Original Research Article

ComparativePhysicochemical, Phytochemical Parameters and antiradical activities of Ximeniaamericana L. (Olacaceae) almond oils From three locals variants

ABSTRACT

Aims: This study aimed to compare local variants of *X. americana* with optimal properties for production in the food and phytomedicine industry. **Methodology:**The plant material was collected from three sites in Burkina Faso, namely Gonsé, Saponé and Kokologho from May to June 2021.The oil yield was estimated andthe physicochemical parameters were performed according to ISO standards. Phytochemical screening of polyphenols and flavonoids was carried out and the antioxidant activities of the oils from different trees were evaluated using DPPH and ABTS tests. **Results**: The average oil extraction yield for the three variants was 42.30 ± 14.34%.The estimated colour oil was yellow. The oil refraction index indicated that the Gonsé site (1.471 ± 0.002) has the highest value. The highest oil temperature value was obtained from Kokologho trees (30.60 ± 0.21°C) followed by the ones collected at Gonsé (22.63 ± 1.72°C) and Saponé (22.60 ± 0.41°C). The oil acid value of almonds from all three sites with an average value of 0.023 ± 0.013 mg KOH/g was lower than the international standard ISO 660-2020. The Saponé and Kokologho sites exhibited the highest oil peroxide values of 0.040 ± 0.000 mEq O2/kg on either side, while the lowest peroxide value was found at Gonsé (0.021 ± 0.000 mEq O2/kg). The highest saponification value is that of Kokologho with a value of 84.81 ± 4.18 mg KOH/g. The polyphenol and flavonoid content of almond oil vary within a site and between sites. Oil extracts have shown free radical scavenging capabilities (DPPH and ABTS) indicating substantial polyphenol and flavonoid content. **Conclusion:**The oil has very good quality and fulfills all standard requirements for use in the phytomedicine and food industry. A mass selection can be performed within the three sites for *X. americana* plantation in agroforestry systems.

Keywords:Physicochemical, phytochemical, antioxidant activities, almond oil, Ximeniaamericana L. (Olacaceae), mass selection.

1. INTRODUCTION

The occurrenceof various crises known as natural disasters, conflicts and pandemics, lead decision-makers and researchers to find alternatives for the well-being ofthe population, especially vulnerable people [1]. Global crises sometimes affect the production chains of basic needs of the population, making them sometimes costly or even not accessible to the poorest people [2]. In recent years, the increased price of edible oils and certain oils used for therapeutic purposescould be pointed outas a result of these crises. Thus, alternative raw materials or oilseed products need to beaddressed in order to overcome difficulties related to the supply of these oils. With regards to alternatives, the almonds of *Ximeniaamericana* L. (Olacaceae) could play an important role as a source of oil in food and health because of its nutritional and therapeutic properties[3].

In fact, *Ximeniaamericana* L. (Olacaceae) is a multi-purpose local plant in Burkina Faso used for food, pharmacopoeia, defensive hedgerows,and ornamentation. Furthermore, its fruits are usedas a non-timber forest product consumed during lean seasons, but the use of the derived almonds is not well known by local communities. However; the almonds from the seeds of *X. americana* were found to contain high fat and could be used for oil and soap production [7,8]. Further studies demonstrated this oil is used in cosmetics [4,5]and treatment of skin diseases [8]. As the oil has softening properties it can also be applied in crafts forbetter treatment of the leather[9].

Moreover, it was also found that oils from thealmonds of*X. americana*containhigh nutrients such as vitamins, protein, carbohydrates and particularly unsaturated fatty acids such as oleic and linoleic acid[10,11]. For that, the oil wasrecommended for nutritional use[10]. In addition, other bioactive, and phytochemicals were found[8,3]. Concerning the green fruits of *X. americana,*Almeida *et a*l. [12]highlighted its high antioxidant activity. It can also be noted that a low content of non-essential substances was observed in the fruits, indicating that little processing would be required before it can be consumed [8].

In order to promote non-timber forest products and to find an alternative for imported oils and cosmetics, which are becoming increasingly expensive for several reasons, it becomes necessary to search for local species with high potential for vegetable oil production. For instance,*X. americana* could be one of these species. However,few studies focused on the variability of the physicochemical, phytochemical

characteristics and antioxidant activities of thisplant species. Therefore, this study aimed tocompare local variants of X. *americana* with optimal properties for production in the food and phytomedicine industry.Our findings would contributeto improving the various uses of*X. americana*almondand also promote its plantationas a strategy to ensure the viability of the species in its natural habitats.

2. MATERIALS AND METHODS

2.1. Study site

The plant material was collected from three sites, namelyGonsé, Saponé and Kokologho(Fig.1).The choice of these sites was made with regard to the evolution of *Ximeniaamericana* which is a wild species not yet domesticated in 3 types of contrasting environments, where the Gonsé site (highly anthropogenic classified forest in the Centre region), the site of Saponé (Protected natural reserve in the South central region) and the site of Kokologho (village grove in the Central Western region of the country).

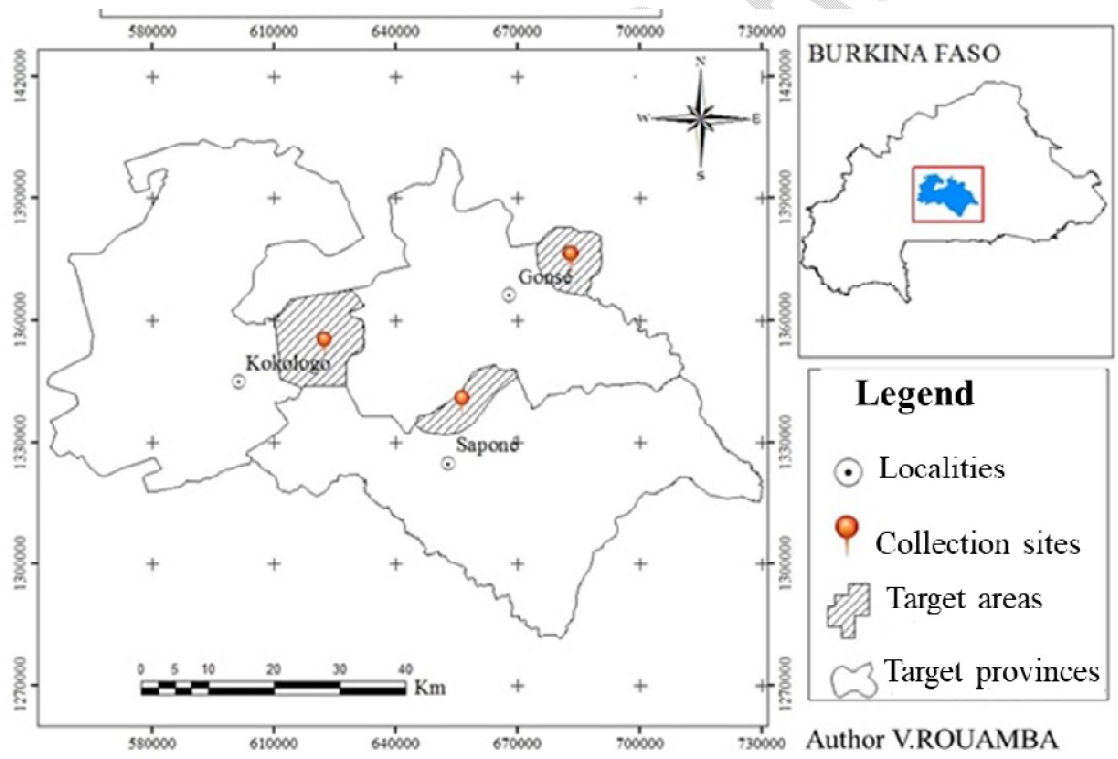

Figure 1. Study site

The classified forest of Gonsé is characterized by mainly ferruginous tropical sandy-clayey or gravelly soils mixed with bare soils in some places[13].It is also a forest subject to degradation by human

action. Saponé soils are gravelly, sandy, clayey and hydromorphic. The Kokologho site is a grove managed by the villagers. On this site we find hydromorphic soils on clayey-sandy materials [14].

2.2. Collection and sample preparation

The identity of the plant has been confirmed by the “Herbier National du Burkina-Faso” (HNBU) located within “Centre National de RechercheScientifique et Technologique” (CNRST) whose attribution codes are 8203N361, 8203N362 and 8203N363 for the sites of Gonsé, Saponé and Kokologho respectively.

Fruits were collected (Fig. 2) from May 28 to June 5, 2021,from eight trees (samples) selected randomly at each site according to the good condition of the tree and the presence of good fruiting. At least 500g of fruit per tree was collected. The fruit samples collected from the different sites were put in an oven at 50°C for 72 hours to eliminate the larvae. After this treatment, they were dried in the sun for a period of 2 weeks. Finally, the almonds were obtained after crushing and separating the shells. All the almond samples were then crushed using an aluminum mortar. Grinding and extraction were carried out simultaneously.

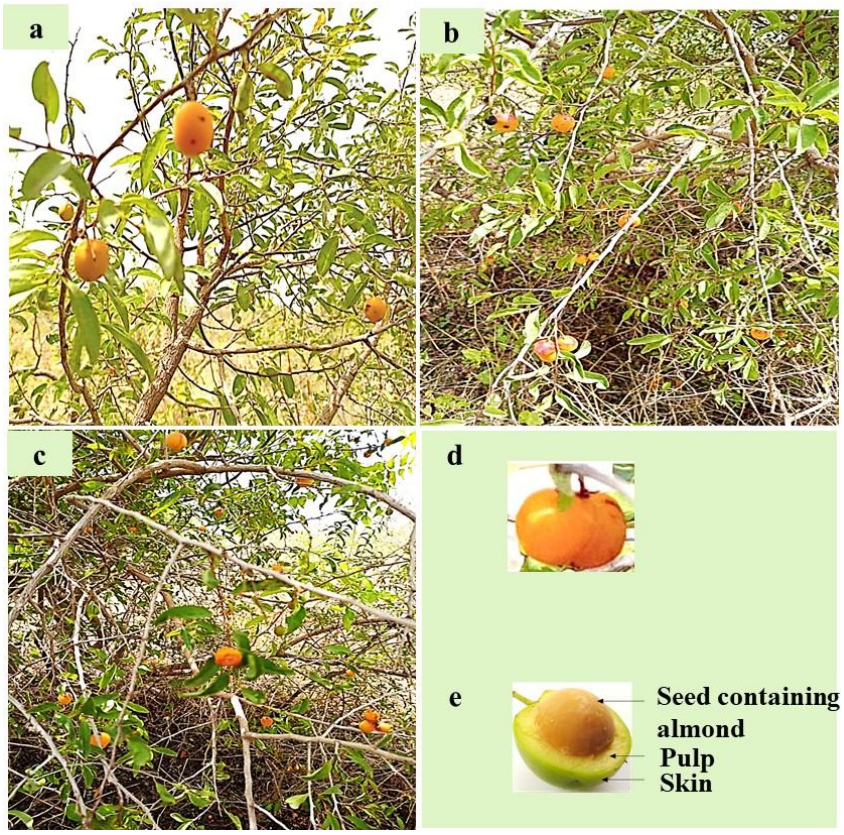

Figure 2. Shrub of *Ximeniaamericana*. Shrub observed in Saponé (a), Kokologho (b) and Gonsé (c). Fruit (d) and longitudinal section of the fruit(e).

2.3. Extraction

The extraction of the fat from the almond paste was carried out with hexane according to the soxhlet method for 10 hours, following the protocol of standard NF V03-924[15].

The oil extraction yield (R) was calculated usingthe following equation:

$$R = \frac{W1}{W2} * 100$$

Where R is the extraction yield, W1is the weight of oil extracted, and W2is the weight of the almond paste.

2.4. Physicochemical parameters determination

The colour was determined using a PCE-CSM1 colorimeter. The results were expressed in terms of luminosity (L*), red-green characteristics (a*), blue-yellow characteristics (b*), hue and saturation angle (H°).The refractive index, the acid value, the peroxide value and the saponification value were determined using ISO values 6320-2017, 660-2020, 3960-2017 and ISO 3657-2020 respectively.

2.5. Polyphenolic contents estimation

The total phenolicsand total flavonoid contents estimation were carried out according to the method of Singleton et al.[16]adapted byLamien-Meda et al. [17].The polyphenol content was expressed in mg gallic acid equivalent per 1 liter (L) of extract or fraction (mg EAG/L of extract) and in mg quercetin equivalent (QE) for 1L of oil extract (mg QE/L) for total flavonoid contents.

2.6. Antiradical evaluation test

The evaluation of the anti-free radical activity using DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS ((2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) was carried out according to the method described by Chaves *et al.*[18], and Re *et al.* [19]with some modifications. The antiradical activity of the oil concentration which scavenges 50% of the free radical DPPH●+, and reduces the radical cation ABTS+● was expressed in mg/mL oil, and mg Trolox equivalent per ml (µmol TE/ml) of extract successively.

2.7. Statistical analysis

The data were analyzed with the Software Minitab version 19.1. An analysis of variance (ANOVA) was carried out in order to detect any significant differences between the trees or the sites for the characters studied. The separation of the means was performedby Tukey's test at the 5% threshold.

3. Results and discussion

3.1. Extraction yield

The extraction yields obtained vary from 36.88 ± 9.17%; 42.12 ± 14.85% and 47.92 ± 10.02% for the sites of Gonsé, Saponé and Kokologho, respectively. The average yield for all three sites is 42.30 ± 14.34. There is no significant difference (P>0.05) between the yields obtained in the three sites. These yields are lower than the yields obtained by Oladipo, *et al*. [20] and Satoto*et al*. [4]using *X. americana* samples from Nigeria and Angola, which were 45.7% and 61.78%, respectively. There are multiple factors that could explain these differences: different pedoclimatic conditions, differences in extraction solvents and the conditions for collection, drying and conservation of the almondsused by these authors.

3.2. Physicochemical parameters

The physiochemical parameters per site are summarized in Table 1 (Colour) and Table 2(refractive index, acid value, peroxide value and saponification value), while the comparison of physicochemical parameters between the sites is present in Figure 3.

The colour angles of the oil extracted from the various trees of Gonsé site vary between 78.90 and 82.33 corresponding to the colour index PY 108 (anthrapyrimidine yellow) to PY35 (cadmium yellow).The hue angles of Saponé trees samples vary from 77.87 to 86.46 corresponding to the colour index PY108 to the colour index PY129 (green gold).The hue angles for Kokologho trees samples vary from 70.08 to 89.90 corresponding to the colour index PY1 (hansa yellow G) to the colour index PY138 (quinophthalone yellow). In general, we can say that the colour of the oil is yellow.For example, the work of HozaifaMedaowe Ahmed[21] showed that the oil *of X. americana* has a bright yellow colour that is line with our results.

Table 1. Colour coordinates (CIELab) of *Ximeniaamericana* almond oils per site

Sites	Trees	L*	a*	b*	C*	H°
Gonsé	$Tree_1$	47.21 ± 3.01[a]	1.96 ± 0.14[a]	14.93 ± 3.21[a]	15.20 ± 3.21[a]	78.95 ± 2.66[a]
	$Tree_2$	47.20 ± 3.00[a]	1.92 ± 0.19[a]	14.92 ± 3.21[a]	15.19 ± 3.21[a]	78.92 ± 2.67[a]
	$Tree_3$	47.19 ± 3.00[a]	1.91 ± 0.19[a]	14.89 ± 3.19[a]	15.18 ± 3.21[a]	78.91 ± 2.67[a]
	$Tree_4$	47.18 ± 3.01[a]	1.76 ± 0.22[a]	14.88 ± 0.78[a]	15.17 ± 3.21[a]	78.90 ± 2.67[a]
	$Tree_5$	47.18 ± 3.01[a]	2.90 ± 0.78[a]	12.50 ± 0.78[a]	12.63 ± 0.80[a]	82.33 ± 1.31[a]
	$Tree_6$	47.19 ±3.01[a]	2.91 ± 0.78[a]	12.51 ± 0.80[a]	12.64 ± 0.80[a]	82.34 ± 1.31[a]
	$Tree_7$	49.03 ± 2.06[a]	1.91 ± 0.40[a]	13.30 ± 1.74[a]	13.43 ± 1.75[a]	81.84 ± 1.57[a]
	$Tree_8$	49.02 ± 2.06[a]	1.90 ± 0.40[a]	13.30 ± 1.74[a]	15.20 ± 1.75[a]	81.84 ± 1.57[a]
Saponé	$Tree_1$	62.96 ± 5.78[a]	1.23 ± 0.51[b]	22.51 ± 1.74[a]	22.55 ± 1.75[a]	86.44 ± 1.60[a]
	$Tree_2$	63.03 ± 5.75[a]	1.28 ± 0.52[b]	22.54 ± 1.76[a]	22.58 ± 1.73[a]	86.46 ± 1.60[a]
	$Tree_3$	47.29 ± 0.90[b]	2.36 ± 0.28[ab]	11.76 ± 0.30[b]	12.01 ± 0.31[b]	79.79 ± 1.21[b]
	$Tree_4$	47.31 ± 0.91[b]	2.37 ± 0.28[ab]	11.80 ± 0.33[b]	12.02 ± 0.31[b]	79.80 ± 1.21[b]
	$Tree_5$	47.40 ± 1.00[b]	2.40 ± 0.30[ab]	11.81 ± 0.33[b]	12.03 ± 0.30[b]	79.83 ± 1.20[b]
	$Tree_6$	52.20 ± 1.08[b]	3.13 ± 0.62[ab]	14.51 ± 2.16[b]	14.85 ± 2.22[b]	77.87 ± 1.26[b]
	$Tree_7$	52.21 ± 1.08[b]	3.14 ± 0.62[a]	14.52 ± 2.16[b]	14.88 ± 2.21[b]	77.87 ± 1.26[b]
	$Tree_8$	52.22 ± 1.08[b]	3.15 ± 0.62[a]	14.53 ± 2.60[b]	14.88 ± 2.21[b]	77.96 ± 1.22[b]
Kokologho	$Tree_1$	52.40 ± 4.90[b]	2.02 ± 0.86[ab]	19.21 ± 1.38[a]	19.44 ± 1.22[a]	83.90 ± 2.84[a]
	$Tree_2$	41.82 ± 1.65[b]	3.54 ± 0.28[a]	09.76 ± 0.43[b]	10.38 ± 0.50[b]	70.08 ± 0.71[b]
	$Tree_3$	52.40 ± 4.90[b]	2.02 ± 0.86[ab]	19.21 ± 1.38[a]	19.44 ± 1.22[a]	83.90 ± 2.84[a]
	$Tree_4$	52.40 ± 4.90[b]	2.06 ± 0.86[ab]	19.21 ± 1.38[a]	19.44 ± 0.90[a]	83.90 ± 2.84[a]
	$Tree_5$	41.82 ± 1.65[b]	3.54 ± 0.28[a]	09.76 ± 0.43[b]	10.38 ± 0.50[b]	70.08 ± 0.71[b]
	$Tree_6$	52.40 ± 4.90[b]	2.02 ± 0.86[ab]	19.21 ± 1.37[a]	19.44 ± 1.22[a]	83.90 ± 2.84[a]
	$Tree_7$	74.73 ± 7.77[a]	0.00 ± 0.00[b]	19.27 ± 0.89[a]	19.30 ± 0.90[a]	89.90 ± 3.70[a]
	$Tree_8$	74.73 ± 7.77[a]	0.03 ± 0.00[b]	19.27 ± 0.89[a]	19.30 ± 0.90[a]	89.90 ± 3.70[a]

Results are presented as mean ± SD (n=3). Values that do not share any letter are significantly different

Table 2. Physicochemical parameters of *Ximeniaamericana* almond oil per site

Sites	Trees	RI	AV	PV	**SV**	**T (°C)**
Gonsé	$Tree_1$	1.470 ± 0.00[a]	0.06 ± 0.02[ab]	0.03 ± 0.01[a]	79.31 ± 5.68[a]	26.70 ± 0.85[a]
	$Tree_2$	1.473 ± 0.00[a]	0.04 ± 0.00[b]	0.02 ± 0.00[b]	79.31 ± 5.68[a]	22.43 ± 0.50[b]
	$Tree_3$	1.471 ± 0.00[a]	0.04 ± 0.00[b]	0.02 ± 0.00[b]	53.29 ± 8.42[b]	21.43± 0.15[bc]

	$Tree_4$	1.470 ± 0.00^{a}	0.04 ± 0.00^{b}	0.02 ± 0.00^{b}	81.02 ± 2.79^{a}	21.13 ± 0.15^{c}
	$Tree_5$	1.470 ± 0.00^{a}	0.04 ± 0.00^{b}	0.02 ± 0.00^{b}	86.77 ± 8.23^{a}	22.50 ± 0.10^{b}
	$Tree_6$	1.471 ± 0.00^{a}	0.07 ± 0.00^{a}	0.02 ± 0.00^{b}	89.58 ± 0.18^{a}	22.30 ± 0.10^{b}
	$Tree_7$	1.474 ± 0.00^{a}	0.04 ± 0.00^{b}	0.02 ± 0.00^{b}	94.61 ± 0.00^{a}	22.10 ± 0.36^{bc}
	$Tree_8$	1.469 ± 0.00^{a}	0.04 ± 0.00^{b}	0.02 ± 0.00^{b}	89.59 ± 5.78^{a}	22.43 ± 0.06^{b}
Saponé	$Tree_1$	1.470 ± 0.00^{ab}	0.004 ± 0.00^{f}	0.04 ± 0.00^{a}	70.12 ± 2.8^{c}	22.43 ± 0.06^{cd}
	$Tree_2$	1.473 ± 0.00^{a}	0.049 ± 0.00^{a}	0.04 ± 0.00^{a}	81.34 ± 2.8^{a}	22.70 ± 0.10^{bc}
	$Tree_3$	1.470 ± 0.00^{ab}	0.007 ± 0.00^{d}	0.04 ± 0.00^{a}	78.54 ± 0.00^{ab}	22.63 ± 0.06^{bc}
	$Tree_4$	1.468 ± 0.00^{ab}	0.008 ± 0.00^{c}	0.04 ± 0.00^{a}	84.15 ± 0.00^{a}	22.93 ± 0.15^{ab}
	$Tree_5$	1.470 ± 0.00^{ab}	0.008 ± 0.00^{c}	0.04 ± 0.00^{a}	81.34 ± 2.8^{a}	23.23 ± 0.15^{a}
	$Tree_6$	1.470 ± 0.00^{ab}	0.030 ± 0.00^{b}	0.04 ± 0.00^{a}	81.34 ± 2.81^{a}	22.73 ± 0.12^{bc}
	$Tree_7$	1.463 ± 0.00^{b}	0.030 ± 0.00^{b}	0.04 ± 0.00^{a}	84.15 ± 0.00^{a}	22.20 ± 0.30^{de}
	$Tree_8$	1.466 ± 0.00^{ab}	0.006 ± 0.00^{e}	0.04 ± 0.00^{a}	72.93 ± 0.00^{bc}	21.93 ± 0.06^{e}
Kokologho	$Tree_1$	1.463 ± 0.00^{a}	0.008 ± 0.00^{d}	0.04 ± 0.00^{b}	92.56 ± 2.80^{a}	30.60 ± 0.00^{c}
	$Tree_2$	1.465 ± 0.00^{a}	0.004 ± 0.00^{ef}	0.04 ± 0.00^{b}	83.81 ± 5.59^{ab}	30.73 ± 0.06^{b}
	$Tree_3$	1.467 ± 0.00^{a}	0.020 ± 0.00^{c}	0.04 ± 0.00^{b}	86.95 ± 2.81^{ab}	30.93 ± 0.06^{a}
	$Tree_4$	1.462 ± 0.00^{a}	0.030 ± 0.00^{b}	0.04 ± 0.00^{b}	78.54 ± 5.61^{b}	30.80 ± 0.00^{b}
	$Tree_5$	1.465 ± 0.00^{a}	0.002 ± 0.00^{f}	0.04 ± 0.00^{b}	84.15 ± 5.61^{ab}	30.60 ± 0.00^{c}
	$Tree_6$	1.465 ± 0.00^{a}	0.015 ± 0.00^{c}	0.04 ± 0.00^{b}	81.34 ± 8.42^{ab}	30.40 ± 0.00^{de}
	$Tree_7$	1.465 ± 0.00^{a}	0.005 ± 0.00^{e}	0.04 ± 0.00^{b}	84.15 ± 0.00^{ab}	30.46 ± 0.06^{d}
	$Tree_8$	1.467±0.00^{a}	0.050 ±0.00^{a}	0.06 ± 0.02^{a}	86.95±2.80^{ab}	30.30 ±0.00^{e}

Results are presented as mean ± SD (n=3). Values that do not share any letter are significantly different. Results are presented as mean ± SD (n=3). Values that do not share any letter are significantly different. RI: Refraction index; AV: Acid value (*mg* KOH/g); PV: Peroxide value (*mEq* O2/kg); SV: Saponification value (*mg* KOH/g), T: Temperature (°C)

Results are presented as mean ± SD (n=3). Values that do not share any letter are significantly different.

Legend: G: Gonsé, S: Saponé, K: Kokologho, 1 to 8: Tree number.

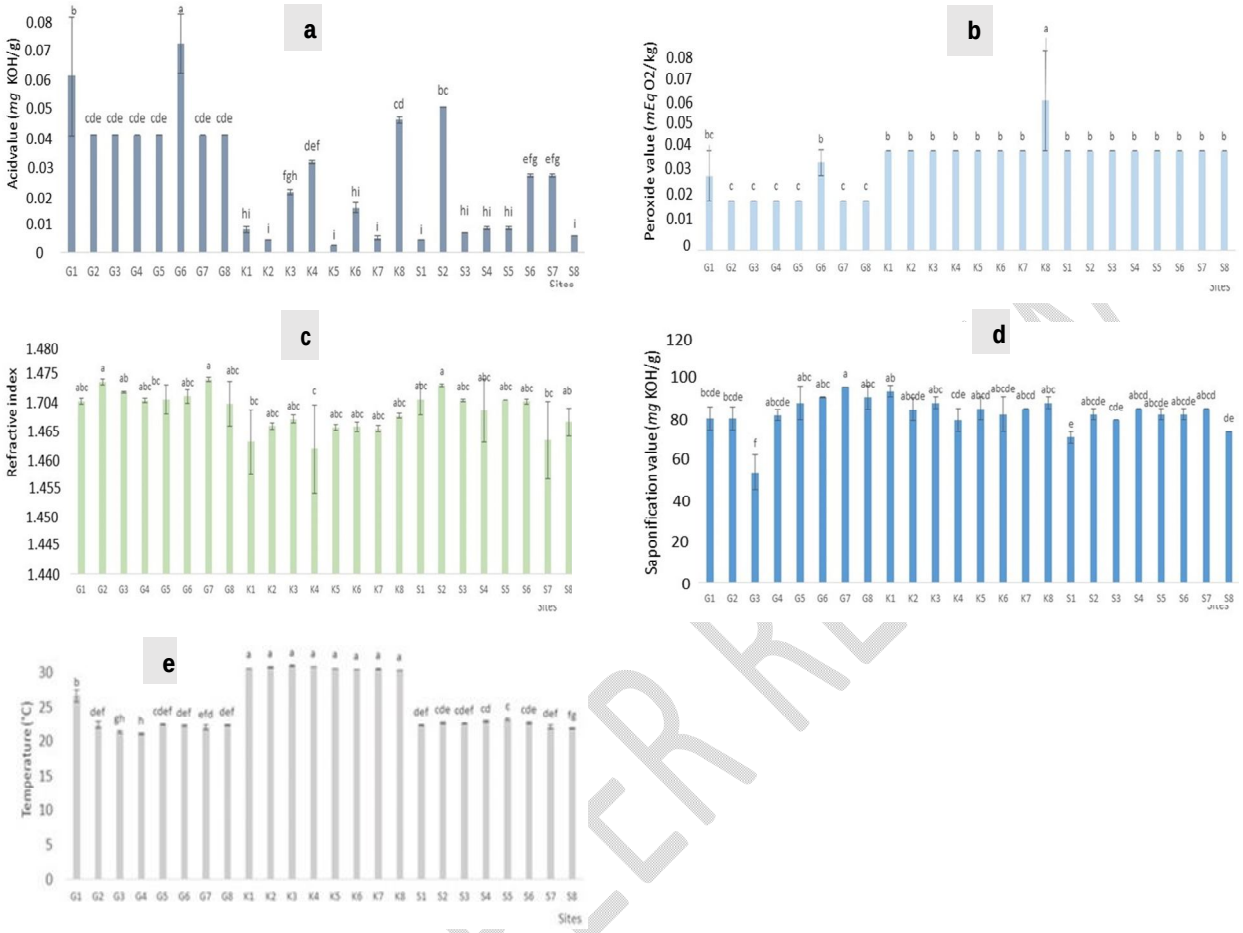

Figure 3. Comparison of*Ximeniaamericana* almond oil physicochemical parameters between the sites: acid value (a), peroxide value (b), refractive index (c), saponification value (d), temperature (e).

Comparingthe refractive index between the three study sites, a significant difference ($p \leq 0.001$) between the Gonsé, Saponé andKokologhositescan be observed. The Gonsé site, particularly trees 1 and 2 indicate the highest value of about 1.47. The refractive index values obtained from all our samples were higher than those found by Tanko *et al*. [22] in Nigeria which was 1.413. These variations could be explained by the temperatures of the oils but also by the extent of refining of the oils. Some authors such asOladipo *et al*. [20], and Sharief *et al*.[10] who also worked on *X. americana*oils found refractive index values similar to ours (1.467 and 1.470). According to the ISO 6320-2017 standard, the values obtained in our study indicate a good purity of the oils. The refractive indices of the almonds harvested from all our study sites demonstrate that the almond oil of *X. americana* could be used as a food oil.

The highest oil temperature value was found in the site of Kokologho for all the tree samples (about 30°C) with a significant difference ($P < 0.001$) regarding the other site's trees samples.

In Gonsé, the minimum and maximum temperature of the almond oils was respectively 21.13 ± 0.15 °C (tree 4) and 26.70 ± 0.85 °C (tree 1). At Saponé the minimum was 21.93 ± 0.058 °C (tree 8) and the maximum was 23.23 ± 0.15 °C (tree 5).

The highest acid value in Gonsé is0.07 ± 0.00mg KOH/g (tree 6). At Saponé the highest acid value (0.1 ± 0.00 mg KOH/g) is from tree 2 and the smallest value (0.007 ± 0.00 mg KOH/g) derives from tree 3, while at the Kokologhosite, the highest value is 0.05 ± 0.00 (tree 8) and the smallest (0.002 ± 0.00 mg KOH/g) is that from tree 5.

The comparison between the acid values of the three sites shows that the Gonsé sample from tree 6 has the highest value and the lowest is from tree 5 of Kokologho. The acid values are lower than the international standard ISO 660-2020 for fatty substances where forrefined oils the limit is 0.6 mg KOH/g oil, while that of virgin fats and oils can reach anacid value of 4.0 mg KOH/g fat or oil [23]. Therefore,according to the Codex Alimentarius*X. americana* oil can be consideredas food. Authors suchEromosele *et al*. [24]and [22]found values of 0.14 mg KOH/g, 0.29 ± 0.15 mg KOH/g, respectively, which are much higher than our values. On the other hand, some authors such asOladipo*et al*.[20]obtaineda value of 16.13 mg KOH/g and which was much higher than the international standard.This very low content offree fatty acids inour oil extracts derived from*X. americana*seeds is an indication that it will have good long-term stability.

The peroxide value of tree 1 (0.03 ± 0.01 mEq O2/kg) in the Gonsé site is significantly different ($P \leq 0.001$) from the rest of the trees sampled. For the Kokologho and Saponé sites, the peroxide values are the same (0.040 ± 0.00mEq O2/kg) for all trees.

In general, the values found in our samples were lower than those obtained by Saeed and Bashier [25]and Sharief*et al*.[10]which were 30 mEq O2/kg oil from *X. americana*. These low values of peroxide could derive either from the presence of antioxidants (polyphenols, flavonoids, etc.) in our oil samples, which prevent the oil from going rancid. Also, suboptimal storage conditions (temperature, light) could increase oxidation processes in crude oil. Moreover, non-similarity in the sample processing could be the main reason for these differences.As the Codex Alimentarius standards [23]set the peroxide value for

refined oils at a value less than or equal to 10 mEqO2/kg and for crude oils at 15 mEqO2/kg,our values are far below these limits.

The saponification values were significantly different (P ≤0.001) between trees of the same site for all locations studied. In Gonsé, tree 7 (94.61 ± 0.00 mg KOH/g) has the highest saponification value and the lowest comes from tree 3 (53.29 ± 8.40 mg KOH/g). At Saponé, trees 4 and 7 show the highest values (84.15 ± 0.00 mg KOH/g) and the lowest saponification value is from tree 1 (70.12 ± 2.8 mg KOH/g). As for the Kokologho site, the saponification value of tree 1 (92.56 ± 2.80 mg KOH/g) was the highest and the lowest value was that of tree 4 (78.54 ± 5.61 mg KOH/g).

The saponification values obtained were lower than those described by the authors Satoto*et al*. [4] andTanko*et al.*[22] which were respectively 295.00 ± 0.17 mg KOH/g and 179.94 ± 1.69 mg KOH/g oil. However, other authors like Saeed & Bashier [25]found values of 11.43 mg KOH/g which were much lower than our results. These differences could be due either to non-similarity sample processing or the fact that our oils contain less free fatty acids, or to different climatic, pedoclimatic or edaphic conditions. In addition, poor separation of the soap during neutralization or by poor washing [26] could be a reason for the differences found.Our low saponification values also indicate that our oils contain a long chain of fatty acids as could be found in other vegetable oils (such as sunflower) or animal oils (such as fatty chicken)[27].

3.4. Total polyphenol and flavonoid content in *Ximeniaamericana* almonds oil

The total polyphenol and flavonoid content per site are indicated inTable 3 and the comparison between the sites is mentioned in Figure 4a and Figure 4b. Within each site, there is a significant difference (p≤ 0.001) between trees for the total polyphenol content in*X. americana* almond oils.In Gonsé, tree 1 (346.02 ± 13.43 mg EAG/L) and tree 2 (339.8 ± 47.5 mg EAG/L) present the highest values of total polyphenols and the lowest value is from tree 3 (143.02±12.52 mg EAG/L). AtSaponé the polyphenol content of almond oil from tree 3 (441.98 ± 0.606 mg EAG/L) is significantly different from the other 7 trees studied.

At Kokologho, the content is 321.37 ± 10.1 mg EAG/L for tree 8 and is statistically different from either other trees. The values of the total polyphenol content in the oils of *X. americana* compared between the

sites indicate that the results are statistically different($p \leq 0.001$) from each other, but the highest content is from saponé tree 3(442 ± 0.60 mg EAG/L).

Table 3. Total polyphenolic, contents, antiradical activities per site

Sites	Trees	TPC	TFC	Anti-DPPH	Anti-ABTS
Gonsé	$Tree_1$	346.02 ± 13.43^{a}	34.76 ± 1.69^{a}	0.63 ± 0.06^{a}	32.75 ± 0.43^{b}
	$Tree_2$	339.80 ± 47.50^{a}	28.32 ± 1.56^{b}	0.50 ± 0.29^{ab}	31.80 ± 0.35^{c}
	$Tree_3$	143.02 ± 12.52^{d}	3.90 ± 0.13^{d}	0.14 ± 0.01^{c}	33.58 ± 0.06^{a}
	$Tree_4$	241.07 ± 6.50^{b}	1.15 ± 0.05^{d}	0.11 ± 0.03^{c}	32.10 ± 0.63^{c}
	$Tree_5$	178.60 ± 25.90^{cd}	29.56 ± 2.13^{b}	0.20 ± 0.14^{bc}	31.41 ± 0.04^{c}
	$Tree_6$	254.61 ± 4.65^{b}	18.53 ± 1.05^{b}	0.40 ± 0.02^{abc}	30.30 ± 0.76^{d}
	$Tree_7$	238.19 ± 1.13^{bc}	30.97 ± 1.36^{b}	0.40 ± 0.01^{abc}	28.73 ± 0.28^{e}
	$Tree_8$	202.60 ± 17.50^{bcd}	30.94 ± 0.36^{b}	0.40 ± 0.05^{abc}	33.45 ± 0.44^{a}
Saponé	$Tree_1$	51.07 ± 0.00^{f}	9.80 ± 0.13^{b}	0.14 ± 0.04^{c}	34.31 ± 0.34^{abc}
	$Tree_2$	197.67 ± 2.52^{cd}	6.81 ± 0.17^{d}	0.16 ± 0.06^{c}	34.21 ± 0.10^{a}
	$Tree_3$	441.98 ± 0.60^{a}	8.56 ± 0.05^{c}	0.27 ± 0.10^{bc}	30.52 ± 0.63^{bc}
	$Tree_4$	144.40 ± 0.40^{e}	6.15 ± 0.05^{e}	0.24 ± 0.00^{bc}	30.52 ± 1.04^{c}
	$Tree_5$	206.17 ± 1.53^{c}	4.312 ± 0.09^{f}	0.45 ± 0.03^{a}	26.67 ± 2.03^{d}
	$Tree_6$	282.05 ± 9.64^{b}	16.17 ± 0.17^{a}	0.16 ± 0.00^{c}	23.19 ± 0.66^{e}
	$Tree_7$	286.40 ± 23.30^{b}	4.12 ± 0.09^{f}	0.33 ± 0.00^{ab}	26.68 ± 1.39^{d}
	$Tree_8$	178.95 ± 4.65^{d}	6.04 ± 0.09^{e}	0.24 ± 0.00^{bc}	$23.63 \pm 0.03d^{e}$
Kokologho	$Tree_1$	196.22 ± 14.95^{cd}	29.02 ± 1.55^{b}	0.51 ± 0.00^{a}	26.55 ± 0.83^{d}
	$Tree_2$	67.64 ± 4.04^{g}	9.85 ± 0.43^{c}	0.51 ± 0.06^{a}	$29.81 \pm 0.50a^{b}$
	$Tree_3$	254.10 ± 12.32^{b}	26.34 ± 0.82^{b}	0.53 ± 0.07^{a}	28.08 ± 0.33^{cd}
	$Tree_4$	171.88 ± 12.53^{de}	4.00 ± 0.55^{d}	0.36 ± 0.04^{b}	23.79 ± 0.62^{e}
	$Tree_5$	130.80 ± 10.26^{f}	7.24 ± 1.12^{cd}	0.08 ± 0.02^{d}	29.16 ± 0.50^{bc}
	$Tree_6$	208.44 ± 4.24^{c}	7.85 ± 1.72^{cd}	0.20 ± 0.00^{c}	30.76 ± 0.68^{ab}
	$Tree_7$	149.66 ± 1.61^{ef}	37.57 ± 4.22^{a}	0.20 ± 0.00^{cd}	27.53 ± 0.19^{cd}
	$Tree_8$	321.37 ± 10.10^{a}	8.76 ± 0.55^{cd}	0.11 ± 0.02^{cd}	30.84 ± 0.39^{a}

Results are presented as mean ± SD (n=3). Values that do not share any letter are significantly different. TPC: Total polyphenol content (mg EAG/L, oil), TFC: Total flavonoid content (mg QE/L, oil), Anti-DPPH (mg/mL), Anti-ABTS (mg QE/L, oil) Results are presented as mean ± SD (n=3). Values that do not share any letter are significantly different.

Legend: TPC: Total polyphenol content, TFC: Total flavonoid content,G: Gonsé, S: Saponé, K: Kokologho, 1 to 8: Tree number.

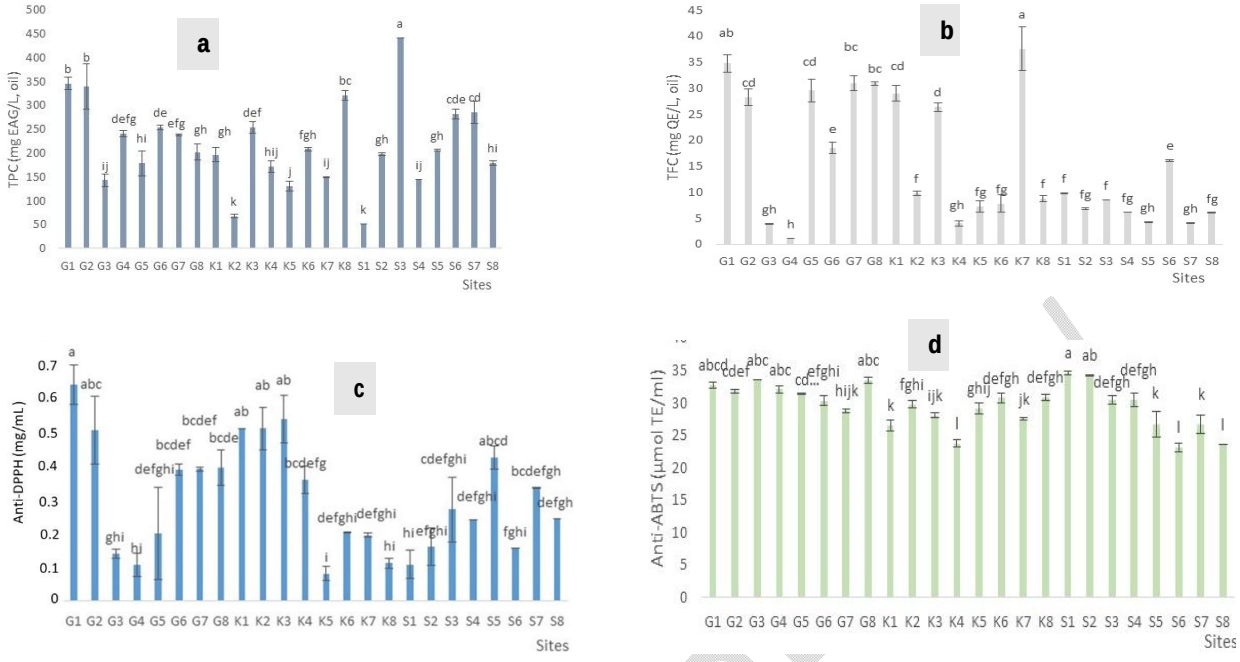

Figure 4. Comparison of*Ximeniaamericana* almond oil total polyphenolic, contents, antiradical activities between the sites: Total polyphenol content (a), Total flavonoid content (b), anti-DPPH (c), Anti-ABTS (d).

The total polyphenol content variation is high within the same site, this can be due to the state ofthe tree (biotic and abiotic factors) in its native environment. In the same way,Laitinen *et al*.[28] were underlined in their work entitled variation in phenolic compounds within a birch population that high chemical variation may be an effective means of adaptation in variable abiotic and biotic environments of trees.

In Gonsé site, tree 1 (34.76 ± 1.69 mg QE/L) presented a high flavonoid content compared to the other trees. At Saponé, the flavonoid content of almond oil (16.17 ± 0.17 mg QE/L) is significantly different ($p \leq 0.001$) for tree 6 compared to the remaining trees. In Kokologho, tree 7 with a content of 37.57 ± 4.22 mg QE/L is statistically different from the other trees.

When the 3 sites are taken into account together, the total flavonoid content of the Kokologho tree 7 is the highest among the remaining trees.

3.5. Antiradical activities

The concentrations of *X. americana* tree almond oil extracts from each site that inhibited 50% of the DPPH radical (IC50),and ABTS radical reduction activities are presented in Table 3. Analyzes of IC50 values of *X. americana* tree almond oils within each site showed highly significant variability ($p \leq 0.001$)when individual trees are compared.

For the Gonsé site, the lowest 50% inhibition value could be detected in the oil fractionsfrom tree4 (0.11 ± 0.03 mg/mL) and tree 3 (0.14 ± 0.01 mg/mL). Concerning the Saponé site, the minimum oil concentration to inhibit 50% of the DPPH radical is from tree 1 (0.11 ± 0.04 mg/mL). As for the Kokologho site, the lowest IC50 value is for tree 5 (0.09 ± 0.02 mg/mL). The oil fraction from this tree has the highest antioxidant activity of all trees tested.

There is a significant difference between the IC50 values of the three sites ($P \leq 0.001$) (Fig. 4c).

Taken together, all *X. americana* oil extracts tested for DPPH scavenging activities show radical scavenging capabilities. WhileBazezew *et al*.[5]reported that the oil from the seed of *X. americana* had radical scavenging capabilities indicating that the seeds of *X. americana*had a capacity to scavenge DPPH* radicals at a concentration of 200 µg/mL and an IC50 of 154 µg/ml.

Work carried out on the DPPH antiradical activity of the fresh fruits of *X. americana* had shown DPPH* radical scavenging capacities at 68.56 ± 0.10 mg TE/100 g[29].But all this author used a completely different processing procedure.

AtGonsé the ABTS radical reduction activities of the almond oils of tree 3 (33.60 ± 0.06) µmolTrolox equivalent /ml) and 8 (33.45 ± 0.44 µmolTrolox equivalent /ml) are significantly different from trees 1, 2, 4, 5, 6 and 7. AtSaponé, tree 1 (34.59 ± 0.34 µmolTrolox equivalent /ml) and 2 (34.21 ± 0.10 µmolTrolox equivalent /ml) present significantly high activities compared to the other trees. AtKokologho, it is the oils from trees 6 (30.76 ± 0.68 µmolTrolox equivalent /ml) and 8 (30.84 ±0.39) which presented a more significant activity compared to the other trees.

The between-site comparison of the average antioxidant activities of almond oils used for the ABTS test showeda significant difference (Fig. 4d).

The variation of the antioxidant activity within the same site could be explained by the disparity of the trees in terms of morphology or physiology or by an ongoing defense reaction againstbio-aggressors.

These results obtained by site demonstrate that our samples contain molecules capable of donating electrons (or hydrogen).

Taken together the nutritional potential of *X. americana* almond oil could be substantiated by the presence of polyphenols and flavonoid antioxidant activities. Some studies have pointed out that the seeds of*X.americana* contain hydrocyanic acid but the toxicity of the oil has not been proven[30]. Moreover, the

oil from the seed is used in food, cosmetics (for hair and skin) and is marketed in Ethiopia [3]. These same authors and other authors likeKefelegn and Desta[3]affirm that if the plant is studied it would have many advantages for food safety, for medicine and could be a basic raw material in the food industry.

4. CONCLUSION

The physicochemical parameters, noted as acid, peroxide and saponification values of *X. americana* oils from the three locations were within the threshold values proposed by the Codex Alimentarius. The parameters of *X. americana*almond oils varied somewhat from site to site. The extraction yield of the oils was favorable and was slightly high with the almonds from the Kokologho site compared to the other sites. In addition, phytochemical screening of the almond oil from *X. americana* showed significant content of phenolic compounds and flavonoids providing the oil with substantial free radical scavenging capacities (DPPH and ABTS).

This study indicates, that the oil of *X. americana*could be used in phytomedicine and food processing. In order to promote and preserve the natural populations of this multipurpose species in Burkina Faso, we propose to make a mass selection of this species for plantation.

ETHICAL APPROVALS

This study does not involve experiments on animals or human subjects.

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