample was higher than that of chia oil obtained (1.64 mg KOH/g) by Patil and Nawab (2006) from Guatemalan seeds using the pressing method of extraction. The saponification value obtained by the hexane extraction method was 186.3±9.31 mgKOH/g.

This value is comparable to the saponification value of common oils (FAO/WHO, 2001) such as soybean (189-195), groundnut (187-196), and cotton (189-198). The higher saponification value suggests the presence of high triacylglycerol content **(**Muhammad et al., 2016).

The peroxide value was 1.58 ± 0.05 $MeqO_2$/kg, a value close to Argentinian chia seeds oil (1.97) obtained by Uzunova et al. (2016) but lower than the 10 $MeqO_2$/kg that characterizes most conventional oils (FAO/WHO, 2001).

Peroxides are unsteady and decay to minor oxidation carbonyl products and are responsible for unfavorable oil flavors. In fact, peroxide index values of less than 10 $MeqO_2$/kg, are generally considered to be an acceptable level of oxidation (Rossell**,** 1994).

4. Conclusion

The results of this study revealed that *P. multiflora* seed oil displays interesting physicochemical properties for several applications. The species therefore has good potential as an oleaginous crop for various uses. However, further studies are needed to investigate its composition and its potential as a raw material for new industrial products and applications, in order to increase the economic feasibility of the tree's future commercial cultivation.

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“The authors declare no conflict of 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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Not applicable

Provenance and peer review

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Data availability statement

The data used to support this study are provided within the article.

Data sharing statement

No additional data are available.

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References

AFNOR (Association Française pour la Normalisation) (1993). *Compendium of French standards, oils and fats, oilseeds and derived products* (5th ed.). AFNOR, Paris, 136-140.

Aïssi, V. M., Soumanou, M. M., Tchobo, F. P., & Kiki, D. (2009). Comparative study of the quality of refined edible vegetable oils used in Benin. *West African Society of Chemistry Information Bulletin, 6*, 25-37.

Al-Kayssi, A. W., Shihab, R. M., & Mustafa, S. H. (2011). Impact of soil water stress on nigella oil content of black cumin seeds grown in calcareous-gypsiferous soils. *Agricultural Water Management, 100,* 46-57. https://doi.org/10.1016/j.agwat.2011.08.007

Alrashidi, M., Darfizzi, D., Jumat, S., & Mohamad, F. Y. (2020). An investigation of physicochemical properties of *Nigella sativa* L. Seed oil from Al-Qassim by different extraction methods. *Journal of King Saud University-Science, 32*(8), 3337-3342. https://doi.org/10.1016/j.jksus.2020.09.019

Alvarado, J., & Aguilera, J. (2001). Methods for measuring physical properties in food industries. *Ed. Acribia. Zaragoza, Spain, 15*, 347-348.

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

Cheikh-Rouhou, S., Besbes, S., Hentati, B., Blecker, C., Deroanne, C., & Attia, H. (2007). *Nigella sativa* L.: Chemical composition and physicochemical characteristics of lipid fraction. *Food Chemistry, 101*(2), 673-681. https://doi.org/10.1016/j.foodchem.2006.02.022

Codex alimentarius 210 (2001). Codex standards for named vegetable oils. *Rome. Revised., 8,* 11-25. Retrieved from https://img.21food.cn/img/biaozhun/20100729/180/11294206.pdf

Decker, E. A. (1998). Strategies for manipulating the prooxidative/antioxidative balance of foods to maximize oxidative stability. *Trends in Food Science & Technology, 9*(6), 241-248. https://doi.org/10.1016/S0924-2244(98)00045-4

Edris, A. E. (2011). The chemical composition and the content of volatile oil: Potential factors that can contribute to the oxidative stability of Nigella sativa L. crude oil. *Journal of Dietary Supplements, 8*, 34-42. https://doi.org/10.3109/19390211.2010.547242

FAO/WHO Food Standards Programme. Codex Alimentarius Commission (2001). *Fats, oils and related products* (2nd ed.). WHO, Rome, Italy. Retrieved from https://www.fao.org/3/y2774e/y2774e00.htm#Contents.

FAO. (2012). *World Agriculture towards 2030/2050: the 2012 Revision*. ESA Working Paper 12-03, FAO, Rome, Italy.

Fine, F., Vian, M. A., Tixier, A.-S. F., Carre, P., Pages, X., & Chemat, F. (2013). Les agro-solvants pour l'extraction des huiles végétales issues de graines oléagineuses. *Oilseeds & fats Crops and Lipids, 20*(5), 502. https://doi.org/10.1051/ocl/2013020

Geller, D. P., & Goodrum, J. W. (2000). Rheology of vegetable oil analogs and triglycerides. *Journal of the American Oil Chemists' Society, 77*(2), 111-114. https://doi.org/10.1007/s11746-000-0018-4

Gharby, S., Harhar, H., Guillaume, D., Roudani, A., Boulbaroud, S., … Charrouf, Z. (2015). Chemical investigation of *Nigella sativa* L. seed oil produced in Morocco. *Journal of the Saudi Society of Agricultural Sciences, 14*(2), 172-177. https://doi.org/10.1016/j.jssas.2013.12.001

Gharby, S., Harhar, H., Roudani, A., Chafchaouni, I., & Charrouf, Z. (2013a). Stability oxidative from cosmetic and alimentary argan oil of thermal treatments. *International Journal of Pharmaceutical Science Invention, 2*(5), 41-46. *Contrôle de la qualité de l'huile d'argan*. Retrieved from http://cns.bf/IMG/pdf/tableau_de_bord_statistique_2021.pdf.

ISO 27608, 2010/Amd1. (2016). *Fats of animal and vegetable origin - Determination of Lovibond® colour - Automatic method -1p.*

ISO 3104 (2020). *Petroleum products - Transparent and opaque liquids - Determination of kinematic viscosity and calculation of dynamic viscosity.*

ISO 6321. (2002). *Animal and vegetable fats and oils* (2nd ed.). Determination of melting point in open capillary tubes (slip point).

ISO 662. (1998). *Animal and vegetable fats and oils* (2nd ed.). Determination of moisture and volatile matter content.

Kapseu, C. & Parmentier, M. (1997). Fatty acid composition of some vegetable oils from Cameroon. *Sciences des Aliments, 17*(3), 85-92.

Karleskind, A. (1992). Fat and oils handbook. *Ed Lavoisier, 2*, 789-1579.

Khan, M. A. (1999). Chemical composition and medicinal properties of *Nigella sativa* Linn. *InflammoPharmacology, 7*, 15-35. https://doi.org/10.1007/s10787-999-0023-y

Koubaa, M., Mhemdi, H., Barba, F. J., Roohinejad, S., & Greiner, R. (2016). Oilseed treatment by ultrasounds and microwaves to improve oil yield and quality: An overview. *Food Research International, 85*(1), 59-66. https://doi.org/10.1016/j.foodres.2016.04.007

Lebrun, J.-P., & Stork, A. L. (1991). Enumeration of the flowering plants of tropical Africa Conservatory and botanical garden. Geneva. *General and Annonaceae to Euphorbiaceae and Pandanaceae, 1*, 353. Retrieved from https://www.malawiflora.com/speciesdata/literature-display.php?literature_id=353

Lecerf, J.-M. (2011). Vegetable oils: Particularities and usefulness. *Médecine des Maladies Métaboliques, 5*(3), 257-262. https://doi.org/10.1016/S1957-2557(11)70237-1

MARAH (Ministère de l'agriculture, des Ressources Animales et Halieutiques) (2021). *Statistical scoreboard for agriculture, animal resources and fisheries*. DGESS/MARAH. Burkina Faso. pp. 96.

Meléndez-Martínez, A. J., Britton, G., Vicario, I. M., & Heredia, F. J. (2007). Relationship between the color and the chemical structure of carotenoid pigments. *Food Chemistry*, *101*(3), 1145-1150. https://doi.org/10.1016/j.foodchem.2006.03.015

Morin, O., & Pagès-Xatart-Parès, X. (2012). Vegetable oils and fats: functional resources and nutritional value. *Oilseeds & fat Crops and lipides, 19*(2), 63-75. https://doi.org/10.1051/ocl.2012.0446

Muhammad, N., Maina, B. M., Aljameel, K. M., Maigandi, S. A., & Buhari, S. (2016). Nutrient intake and digestibility of Uda rams fed graded levels of *Parkia biglobosa* (African locust bean) yellow fruit pulp. *International Journal of Livestock Research, 6*(5), 33-42. https://doi.org/10.5455/ijlr.20160427090936

Nadembega, P. (2015). *Traditional African medicine: concepts, recipes, illustrated plants and a case study of ethnic groups* (Edro 21 ed.). Montréal, Canada. pp. 128.

Ndjouenkeu, R., & Ngassoum, M. (2002). Comparative study of frying behaviour of some vegetable oils. *Journal of Food Engineering, 52*(2), 121-125. https://doi.org/10.1016/S0260-8774(01)00093-0

Novidzro, K. M., Wokpor, K., Amoussou Fagla, B., Koudouvo, K., Dotse, K., Osseyi, E. & Koumaglo, K. H. (2019). Study of some physicochemical parameters and analysis of mineral elements chlorophyll pigments and carotenoids in *Griffonia simplicifolia* seed oil. *International Journal of Biological and Chemical Sciences, 13*(4), 2360-2373. http://doi.org/10.4314/ijbcs.v13i4.38

Oyeyiola, J. A. (1993). *Nigerian Foods and Feeding Stuff*. IUP Ibadan. pp. 50-52.

Patil, R. T., & Nawab, A. (2006). Effect of Pre-Treatments on Mechanical Oil Expression of Soybean Using a Commercial Oil Expeller. *International Journal of Food Properties, 9*(2), 227-236. https://doi.org/10.1080/10942910600592315

Poulli, K. I., Mousdis, G. A., & Georgiou, C. A. (2009). Monitoring olive oil oxidation under thermal and UV stress through synchronous fluorescence spectroscopy and classical assays. *Food Chemistry, 117*(3), 499-503. https://doi.org/10.1016/j.foodchem.2009.04.024

Ramadan, M. F., & Morsel, J.-T. (2002). Neutral lipid classes of black cumin (*Nigella sativa* L.) seed oils. *European Food Research and Technology, 214*, 202-206. https://doi.org/10.1007/s00217-001-0423-8

Ramadan, M. F., Kroh, L. W., & Morsel, J.-T. (2003). Radical scavenging activity of black cumin (*Nigella sativa* L.), coriander (*Coriandrum sativum* L.), and niger (*Guizotia abyssinica* Cass.) crude seed oils and oil fractions. *Journal of Agricultural and Food Chemistry, 51*(24), 6961-6969. https://doi.org/10.1021/jf0346713

Rossell, J. B. (1994) Stable Carbon Isotope Ratios in Establishing Maize Oil Purity. *Fett Wissenschaft Technologie/Fat Science Technology, 96*(8), 304-308. https://doi.org/10.1002/lipi.19940960806

Sama, H., Traoré, K. D., Guenné, S., Hilou, A., & Dicko M. H. (2022). *Effect of pedo-climatic conditions on physicochemical characteristics and agro-industrial potential of three native oilseeds fruits from Burkina Faso.* https://doi.org/10.1186/s12870-022-03713-7

Sarwar, M. F., Sarwar, M. H., Sarwar, M., Qadri, N. A., & Moghal, S. (2013). The role of oilseeds nutrition in human health: A critical review. *Journal of Cereals and Oilseeds, 4*(8), 97-100. https://doi.org/10.5897/JCO12.024

Segura-Campos, M., Ciau-Solís, N., Rosado-Rubio, G., Chel-Guerrero, L., & Betancur-Ancona, D. (2014). Physicochemical characterization of chia (*Salvia hispanica*) seed oil from Yucatán, México. *Agricultural Sciences, 5*(3), 220-226. https://doi.org/10.1155/2014/241053

Sharma, M., Gupta, S. K., & Mondal, A. K. (2012). Production and trade of major world oil crops. In S. K. Gupta (Ed.), Technological Innovations in Major World Oil Crops (pp. 1-11). Springer, New York, NY, USA. https://doi.org/10.1007/978-1-4614-0356-2_1

Sultan, M. T., Butt, M. S., Anjum, F. M., Jamil, A., Akhtar, S., & Nasir, M. (2009). Nutritional profile of indigenous cultivar of black cumin seeds and antioxidant potential of its fixed and essential oil. *Pakistan Journal of Botany, 41*(3), 1321-1330. Retrieved from https://api.semanticscholar.org/CorpusID:4203778

Tietiambou, F. R. S. (2018). Underused local oilseed trees: potential for promoting oil value chains and implications for sustainable resource management in Kenedougou, western Burkina Faso. *Bois & Forêts des Tropiques, 335*, 71-72. https://doi.org/10.19182/bft2018.335.a31500

Uzunova, G., Nikolova, K., Perifanova, M., Gentscheva, G., Marudova, M., & Antova G. (2016). Physicochemical characterization of chia (*Salvia hispanica*) seed oil from Argentina. *Bulgarian Chemical Communications, 48*(SIG), 131-135.