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Impact of production area and extraction solvent on phenolic compounds of black plum (*Vitex doniana*) seed from Côte d'Ivoire

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***Abstract**: The objective of this study is to investigate the effect of production area and extraction solvent on phenolic compounds (total polyphenols, flavonoids and tannins) of dried black plum seed from Côte d'Ivoire. Thus, ripe black plum fruits harvested in four localities (Korhogo, Boundiali, Ferkessédougou and Yamoussoukro) of Côte d'Ivoire were pulped and dried to obtain the seed. For the characterization of the dried seeds, three extraction solvents (water, ethanol, methanol) of phenolic compounds and classical physicochemical analysis methods were used. The results obtained showed that the production areas of the black plum seed and the extraction solvents of the phenolic compounds have a significant impact on the values of the contents of the latter. The results indicate total polyphenols are more extracted with methanol (between 132.30±1.05 and 159.02±2.22mg gallic acid equivalent (GAE)/100g of Dry Weight (DW) than with ethanol (between 125.82±2.84 and 146.30±0.69mg GAE/100g DW) and even less with water (62.05±1.70 and 80.37±1.01mg GAE/100g DW). As for flavonoids, they are more extracted with ethanol (between 50.60±1.01 and 78.78±1.60mg quercetin equivalent (QE)/100g of Dry Weight (DW) than with methanol (between 41.79±0.25 and 63.99±1.63mg QE/100g DW) and even less with water (between 14.94±0.33 and 23.15±0.33mg QE/100g DW). Finally, for tannins, methanol and ethanol have the same extraction rate (varying respectively between 4.46±0.04 and 7.47±0.03mg catechol equivalent (CE)/100g DW and between 5.00±0.04 and 7.25±0.03mg CE/100g DW) against a low extraction of tannins with water (between 2.58±0.05 and 5.84±0.02mg CE/100g DW). Moreover, the results indicate the seeds of the black plum of the zone of Boundiali followed by that of Ferkessédougou provide more phenolic compounds than those of Korhogo and Yamoussoukro. In addition, sun-dried seeds in the open air preserve more phenolic compounds than those dried in a direct solar dryer under greenhouse.*

***Keywords**: Black plum (Vitex doniana) seed, Total polyphenols, Flavonoids, Tannins, Direct solar drying, Sun drying.*

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I. Introduction

The use of synthetic antioxidant molecules is currently questioned due to the potential toxicological risks associated with their use [1]. As a result, new plant sources of natural antioxidants are therefore sought nowadays [2]. Indeed, polyphenols, specific molecules of the plant kingdom, are known for their antioxidant power and their biological virtue. They therefore contribute to the prevention of degenerative [3] and cardiovascular diseases [4]. They are capable of scavenging free radicals generated permanently by the body or formed in response to aggressions caused by the environment (cigarettes, pollutants, infection etc.) that promote cellular aging [5]. In addition to their beneficial effects on health, polyphenols are also used as additives in the food, pharmaceutical and cosmetic industries [6].

However, there is a plant species, the savannah plum (*Vitex doniana*) belonging to the order Lamiales, and family Lamiaceae, which is rich in natural phenolic compounds with many favorable biological properties reported as antioxidants [7], hepatoprotective[8], anti-bacterial[9] etc .... It is highly prized in some regions of Côte d'Ivoire, including the Gontougo region (in Bondoukou) [10], the Poro region (in Korhogo and Tengrela) and the Worodougou region (in Séguéla) [11], for its edible fruits and leaves. The fruits, called black plums, and leaves

of this plant are used as protective and curative elements against several disorders. In addition, they are known for their many medicinal properties in traditional medicine [12].
Moreover, studies conducted on the seed of the black plum, representing about 50% of the whole fruit [13], is a good source of phenolic or polyphenolic compounds [3], the main players in the antioxidant capacity of plants. However, according to [14], the solubility of polyphenols is governed by the type of extraction solvent of which the most used are alcohols (methanol, ethanol), acetone, ethyl ether and ethyl acetate [12]. Also, a stabilization and therefore a better conservation of the black plum seed can be achieved by drying.
Drying the products consists in reducing their moisture content to very low residual values, thus improving their shelf life. Indeed, the reduction of the humidity of the products allows to slow down the development of microorganisms, to inhibit enzymatic reactions and to minimize most of the deterioration reactions related to the oxidation of lipids [15]. There are several methods of drying products. These include freeze-drying, hot air drying, vacuum drying, osmotic drying, microwave drying, and solar drying (open air and direct or indirect greenhouse) commonly used for drying fruits and vegetables [16].
Ultimately, it should be noted the source of the product, the type of extraction solvent used, and the drying method could impact the values of phenolic compounds content of this product. The objective of this study is to investigate the effect of the production area, the extraction solvent and the drying mode on the values of total polyphenols, flavonoids and tannins contents of the dried black plum seed (Vitex doniana) from Côte d'Ivoire. Thus, this work is part of the research and development of bioactive substances such as natural substances with antioxidant activities that are of interest for health.

II. Material and Methods

The plant material used in this study is the seed from ripe black plum (*Vitex doniana*). These fruits were collected in four localities in Côte d'Ivoire (Figure no1): Korhogo, Ferkessédougou (Ferké), Boundiali and Yamoussoukro located respectively in the regions of Poro, Tchologo, Bagoué (Savannah zones, in the north of Côte d'Ivoire) and Lacs (between the savannah zone and the forest zone, in the center of Côte d'Ivoire). These fruits were harvested randomly in July for Korhogo, Ferké and Boundiali and in September for Yamoussoukro. They were then transported in boxes to the laboratory to be sorted, washed with tap water and stored in a cold room at -4°C.

Figure no1: Map of different study areas: Yamoussoukro (6° 49' 0.001" N 5° 16' 59.999" W) located 240 km from Abidjan; Korhogo (9° 25' 0.001" N 5° 37' 0. 001" W) located 563 km from Abidjan; Ferkessédougou (9° 35' 60" N 5° 12' 0" W) located 570 km from Abidjan; Boundiali (9° 31' 59.999" N 6° 28' 59.999" W) located 660 km from Abidjan.

Methods of obtaining the black plum seeds: The same day of the drying of black plum seeds; the fruits were taken out of the cold room (-4°C) and left at room temperature (23°C) on the bench during 30 min. Then the fruits were pulped following a dilution in city water at room temperature. The seeds obtained after pulping underwent two types of drying.

Drying

Sun drying: A 250 g mass of wet black plum seeds was spread out in a thin layer (grain diameter) on a rack (Figure no 2).

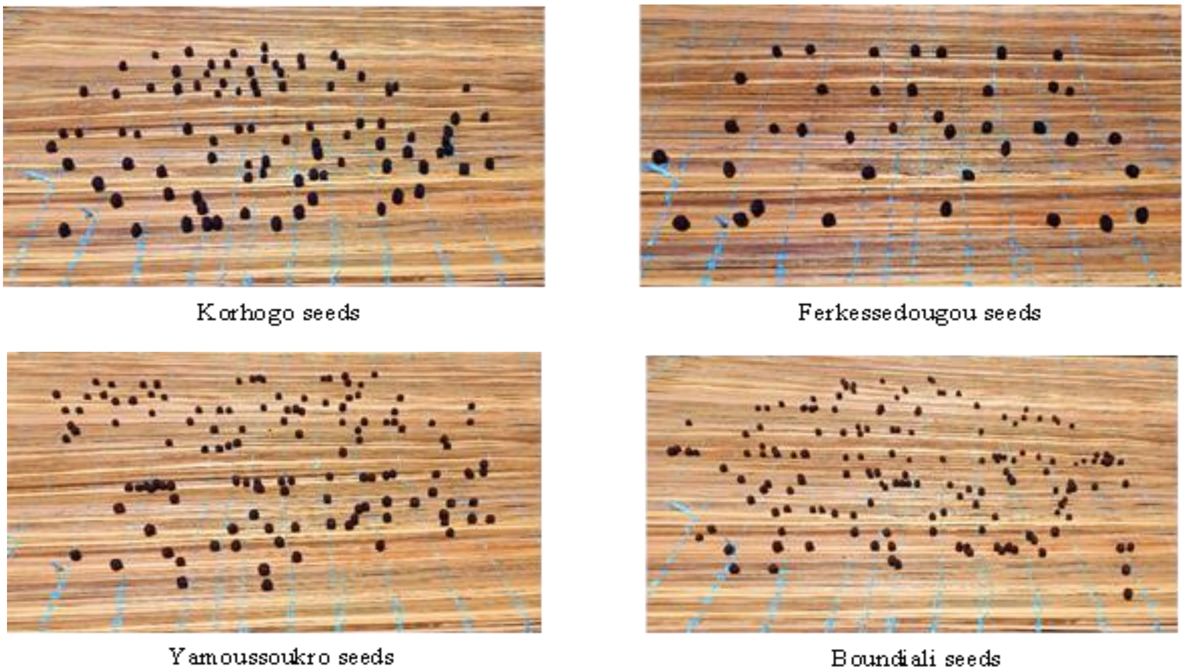

Figure no2: Drying of black plum seeds in the sun in the open air on a rack: dried seeds according to the different origins (Korhogo, Ferkessedougou, Yamoussoukro, Boundiali).

Direct solar dryer greenhouse type: A mass of 250 g of wet black plum seeds is placed in this type of direct solar dryer, whose top is glazed. The samples are placed on a rack (1 m² surface) made of sheet metal (aluminum-zinc alloy) raised one meter above the ground (Figure no 3).

Figure no 3: Drying in a direct solardryer on a sheetmetaltray (aluzinc)

Drying kinetics: Drying kinetics were established by measuring the mass of the dried seeds with a precision balance (Sartorius, France) (to 0.001 g) at regular intervals of 2 hours. Then, using the evaluation of dry matter by the gravimetric method [17], the evolution of the wet base water contents (Xh) (%) at each time t was determined according to the following equation 1:

$$X_h = \frac{M_t - M_s}{M_t} \text{x} 100 \qquad \text{(E1)}$$

Mt: mass of the sample at time t (g), Ms: mass of the dry matter of the sample (g). The variations of the water content of the product were determined as a function of time (t). A comparison of the two drying kinetics, from the two drying modes, allowed to identify the one that reduces the drying time allowing to stabilize the black plum seeds.

Phytochemical characterization

Phenols extraction

Phenols were extracted by centrifugation from three extraction solvents by the method described by [18]. These include distilled water, ethanol (8/2) and methanol (8/2). For this purpose, 1 g of black plum seed crush was solubilized in 10mL of 70% solvent acidified with 0.5% 1 M hydrochloric acid (HCl). The mixture was centrifuged at 6000rpm using a centrifuge (Labofuge, Germany) for 10min. The supernatant obtained was collected and then, a second extraction was made from the pellet, under the conditions described above. The final extract (mixture of the two supernatants) was used for the determination of total phenols, flavonoids and tannins.

Determination of total phenols

Total phenolic compounds (TPC) determination was determined according to the method using the Folin-Ciocalteu reagent [18]. Thus, in a test tube, a volume of 1mL of 10% prepared Folin-Ciocalteu reagent was added to 1mL of extract. After 3 minutes, a volume of 1mL of 20% sodium carbonate (Na2CO3) was added to the mixture. The resulting mixture was made up to 10mL with distilled water and placed in the dark for 30 min. The optical density reading was taken at 745nm against a blank control, prepared under the same conditions, containing only methanol. A standard range was established from a stock solution of gallic acid (0.1 mg/mL) under the same conditions as the assay. The concentrations of polyphenols in the black plum seed extracts, expressed as mg gallic acid equivalent (GAE)/100 g DW, were calculated using the linear regression equation of the gallic acid calibration curve plotted.

Determination of total favonoids

Total flavonoids (TF) contents were determined using the method described by [19]. A volume of 0.5mL of extract was introduced into a test tube containing 0.5mL of distilled water, 0.5mL of 10% aluminum chloride, 0.5mL of 5% sodium acetate and finally 2mL of distilled water. The resulting mixture was placed in the dark for 30min and at room temperature. Then the absorbance was measured at 415nm against a blank. Flavonoid concentrations were determined with reference to a calibration curve performed with quercetin (0.1 mg/mL). The flavonoid concentration was expressed as milligram equivalent of quercetin per 100g dry matter (mg QE/100 g DW).

Determination of total tannins

Total tannins (TT) contents were determined according to the method described by [20]. A volume of 1mL of extract was introduced into a test tube to which 5mL of vanillin (1%) prepared in 70% sulfuric acid was added. The absorbance of the solution was measured at 500nm after 30min in the dark against a blank. The tannin content was obtained with a standard range using a catechol stock solution made under the same conditions as the tests. Tannin concentrations were determined with reference to a calibration curve performed with catechol (0.1 mg/mL). Tannin concentration was expressed as milligram equivalent of catechol per 100g dry matter (mg CE/100 g DW).

Statistical analysis

All trials were performed in triplicate and results are expressed as mean ± standard deviation ($\bar{X} \pm \sigma$). Analysis of variance ANOVA at the 5% threshold was used for comparison of means, using Statistica 7.1 software (Feinberg, 1996). Duncan's test was used to indicate significant differences between means.

III. Results

Drying kinetics of black plum seed

The initial average moisture content (wet basis) of the black plum seed is 58%. This water content decreases progressively until reaching a final value of 7.7% at 16 h for the direct solar dryer while it is reached only after 18h of drying in the open air. The drying kinetics curve of black plum seed from the 4 locations, describing the evolution of their moisture content (Xh) as a function of the drying time (t) (Xh= f(t)), is presented in (Figure no 4).

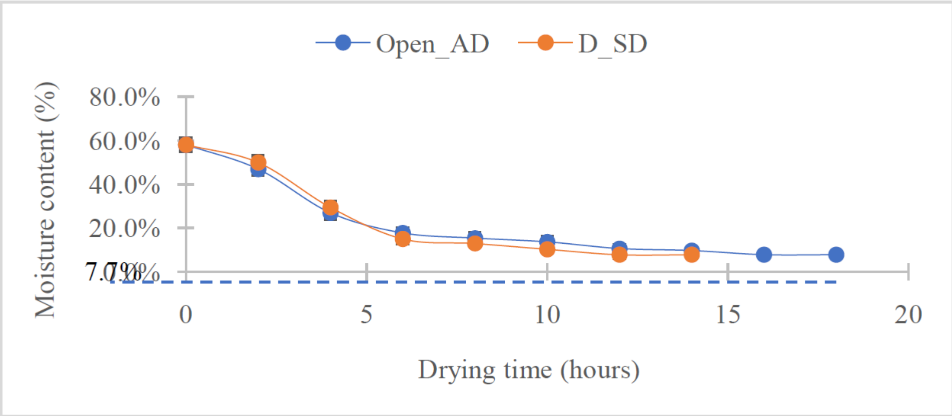

Figure no 4: Evolution of water content (wet basis) of black plum seeds as a function of drying time according to 2 drying modes (solar air drying and direct solar drying under greenhouse). *Open_AD: Open air drying, D-SD: Direct solar drying greenhouse type

Influence of the extraction solvent on the phenolic compounds of black plum seed

Table no 1 present the influence of the extraction solvent on the contents of phenolic compounds (total polyphenols, flavonoids and tannins) of the black plum seed dried on the one hand in the sun in the open air and on the other hand in the direct solar dryer type greenhouse. The statistical analysis shows a significant difference between the means of the three extraction solvents at the 5% threshold for the studied parameters (drying mode, extraction solvents). Thus, the highest contents of total polyphenols and tannins were obtained with methanol.

The values recorded for open air drying of black plum seed are in the order of 159.02±2.22mg GAE/100g DW for total polyphenols and 7.47±0.03mg CE/100g DW for tannins. As for the values recorded for the direct solar dryer, the contents are of the order of 156.12±0.56mg GAE/100g DW and 6.72±0.04mg CE/100g DW for tannins. On the other hand, flavonoids were extracted in large quantities with ethanol. The values obtained after air-drying of black plum seed are about 78.78±1.60mg QE/100g DW and those obtained after direct solar drying are about 78.63±1.51mg QE/100g DW.

Table no 1: Influence of the extraction solvent and the production area on the contents of total polyphenols, flavonoids and tannins in black plum seed

Samples		**TPC (mg GAE/100g DW)**			**TF (mg QE/100g DW)**			**TT (mg CE/100g DW)**		
		Water	**Ethanol 8/2**	**Methanol 8/2**	**Water**	**Ethanol 8/2**	**Methanol 8/2**	**Water**	**Ethanol 8/2**	**Methanol 8/2**
Yamoussoukro	Open air drying	80,37± 1,01c	128,26± 0,97b	**148,30± 1,24a**	20,97± 0,58c	**51,72± 2,18a**	46,61± 0,22b	3,68± 0,07c	5,53± 0,08b	**6,72±0,04a**
	Direct solar drying	74,89 ± 0,64c	126,19± 0,63b	**138,90± 2,85a**	20,71± 0,55c	**50,60± 1,01a**	41,79± 0,25b	3,31± 0,06c	5,49± 0,02b	**6,01±0,09a**
Korhogo	Open air drying	62,48± 0,69c	127,53± 1,12b	**134,14± 0,58a**	17,38± 0,55c	**63,62± 1,02a**	54,56± 0,33b	3,46± 0,06c	**5,23± 0,22a**	4,46±0,04b
	Direct solar drying	62,05± 1,70c	125,82± 2,84b	**132,30± 1,05a**	14,94± 0,33c	**60,44± 1,66a**	52,96± 1,44b	2,58± 0,05c	**5,00± 0,04a**	4,59±0,04b
Ferké	Open air drying	77,02± 0,27c	142,08± 1,65b	**153,15± 0,18a**	23,15± 0,33c	**64,58± 0,22a**	55,01± 0,67b	5,14± 0,02c	**7,25± 0,03a**	6,85±0,01b
	Direct solar drying	70,01± 1,70c	131,14± 1,83b	**151,50± 2,11a**	20,34± 0,64c	**63,17± 1,04a**	53,93± 0,58b	3,90± 0,01c	5,45± 0,07b	**6,55±0,05a**
Boundiali	Open air drying	77,24± 2,11c	146,30± 0,69b	**159,02± 2,22a**	19,31± 0,58c	**78,78± 1,60a**	63,99± 1,63b	5,84± 0,02c	7,21± 0,07b	**7,47±0,03a**
	Direct solar drying	77,15± 1,16c	142,76± 1,28b	**156,12± 0,56a**	18,71± 0,25c	**78,63± 1,51a**	56,29± 0,12b	4,63± 0,06c	**6,64± 0,05a**	6,45± 0,03b

Influence of the origin of the black plum seed on the contents of total polyphenols, flavonoids and tannins

Tables II and III present the contents of total polyphenols, flavonoids and tannins of the seed of the black plum, dried on the one hand in the open air and on the other hand with the help of direct solar drier, resulting from 4 localities of Côte d'Ivoire (Boundiali, Ferké, Korhogo and Yamoussoukro).The results indicate that the contents of total polyphenols, flavonoids and tannins are higher in the seeds from Boundiali and Ferké, while the lowest contents are observed in the seeds from Yamoussoukro and Korhogo.

Indeed, in close relation with the mode of drying used, the content of total polyphenols of the seed resulting from Boundiali is of 159,02±2,22mg GAE/100g DW for the drying in the open air and 156,12±0,56mg GAE/100g DW for the direct solar drying. That of Ferké contains a total polyphenol content of 153.15 ± 0.18mgGAE/100g DW for open air drying and 151.50±2.11mg GAE/100g DW for direct solar drying. As for the Yamoussoukro product, it has a total polyphenol content of 148.30±1.24 mg GAE/100 g DW for open air drying and 138.90±2.85 mg GAE/100 g DW for direct solar drying. Finally, the total polyphenol content of Korhogo seed was 134.14±0.58mg GAE/100g DW for open air drying and 132.30±1.05mg GAE/100g DW for direct solar drying. Statistical analysis shows that these total polyphenol contents are significantly different at the 5% threshold ($P<0.05$).

In addition, the values recorded for flavonoids show a significant difference between those of fruits from Boundiali (78.78±1.60 mg QE/100 g DW for open air drying and 78.63±1.51 mg QE/100g DW for direct solar drying) and Yamoussoukro (46.61±0.22 mg QE/100g DW for open air drying and 41.79±0.25mg QE/100 g DW for direct solar drying). However, the seeds from Ferké and Korhogo were significantly identical ($P >0.05$). Moreover, the seed from Ferké has a flavonoid content of 55.01±0.67 mg QE/100g DW for open air drying and 53.93±0.58mg QE/100g DW for direct solar drying. And that of Korhogo dried in the open air, has a flavonoid content of 63.6±1.02mg QE/100g DW against 60.44±1.66 mg QE/100g DW for that dried with the direct solar drier.

Finally, the tannin contents recorded for the black plum seeds are statistically different. Thus, the seed from the locality of Boundiali has a tannin content of 7.47±0.03mg CE/100g DW and 6.45±0.03mg CE/100g DW respectively for the for open air drying and direct solar drying, followed by that of Ferké (6,55±0.01mg CE/100g DW for open air drying and 6.55±0.05 mg CE/100g DW for direct solar drying) and Yamoussoukro (6.72±0.04 mg CE/100g DW for open air drying and 6.01±0.09 mg CE/100g DW for direct solar drying). Then, the seed from the Korhogo locality dried in the open air, has a tannin content of 4.46±0.04 mg CE/100g DW against 4.59±0.04mg CE/100g DW for that dried with the direct solar dryer.

Table no 2: Influence of the origin of the sun-dried black plum seed on the contents of total polyphenols, flavonoids and tannins.

Open air drying	TPC (mg GAE/100g DW)	TT (mg CE/100g DW)	TF (mg QE/100g DW)
Yamoussoukro	148,30±1,24c	6,72±0,04c	51,72±2,18d
Korhogo	134,14±0,58d	4,46±0,04d	63,62±1,02c
Ferké	153,15±0,18b	6,8 ±0,01b	64,58±0,22b
Boundiali	159,02±2,22a	7,47±0,03a	78,78±1,60a

Results are expressed as the mean ± standard deviation of three separate extractions and determinations. Data were analyzed by ANOVA and in each row for each locality, different letters indicate statistically different values at $p <0.05$.

Table no 3: Influence of the origin of the direct solar dried black plum seed on the contents of total polyphenols, flavonoids and tannins.

Direct solar drying	TPC (mg GAE/100g DW)	TT (mg CE/100g DW)	TF (mg QE/100g DW)
Yamoussoukro	138,90±2,85c	6,01±0,09c	50,60±1,01d
Korhogo	132,30±1,05d	4,59 ± 0,04d	60,44 ± 1,66c
Ferké	151,50±2,11b	6,55±0,05a	63,17±1,04b
Boundiali	156,12±0,56a	6,45±0,03b	78,63±1,51a

Results are expressed as the mean ± standard deviation of three separate extractions and determinations. Data were analyzed by ANOVA and in each row for each locality, different letters indicate statistically different values at $p <0.05$.

IV. Discussion

Drying is an operation that consists in reducing the water content of a product [21]. Thus, each product has its own drying kinetics [22]. Figure 4 shows the evolution of the water content (wet base) of the plum as a function of drying time. This water content of the black plum seed decreases with time. Indeed, it passes from 58 % at the beginning of drying (whatever the mode of drying) to 7,7 % at the end of drying, after 12 hours in direct solar drying under greenhouse and after 14 hours in solar drying in the open air.

This figure 4, shows a phase of slow decay of 2 hours which augurs the presence of a phase of setting in temperature of the product (not visible here) because the times of setting of masses are rather important (2 hours). Then, after the 2 hours, it is observed a phase of fast decay (or phase I) which lasts 4 hours; where the product sees its water being eliminated thanks to the energy of vaporization (ΔHv). In this phase, the difference in temperature (ΔT) between the outside (T. high) and the inside (T. low) of the product, causes a difference in pressure (ΔP) between the inside (P. high) and the outside (P. low) which allows the elimination of water, by pressure gradient, from the inside to the outside. Finally, after 6 hours of time, it is noted a phase II (phase with decreasing pace but slower) which would mean that the rate of drying is limited by the diffusion of water from the inside of the product to its surface [23]. This result is consistent with those obtained in many cases of drying plants including spearmint, plum, tomato, okra, ginger etc. [16], [24], [25].

Moreover, it appears from the analysis of Figure 4 that direct solar drying allows a reduction in drying time (12 hours vs. 16 hours for open air solar drying). Thus, the results obtained corroborate those reported by [26], during their study on dates, who suggested that open air drying required a longer drying time in contrast to the direct solar dryer, where the products dry faster due to the storage system of sensible heat [27]. This efficiency of the direct solar dryer could be explained by the high temperature (on average 40.3 °C) inside this dryer against a low temperature in the open air (on average 27 °C).

The choice of a good extraction solvent is based on its ability to extract a greater quantity of compounds [28]. Thus, the choice of extraction solvent is very important to extract phenolic compounds. In this study, the solvents used (methanol and ethanol) were combined with water. Indeed, this combination of water with organic solvents increases, by modulation of the polarity of an organic solvent, the solubility of polyphenols [29]. This increase could be due to ionization of phenolic compounds in such solutions, increased basicity and weakening of hydrogen bonds in aqueous solutions [29]. Similarly, the addition of a percentage of water to the extraction solvents allows an increase in the solubility of flavonoids [30].

The maximum extraction of total polyphenols and tannins from plum seed by methanol corroborates the results obtained by other researchers [31], [32]. According to these authors, methanol remains the appropriate solvent for the extraction of polyphenols. In addition, combined with water, it extracts particularly tannins [31]. On the other hand, flavonoids contained in black plum seed are extracted in large quantities with ethanol. This is in agreement with the work done by [33] in their studies on the extraction of phenolic compounds from artichoke. For these authors, ethanol remains the best solvent for flavonoid extraction.

Polyphenols, flavonoids, and tannins are the main bioactive compounds found in fruits.
Indeed, Mwaurah et al [34] defines bioactive compounds as primary or secondary metabolites that exhibit specific biological effects while being functional food ingredients at low concentrations. As such, they impact physiological or cellular activities in those who consume them [35]. The results of our study revealed that the contents of total polyphenols, flavonoids and tannins, extracted from the seed of the studied black plum differed significantly from one locality to another. The results also show that the seeds from Boundiali and Ferké have higher contents of phenolic compounds, followed by that of Yamoussoukro. On the other hand, the seed from Korhogo has the lowest content of total polyphenols. This result could be explained by the type of soil encountered in these localities. In fact, in Côte d'Ivoire, in the locality of Boundiali, modal reworked soils from granite or schist are found [36]. This author indicates that the soils of this locality have very variable chemical properties and have a high fertility potential. However, in the localities of Ferké and Yamoussoukro, ferralitic soils are found [36], [37]. In Korhogo, the soils are deep gravelly with a heavy texture, poor in matter (clay-loam-sand) [38].

In addition, the average phenolic compound value of black plum seed is 146.68 mg GAE/100g DW. This value is lower than that of Kenyan black plum seed (170 mg GAE/100g DW) [3] but higher than that of *Ocimum basilicum*, *Apium graveolens* and *Lepidium sativum* seeds (51-92mg GAE/100g DW), and three times higher than that of bitter almond (48 mg GAE/100g DW) [39]. Thus, according to [39], bitter almond is known for its richness in polyphenols and therefore has a high antioxidant power. Based on this observation, it should then be concluded that the seed of the black plum is a good source of polyphenols, thus natural antioxidants capable of contributing to the prevention of certain diseases such as hypertension, cardiovascular accidents etc... [40]. Because of its high content of phenolic compounds, the seed of the black plum could be introduced in the diets and also be used in

the food field as additive. Thus, its valorization in food products could exert beneficial effects on health by protecting the body against hormone-dependent diseases such as osteoporosis [41].
Again, the flavonoid content (53.14 mg QE/100g DW) in black plum seed is higher than that of Kenyan black plum seed (3.75 mg QE/100g DW) [3], melon seed (3.75 mg/100g DW) and water melon seed (3.75 mg/100g DW) [42].

V. Conclusion

The objective of this study was to investigate the effect of the production area, the extraction solvent and the drying method on the values of total polyphenol, flavonoid and tannins contents of the dried black plum (*Vitex doniana*) seed from Côte d'Ivoire.
It appears from this study the extraction solvent and the origin have indeed an impact on the values of the contents of phenolic compounds of the seed of the black plum. Moreover, the contents obtained show this seed is an excellent source of bioactive compounds (total polyphenols, flavonoids and tannins), known for their antioxidant properties. The results obtained also show methanol is the appropriate extraction solvent for the extraction of phenolic compounds. As for flavonoids, they are extracted in large quantities by ethanol. In general, the black plum seed dries faster in the solar dryer than in the open air. However, these drying methods used do not influence the phenolic content of the seed. However, the use of a greenhouse dryer could be considered in order to study its effect on the phytochemical quality of the black plum seed.

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