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RESEARCH ARTICLE

PHYSICOCHEMICAL CHARACTERIZATION AND OXIDATIVE STABILITY OF THE KERNEL OIL OF *GRIFFONIASIMPLICIFOLIA* (DC.) BAILL. (FABACEAE) FROM TOGO

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ABSTRACT

Griffoniasimplicifolia is a plant species whose seeds offer potential for the valorization of local oil resources. Characterizing their oil is necessary to assess its physicochemical properties, its storage stability and its suitability for food applications. Kernels from a seed batch stored for 12 months (in plastic bottles) were visually sorted into pale yellow kernels, blackened kernels and a mixture, in order to determine their oil content and oil acidity. A recent batch, collected between December 2025 and March 2026 and sorted to retain pale yellow kernels, was used for oil extraction by mechanical pressing and for oil characterization. The oil content ranged from 24.74% (blackened kernels) to 29.32% (pale yellow kernels). The acid value of the oils from the stored batch (5.19–16.72 mg KOH/g) exceeded the Codex limit for virgin oils (4.0 mg KOH/g), unlike that of the recent batch (1.20 ± 0.08 mg KOH/g). The oil from the recent batch had a density of 0.92 g/cm³ at 20 °C, a kinematic viscosity of 35.80 mm²/s at 40 °C and a refractive index of 1.4715. Its cloud and slip points were 9.5 and 18.7 °C, respectively; its iodine value was 106.2 g I_2/100 g, its saponification value 190.0 mg KOH/g and its unsaponifiable matter content 1.50%. Its induction time was 8.50 h at 110 °C, and its peroxide value increased from 3.20 to 8.23 meq O_2/kg over 120 days, remaining below the limit of 15 meq O_2/kg. *Griffoniasimplicifolia* kernel oil therefore shows satisfactory oxidative stability, but its quality depends on kernel sorting and on the storage time of the seeds.

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INTRODUCTION

Vegetable oils are a major source of lipids in the human diet (3) (Coupland and McClements, 1997) and are used in the food, pharmaceutical and cosmetic industries. Their nutritional and technological properties depend mainly on their fatty acid composition, their minor constituents and their oxidative stability (2, 8) (Choe and Min, 2006; Gunstone *et al*., 2007). These characteristics vary with plant species, growing conditions, extraction process and storage conditions. The study of oils from under-exploited plant resources is therefore an important step in determining their quality and potential uses. Among these resources, *Griffoniasimplicifolia* (DC.) Baill., a legume native to West Africa, has attracted particular scientific interest because of the composition of its seeds, notably their content of 5-hydroxytryptophan (5-HTP), the metabolic precursor of serotonin. The presence of this compound in the seeds was reported by (5) Fellows and Bell (1970), and (11) Lemaire and Adosraku (2002) proposed a high-performance liquid chromatography method for its determination. The seeds are therefore exploited industrially for the extraction of 5-HTP (21) (Vigliante *et al*., 2019), whereas their lipid fraction remains largely unexploited. However, seed properties cannot be directly extrapolated to the extracted oil, since the distribution of constituents depends on their chemical properties and on the extraction process. The work of (14, 15) Novidzro *et al*. (2019a, 2019b) contributed to the characterization of *Griffoniasimplicifolia* oil, in particular through the study of its fatty acid composition, some of its pigments and several physicochemical parameters. These parameters include density, refractive index, and acid, iodine, saponification and peroxide values, which respectively provide information on physical properties, degree of unsaturation, free fatty acid content, characteristics of saponifiable lipids and oxidative status of the oil. Their determination is therefore essential for assessing oil quality. This oil is rich in linoleic acid, which accounts for 60–73% of its fatty acids (14, 16) (Petkov and Ramazanov, 2003; Novidzro *et al*., 2019a), making it potentially susceptible to oxidation and justifying the study of its stability.

Furthermore, the extraction process can affect the yield and certain characteristics of the final product. Likewise, the duration and conditions of seed storage can alter the kernels: moulds colonizing them produce lipases that hydrolyse triglycerides into free fatty acids and increase oil acidity (9, 13) (Hasan, 2000; Negedu *et al*., 2012). The study of the thermal and organoleptic properties, chemical indices and oxidative stability (induction time and change in peroxide value over 120 days), together with the influence of kernel colour on acidity, complements the characterization of the oil and helps identify factors that may limit its storage or potential uses. These parameters should nevertheless be interpreted with caution, as the nutritional quality and safety of an oil cannot be established on the basis of physicochemical indices alone. In this context, the present study aimed to characterize the oil extracted from *Griffoniasimplicifolia* kernels and to determine its main physicochemical properties. More specifically, it aimed to: determine the oil content of the kernels and assess the effect of their condition (pale yellow or blackened) on this content and on oil acidity; characterize the physical, thermal and organoleptic properties of the oil; determine its chemical quality indices; and evaluate its oxidative stability during 120 days of storage.

MATERIALS AND METHODS

Plant material: Two batches of *Griffoniasimplicifolia* seeds were collected from the botanical garden of the Faculty of Sciences, University of Lomé. The first batch, harvested during the previous season, was stored for 12 months in plastic bottles; its kernels were visually sorted into pale yellow kernels, blackened kernels and a mixture. The second batch, harvested between December 2025 and March 2026, was sorted before extraction. The seeds were manually dehulled to obtain the kernels. *Griffoniasimplicifolia* oil was extracted from the kernels at the Physicochemical Analysis Laboratory of NIOTO.



Figure 1. Seeds of Griffoniasimplicifolia

Extraction method: The oils from the sorted kernels of the first batch were obtained by Soxhlet solvent extraction with hexane using a Gerhardt Soxtherm extractor, whereas the oil from the second batch was extracted by mechanical pressing with a mini oil press (OIL PRESS) at 150 °C, in order to reduce oil viscosity and facilitate its flow out of the matrix. Figures 3 and 4 show the extraction of the oils from the first batch and the oil obtained by mechanical pressing, respectively.



Figure 2. Griffoniasimplicifolia kernels: pale yellow (left) and blackened (right)

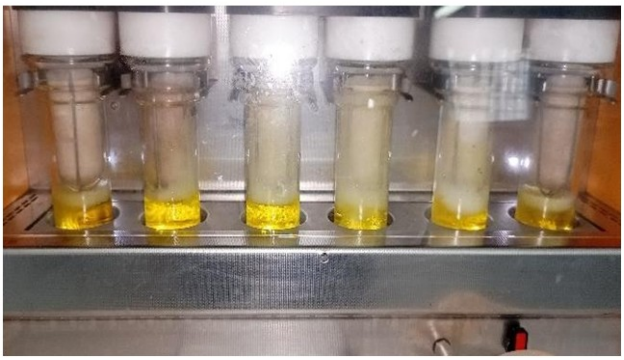


Figure 3. Hexane extraction of *Griffoniasimplicifolia* oil



Figure 4. *Griffoniasimplicifolia* kernel oil obtained by single mechanical pressing

Cloud point and slip point: The cloud point and slip point of *Griffoniasimplicifolia* oil were determined by progressive cooling and by the capillary method, respectively. The cloud point corresponds to the temperature at which the first crystals or a persistent turbidity appear in the oil, whereas the slip point is the temperature at which the fat begins to rise in an open capillary tube during progressive heating. Measurements were performed in triplicate and results are expressed as mean ± standard deviation, in °C. The slip point determination was based on the principle of ISO 6321:2021.

Refractive index: The refractive index characterizes the deviation of light as it passes from one medium to another. It was determined with a binocular Abbe refractometer (AZZOTA) fitted with a thermometer, following the principle described by (4) Denis *et al.* (1997). After the prisms had been cleaned with lens tissue and the instrument calibrated with distilled water, a few drops of *Griffoniasimplicifolia* oil were placed on the prism. The boundary line between the light and dark fields was adjusted, and the refractive index was read at the measurement temperature and corrected to 20 °C using a correction factor.

Chemical parameters

Determination of acid value and acidity: The acid value (AV) is the amount of KOH, in mg, required to neutralize the free fatty acids contained in 1 g of oil. It was determined by titration according to standard NF V 03-906 (AFNOR, 1984). Briefly, 5 g of oil were dissolved in previously neutralized ethanol and titrated under stirring with 0.1 N ethanolic KOH, using phenolphthalein as indicator. The end point was indicated by the colour change.

Determination of iodine value: The iodine value expresses the amount of iodine, in grams, absorbed by 100 g of lipids and reflects their degree of unsaturation. It was determined by the Wijs method. A test portion of 0.2 g of *G. simplicifolia* oil was dissolved in 5 mL of chloroform and mixed with 25 mL of Wijs reagent. After 1 h in the dark, 5 mL of 10% potassium iodide solution and 150 mL of distilled water were added. The liberated iodine was then titrated with 0.1 N sodium thiosulfate, using starch solution as indicator.

Determination of saponification value: The saponification value (SV) is the mass of KOH, in mg, required to neutralize the free fatty acids and saponify the esters contained in 1 g of oil. It was determined according to standard AFNOR NF T60-206 (1988). Briefly, 2 g of oil were dissolved in 25 mL of 0.5 N KOH and heated under reflux for 1 h. After cooling, a few drops of phenolphthalein were added and the excess KOH was titrated with 0.48 N HCl until the pink colour disappeared. A blank test was carried out under the same conditions. The ester value (EV) was calculated as the difference between the saponification value and the acid value.

Peroxide value (PV): The peroxide value (PV) assesses the degree of primary oxidation of an oil by measuring the peroxides and hydroperoxides it contains. It was determined titrimetrically according to the IUPAC method. Two grams of oil were dissolved in 10 mL of chloroform, followed by 15 mL of acetic acid and 1 mL of potassium iodide solution. After shaking and incubation in the dark for 5 min, 75 mL of distilled water were added. The liberated iodine was then titrated with 0.01 N sodium thiosulfate, using starch solution as indicator.

RESULTS

Physicochemical quality parameters of the oil

Oil content: The oil content of *Griffoniasimplicifolia* kernels (Table 1) ranged from 24.74% (blackened kernels) to 29.32% (pale yellow kernels), with a mean of 27.01 ± 2.29%. This value is close to those reported by (15) Novidzro *et al.* (2019b), i.e. 30.72 ± 1.45% by refractometry and 28.40 ± 1.20% by gravimetry, confirming the oil potential of this species.

Table 1. Oil content of *Griffoniasimplicifolia* kernels

Parameters	Oil content of *Griffoniasimplicifolia* kernels (%)
Maximum (pale yellow kernels)	29.32 ± 1.02
Median (kernel mixture)	26.98 ± 0.53
Minimum (blackened kernels)	24.74 ± 0.17
Mean ± SD	27.01 ± 2.29

Results expressed as mean ± standard deviation (n = 3)

Density, viscosity and refractive index: The physicochemical characteristics of *Griffoniasimplicifolia* kernel oil (Table 2) show a density at 20 °C of 0.92 ± 0.004, a kinematic viscosity of 35.80 ± 1.40 mm²/s and a refractive index of 1.4715 ± 0.0005. These parameters provide information on the density, flow properties and optical characteristics of the oil, respectively.

Table 2. Physicochemical characteristics of *Griffoniasimplicifolia* kernel oil

Parameters	*Griffoniasimplicifolia* oil
Density at 20 °C	0.92 ± 0.004
Kinematic viscosity at 40 °C (mm²/s)	35.80 ± 1.40
Refractive index at 20 °C	1.4715 ± 0.0005

Results expressed as mean ± standard deviation (n = 3)

Cloud point and slip point: The characteristic temperatures of *Griffoniasimplicifolia* kernel oil (Table 3) show a cloud point of 9.5 ± 0.3 °C and a slip point of 18.7 ± 1.2 °C. These parameters characterize the thermal behaviour of the oil and the changes in its appearance and fluidity with temperature.

Table 3. Cloud point and slip point of *Griffoniasimplicifolia* kernel oil

Parameters	*Griffoniasimplicifolia* oil
Cloud point (°C)	9.5 ± 0.3
Slip point (°C)	18.7 ± 1.2

Results expressed as mean ± standard deviation (n = 3)

Organoleptic characteristics: The organoleptic characteristics of *Griffoniasimplicifolia* kernel oil (Table 4) concern mainly its colour and odour. The colour, measured on the Lovibond scale in a 5¼-inch cell, was 6.5 ± 0.1 red and 35 yellow units (6.5 R / 35 Y), and the odour was characteristic of the seed. These parameters describe the visual appearance and olfactory profile of the oil.

Table 4. Organoleptic characteristics of *Griffoniasimplicifolia* kernel oil

Parameters	*Griffoniasimplicifolia* oil
Lovibond colour (5¼-inch cell)	6.5 ± 0.1 R / 35 Y
Odour	Characteristic of the seed

Results expressed as mean ± standard deviation (n = 3)

Chemical parameters

Oil degradation parameters: The acidity and acid value of *Griffoniasimplicifolia* oil were determined according to kernel colour (pale yellow, blackened and mixture) in order to assess the effect of kernel deterioration on oil quality (Table 5).

Blackened kernels showed the highest values, with an acidity of 8.40 g oleic acid/100 g oil and an acid value of 16.72 mg KOH/g, compared with 2.61 g/100 g and 5.19 mg KOH/g, respectively, for pale yellow kernels. The mixture showed intermediate values of 5.52 g/100 g and 11.00 mg KOH/g. The mean acidity was 5.51 ± 2.89 g/100 g and the mean acid value 10.96 ± 5.77 mg KOH/g. All these values exceed the reference limits shown in the table (Codex Alimentarius, 1981), i.e. 2 g oleic acid/100 g oil and 4 mg KOH/g, indicating insufficient acid quality of the oil, particularly when kernels are blackened.

Table 5. Effect of kernel colour on oil acidity

Parameters	Acidity (g oleic acid/100 g oil)	Acid value (mg KOH/g oil)
Maximum (blackened kernels)	8.40 ± 0.04	16.72 ± 0.08
Median (kernel mixture)	5.52 ± 0.01	11.00 ± 0.02
Minimum (pale yellow kernels)	2.61 ± 0.01	5.19 ± 0.02
Mean ± SD	5.51 ± 2.89	10.96 ± 5.77
Codex limit CXS 19-1981 (virgin oils)	≤ 2.00	≤ 4.00

Results expressed as mean ± standard deviation (n = 3)

The oxidative stability study of *Griffoniasimplicifolia* oil (Table 6) showed an induction time of 8.50 ± 0.60 h. The peroxide value increased from 3.20 ± 0.36 meq/kg on day 0 to 8.23 ± 1.08 meq/kg on day 120, reflecting the accumulation of primary oxidation products during storage.

Table 6: Oxidative stability of *Griffoniasimplicifolia* oil

Parameters	Results
Oxidation induction time at 110 °C (h)	8.50 ± 0.60
Peroxide value on day 0 (meq/kg)	3.20 ± 0.36
Peroxide value on day 120 (meq/kg)	8.23 ± 1.08

Results expressed as mean ± standard deviation (n = 3)

Intrinsic chemical indices: The chemical indices of *Griffoniasimplicifolia* oil (Table 7) show an iodine value of 106.20 ± 1.00 g I_2/100 g oil, indicating a substantial degree of unsaturation. The saponification value was 190.00 ± 3.00 mg KOH/g and the ester value 188.80 ± 2.90 mg KOH/g. The unsaponifiable matter content was 1.50 ± 0.10%.

Table 7. Characteristic chemical indices of *Griffoniasimplicifolia* kernel oil

Parameters	Kernel oil of *Griffoniasimplicifolia*
Iodine value (g I_2/100 g)	106.20 ± 1.00
Saponification value (mg KOH/g)	190.00 ± 3.00
Ester value (mg KOH/g)	188.80 ± 2.90
Unsaponifiable matter (%)	1.50 ± 0.10

Results expressed as mean ± standard deviation (n = 3)

Chemical quality indices of the oil: The chemical quality indices of the oil extracted from the second batch of recent, sorted *Griffoniasimplicifolia* kernels (Table 8) show an acid value of 1.20 ± 0.08 mg KOH/g oil, corresponding to an acidity of 0.60 ± 0.04% as oleic acid. The peroxide value was 3.22 ± 0.25 meq O_2/kg oil. These parameters assess the free fatty acid content and the degree of primary oxidation of the oil, respectively.

Table 8. Chemical quality indices of *Griffoniasimplicifolia* kernel oil

Parameters	Kernel oil of *Griffoniasimplicifolia*
Acid value (mg KOH/g)	1.20 ± 0.08
Acidity (% oleic acid)	0.60 ± 0.04
Peroxide value (meq O_2/kg)	3.22 ± 0.25

Results expressed as mean ± standard deviation (n = 3); independent measurement performed on receipt of the oil

DISCUSSION

The physical characteristics of *Griffoniasimplicifolia* kernel oil, notably its density and refractive index, are comparable to those reported by (15) Novidzro *et al*. (2019b). These similarities suggest relatively close physical properties, although experimental conditions may influence the results. Blackened kernels had lower lipid contents and high acidity. These results agree with the work of (22) Worang *et al*. (2008) on *J. curcas* seeds stored for six months, whose lipid content also decreased while lipase activity and free fatty acids increased. Kernel blackening may therefore reflect a partial consumption of lipid reserves during storage. (7) Giurleo (2017) also showed that *Griffoniasimplicifolia* seeds with a black endosperm contain less 5-HTP than seeds with a yellow endosperm, which confirms that blackening is accompanied by a general deterioration of the seed.

Kinematic viscosity depends mainly on temperature and fatty acid composition (17) (Rodenbush *et al*., 1999), whereas the cloud and slip points reflect the thermal behaviour of the oil, which is itself related to its lipid composition (10) (Karmakar *et al*., 2017). The cloud point (9.5 °C) and slip point (18.7 °C) obtained are relatively high for an oil rich in linoleic acid. They can be explained by its saturated fraction: (14) Novidzro *et al*. (2019a) reported 14.69% stearic acid and 11.12% palmitic acid, i.e. about 26% saturated fatty acids, compared with about 10% in unrefined sunflower oil (6.4% palmitic and 3.2% stearic acid; (6) Gandova *et al*., 2024). (16) Petkov and Ramazanov (2003) also reported 3–4% arachidic acid (C20:0) in *Griffoniasimplicifolia* oil. Triglycerides containing long-chain saturated fatty acids are the first to crystallize on cooling. However, this composition should not be directly attributed to the oil studied here without specific analysis. The observed colour may be associated with natural pigments, notably chlorophylls and carotenoids. *Griffoniasimplicifolia* seeds contain 253 µg/g of chlorophyll a, 436 µg/g of chlorophyll b and 65 µg/g of total carotenoids. Chlorophylls act as photosensitizers and promote oxidation under light (2) (Choe and Min, 2006). A correlation has been reported between chlorophyll pigment content and Rancimat induction time (r = 0.62 in a study of 27 cold-pressed oils), and chlorophyll a has been proposed as an indicator of the oxidative status of oils (1, 19) (Symoniuk *et al*., 2018; Chen *et al*., 2024).

Chlorophylls may therefore promote the oxidation of oil exposed to light, which justifies storing it protected from light. Likewise, the characteristic odour may arise from volatile compounds originating from the raw material or formed during extraction. With regard to chemical quality, the low acid value of the recent, sorted batch (1.20 mg KOH/g), which complies with the Codex limit (4.0 mg KOH/g), contrasts with the values of the stored batch (5.19–16.72 mg KOH/g). The high values recorded suggest substantial hydrolytic degradation of

lipids in blackened kernels. This gradient probably reflects enzymatic hydrolysis of triglycerides. Indeed, (9) Hasan (2000) showed, on stored safflower seeds, that the increase in free fatty acids was correlated with infestation by *Penicillium chrysogenum*, *Aspergillus flavus* and *A. niger*. These differences highlight the importance of kernel sorting and of proper storage before extraction. The initial peroxide value indicates a low accumulation of primary oxidation products at the time of analysis. Its increase during monitoring, together with the measured induction time, nevertheless reveals oxidative changes under the experimental conditions. This may be favoured by the presence of unsaturated fatty acids and by exposure to oxygen, light or heat (2) (Choe and Min, 2006).

However, the final value (8.23 meq O_2/kg) remains below the limit of 15 meq O_2/kg set for virgin oils (Codex Alimentarius, 1981). The induction time of 8.50 h at 110 °C is comparable to that of the best cold-pressed sunflower oils studied by (12) Lužaić *et al*. (2022) (3.32–9.55 h at 110 °C). It is higher than that of cold-pressed rapeseed oils (23) (5.08 h; Wroniak *et al*., 2008) and lies within the range reported for unconventional oilseeds (1.32–43.44 h at 110 °C; (20) Uluata and Özdemir, 2012). Analysis of secondary oxidation products would nevertheless complete this assessment. The iodine value reflects the degree of unsaturation of the oil, whereas the saponification value provides information on the saponifiable lipids. (12) Lužaić *et al*. (2022) reported a strong negative correlation between iodine value and induction time ($r = -0.96$), with an induction time of 9.55 h for an iodine value of 81 and 3.32 h for an iodine value of 127.

With an iodine value of 106.2 g I_2/100 g and an induction time of 8.50 h, *Griffoniasimplicifolia* oil therefore appears more stable than its degree of unsaturation would predict. This stability may be due to its antioxidant content, notably tocopherols, and to other compounds of the unsaponifiable fraction (8) (Gunstone *et al*., 2007). According to (7) Giurleo (2017), *Griffoniasimplicifolia* seeds contain γ-tocopherol (86.58 µg/g) and α-tocopherol (22.62 µg/g). (16) Petkov and Ramazanov (2003) also identified phytosterols in the unsaponifiable fraction, namely β-sitosterol (60%), stigmasterol (29%) and campesterol (11%). These compounds are recognized for their cholesterol-lowering effect and are also being studied for their anti-inflammatory and antioxidant activities (18) (Shen *et al*., 2024). The unsaponifiable matter content of 1.50% measured here, which lies within the usual range for crude vegetable oils, therefore justifies a determination of the sterols of this oil. The presence and levels of these constituents must nevertheless be confirmed by specific analyses before any particular nutritional benefit can be inferred. Furthermore, the saponification value (190.0 mg KOH/g) corresponds to a mean triglyceride molar mass of about 886 g/mol, indicating a predominance of C18 fatty acids. These results are consistent with the fatty acid composition published for this species. Overall, *Griffoniasimplicifolia* oil shows interesting physical characteristics and low acidity in the recent, sorted batch. However, its degree of unsaturation and the change in its oxidative status underline the importance of appropriate extraction and storage conditions. Further analyses of fatty acid composition, minor compounds and oxidation products would allow a more complete characterization and a better assessment of its valorization potential.

CONCLUSION

This study characterized the oil extracted from *Griffoniasimplicifolia* kernels. The oil content of the kernels confirms the oil potential of the species. However, kernel condition emerged as the determining factor for oil quality: blackened kernels from the stored batch contained less oil and yielded a more acidic oil than pale yellow kernels. The density, iodine value and saponification value of this oil classify it as a semi-drying oil with predominantly C18 fatty acids. Its relatively high cloud and slip points reflect a substantial saturated fraction, and its induction time indicates good oxidative stability given its degree of unsaturation. The valorization of this oil as a co-product of 5-HTP production therefore requires kernel sorting and controlled storage of the seeds and of the oil, protected from heat, light and oxygen. Further work is needed to confirm these preliminary results, notably the determination of fatty acid composition by gas chromatography, the quantification of tocopherols and phytosterols, and the monitoring of secondary oxidation products.

Abbreviations

DC: De Candolle, author of the species description
Baill: Baillon, author of the current combination *Griffoniasimplicifolia* (DC.) Baill.

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Author Contributions

Dandonougbo Koffi: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing

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Melila Mamatchi: Supervision, Writing – review & editing

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Standards

AFNOR (1984). NF V 03-906. Corps gras d'originesanimale et végétale — Détermination de l'indiced'acide et de l'acidité (Animal and vegetable fats and oils — Determination of acid value and acidity). Paris: Association française de normalisation.

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