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Evaluation of Phenolic Content and Antioxidant Activity of Aqueous Extracts of Three *Carica papaya* Varieties Cultivated in Senegal

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Abstract

The aqueous extracts of different parts (old leaves (OL), young leaves (YL), peels (PE) and delipidated seed residues (DS)) of three varieties of papaya are studied. Extraction conditions are optimized: an extraction time of 20 minutes, a temperature of 70˚C and a plant material/water mixture of 1% give the best yield of polyphenol. The amount of polyphenols, flavonoids, saponins and proanthocyanins of each aqueous extract was investigated. Antioxidant activities are measured using two different methods (DPPH and ABTS). The delipidated seeds (DS) of V1 have the highest total phenolic content (TPC = 72.56 ± 3.16 mg GAE/g) while they have the lowest total flavonoid content (TFC = 0.22 ± 0.01). With regard to saponins, the PE of V3 is much richer in saponins (194.03 ± 15.78 mg AeE/g) than all the other extracts studied. The OL of V2 and PE of V1 contain the most proanthocyanidins with very similar values of 2.51 ± 0.03 mg CE/g and 2.53 ± 0.34 mg CE/g respectively. The study of the antioxidant activities of the extracts showed a correlation between the amount of polyphenols and IC50. DPPH OL and YL V2, which are rich in polyphenols, have the lowest IC50 of 0.072 mg/ml and 0.080 mg/ml respectively, whereas for ABTS we have PE of V1 that is very rich in polyphenols which has the smallest IC50 value of 0.218 mg/ml.

Keywords

Carica papaya, Extraction, Antioxidant, Polyphenols, Flavonoids, Proanthocyanidins, Saponins

1. Introduction

Metabolic and respiration processes generate oxidation reactions in living. During these metabolic reactions, the use of oxygen can require highly reactive oxygen forms (ROS) such as free radicals or peroxidised ($O_2^{\cdot-}$, $HO^{\cdot}$, H_2O_2, $ONOO^-$, $^1O_2$, ROOH, NO) [1]. Their actions on macromolecules can induce often irreversible damage [2] [3] [4]. It is generally recognized that the presence of free radicals contributes to the occurrence of serious diseases such as cancer, cirrhosis, diabetes, emphysema, cardiovascular diseases and rheumatism [5] [6] [7] [8]. Since the process of onset of ROS is natural, one must try to control their concentrations in the human body in particular. For this purpose it is necessary to provide supplements able to neutralize them without generating harmful species. This is possible with antioxidants such as polyphenols [9] [10] [11] [12]. Polyphenols are a set of chemical compounds such as phenolic acids, coumarin, flavonoids, anthocyanin, tannin, lignin, which are widespread in the plant kingdom and derived from the secondary metabolism of plants [13] [14] [15] [16]. Synthetic antioxidants can also be used but unfortunately, their use is very restricted [17] [18] [19] [20]. For several years natural antioxidants from fruit and vegetable plants have been widely examined to understand their role in the reduction of ROS in cells [11] [21] [22] [23]. Usually, only fruits and vegetables were consumed for their bioactive components but investigations showed that other organs of the plant (leaves, bark, peelings, roots...) can contain bioactive chemical species, in particular polyphenolic compounds [24] [25] [26]. Thus these organs which constituted a problem of waste management can be used advantageously to extract the bioactive species which have a rather important added value. In this context, *Carica papaya* known for its nutritional and therapeutics interests offers an advantageous opportunity. In fact, leaves are used as to relieve nerve pain, asthma attacks or sugar's levels control [27]. The seeds are used in the treatment of ulcers [28], diabetes [29], hypertension [30], hypercholesterolemia [31] and liver diseases.

The principal aim of this study is to optimize the extraction of polyphenols in the different parts (old leaves (OL), young leaves (YL), peels (PE) and defatted seeds (DS)) of three varieties of *Carica papaya*. Secondary, the different categories of molecules (polyphenols, flavonoids...) of interest are quantified and the antioxidant activities of the three varieties are studied according to the different parts.

2. Experimental

2.1. Plant Material

Three varieties of *Carica papaya* L. were harvest at the Sébikhotane protected forest (region of Dakar in Senegal 14˚43'14.4"N, 17˚08'16.4"W): Ordinary (V1), Red Lady (V2) and Sunrise (V3). Old (OL) and young (YL) leaves, the seed (DS) and the peels (PE) from mature fruits were collected. The ordinary variety produces round fruits with a yellowish flesh while Sunrise ones are oblong with red

flesh, fragrant, juicy and sweet. The Red Lady fruits are also oblong with a sweet-fruited cultivar, but they are three to four times larger than the fruit of the Sunrise variety. Samples were rinsed with water and distillate water and were air-dried free for 3 days. After this process, they were dried at 55˚C during 48 hours in an oven. Then, the different organs of *C. papaya* L. (OL, YL and PE) have been finely ground using a grinder and stored at 4˚C for later use. The seeds were ground and defatted with hexane and the residue (DS: defatted seed) was air dried and stored at 4˚C for further uses.

2.2. Extraction Process

Extraction process was done according to the procedure used by Vuong *et al.* [32]. TPC is used as response value. For the determination of optimum temperature leaves were crushed and 0.5 g of powder is extracted in 50 ml of distillate water at variable temperatures (50˚C, 60˚C, 70˚C, 80˚C and 90˚C) for 20 minutes using an agitated water bath whose temperature is well controlled. This optimal temperature is used to determine the optimum extraction duration. Then 0.5 g of papaya leaves' powder was extracted with 50 ml of water at the optimum temperature with varying extraction times (5, 10, 20 and 30 min). The optimum temperature and the optimum duration are used to determine the optimal ratio in the range of 0.5 - 1.0 - 1.25 - 2.5 - 3.25 and 5.0 g with 50 ml of water. For further study, the optimal values of these three parameters are used. Prior the extraction, the seeds were defatted by hexane. Then the extract was filtered through a Whatmann filter paper N˚1. The extract obtained was stored at 4˚C for further use.

2.3. Determination of the Total Phenolic Content

The assay was due according to Mohdaly *et al.* [33] with some modifications. A test sample of 200 µl final (several dilution were made) was mixed with 150 µL of Folin-Ciocalteu reagent, 600 µl of Na_2CO_3 20% and 2.32 ml of distillate water. After 1h of incubation in the darkness at room temperature, the absorbance was read at 760 nm with a Perkin-Elmer UV/Visible spectrophotometer Lambda 365. Gallic acid (GA) was used as a standard. The results were expressed as mg GAE/g ± Standard deviations.

2.4. Determination of the Flavonoids Contents

According to the method of Ordoñez *et al.* [34], 2.5 ml of sample were mixed with 2.5 ml of an ethanolic solution of $AlCl_3$. After 1 h of incubation in the darkness at room temperature, the absorbance was read at 425 nm with a Perkin-Elmer UV/Visible spectrophotometer Lambda 365. Quercetin (Q) was used as a standard. The results were expressed as mg QE/g ± Standard deviations.

2.5. Determination of Saponins Content

The procedure developed by Vuong *et al.* [32] was used with a little modifiction.

0.5 ml of sample (dilutions were made if they are required) were mixed with 0.5 ml of a vanillin ethanolic solution and 5 ml of H_2SO_4 at 72%. The samples were incubated at 70˚C in a water bath during 10 minutes. After that they were cooled slowly at room temperature. The absorbance was measured at 560 nm with a Perkin-Elmer UV/Visible Spectrophotometer Lambda 365. Aescin was used as a standard and results were expressed as mg AeE/g ± Standard deviations.

2.6. Determination of Proanthocyanidins

The proanthocyanidin content was determined according to the procedure described by Li *et al* (2006) [35]. To 0.5 mL of diluted sample, 3 mL of 4% (w/v) vanillin is added before adding this mixture to 1.5 mL of concentrated HCl. This mixture is incubated at room temperature for 15 min before reading the absorbance at 500 nm. Catechin (C) was used as standard and the results are expressed as mg CE/g ± Standard deviations.

2.7. Antioxidant Capacity

2.7.1. DPPH Free Radical Scavenging

Before determining the IC50 we have to determine the TEAC (Trolox Equivalent Antioxidant Capacity) according to Akhtar *et al.* [36] with modifications. Firstly, 0.1014 mM of fresh DPPH in methanol was prepared. Trolox was used as a standard; dilutions were made to have a final volume of 200 µl. The different extracts or Trolox solutions (200 µl) were mixed with 3.8 ml of DPPH. After 30 minutes of incubation in the dark at room temperature we read the absorbance at 517 nm. Next, we made adequate dilution to determine the IC50. Results were expressed as µg TrE/g ± Standard deviations. DPPH scavenging activity was determined by calculating the percentage of inhibition:

$$\text{Scavenging activity} = \frac{\text{Absorbance}_{\text{control}} - \text{Absorbance}_{\text{sample}}}{\text{Absorbance}_{\text{control}}} \times 100 \quad (1)$$

2.7.2. ABTS Free Cation Radical Scavenging

Like DPPH assay, we have to determine the TEAC and the IC50. The assay developed by Thaipong *et al.* [37] with modifications was used. A stock solution by mixing an equal volume of a 3 mM potassium persulfate ($K_2S_2O_8$) solution with ABTS solution 8 mM was prepared and stocked in the darkness during 16h before use. A working solution is prepared by diluting the stock solution with a phosphate buffer (0.2 M, pH 7.4, 150 mM NaCl) up to get an absorbance of 1.2 at 734 nm. The different extracts or Trolox solutions (100 µl) were mixed with 2.9 ml of ABTS working solution. 30 minutes after incubation absorbance is read at 735 nm. Then, adequate dilution is made to determine the IC50. Results were expressed as µg TrE/g ± Standard deviations. ABTS scavenging activity was determined by calculating the percentage of inhibition (Equation (1)).

2.8. Statistical Analyses

All the measurements were carried out in triplicate. The mean values and stan-

dard deviations were calculated and the data were expressed as mean ± SD. Xlstat 2019 software was used for the data and statistical analysis. Differences were considered significant at the $p < 0.05$ level based on Duncan's new multiple range test.

3. Results and Discussion

3.1. Optimisation of the Extraction

Under the described experimental conditions, **Figure 1** summarizes the variation of polyphenols extraction according the temperature (a), the duration (b) and the ratio (c). It shows that the temperature, the time and the ratio parameters have an influence on the yield of the extraction of polyphenols during the aqueous extraction of papaya leaves. The yield increases with the temperature to reach a maximum at 70˚C which will be considered as the optimum. This observation is consistent with that reported by Vuong *et al.* [32]. Similarly, the extractability of the polyphenols increases and reaches a maximum at 20 minutes. Beyond this extraction time, there is a degradation of the yield of polyphenols. Therefore, the optimal temperature of 70˚C and the extraction time of 20 minutes are chosen to study the influence of the ratio on material plant/water (w/v). It is observed in **Figure 1(c)** that the extraction efficiency is better for the 1/100 ratio. This result seem to be logical as it is reported by Gertenbach *et al.* [38] that the lower the plant/water ratio (w/v), the higher is the rate of extraction. Indeed, there is a concentration gradient between the phenolic compounds inside the foliar particles and the ones located on the surface, thus leading to an acceleration of the extraction process at high dilution.

For the present work the extractions are carried out at a temperature of 70˚C for 20 minutes in a vegetable/water ratio of 1/100 to quantify total phenolic, total flavonoid, saponins and proanthocyanidins.

3.2. Total Phenolic and Total Flavonoid Content from Three Varieties of *Carica papaya*

The results of the quantitative determination of the polyphenol contents of the

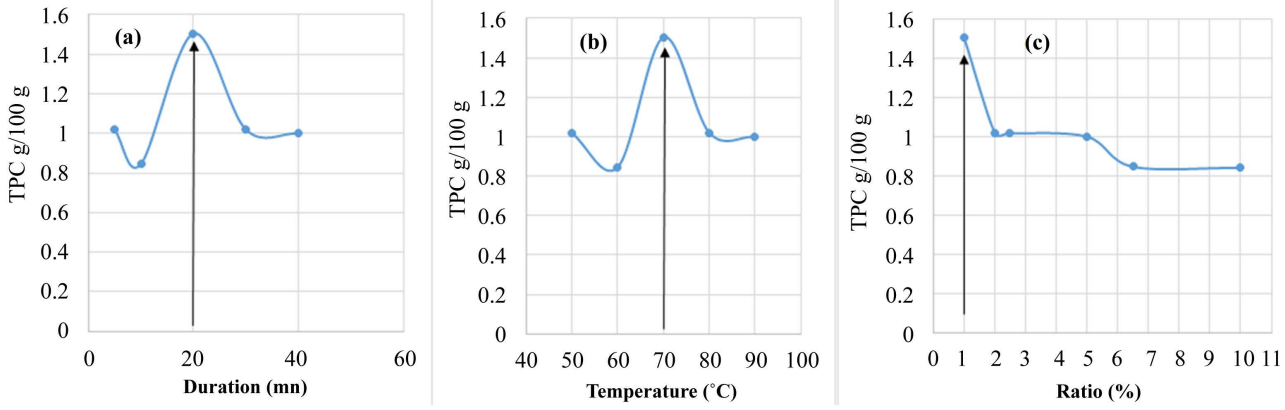

Figure 1. Optimisation parameters of the aqueous extraction. (a) Duration; (b) Temperature; (c) Ratio.

different varieties are given in Table 1. It is noted that for ordinary variety (V1), the residue of defatted seeds (DS) is much richer in polyphenols (72.56 ± 3.16 mg GAE/g) followed by young leaves (YL) (38.03 ± 1.18 mg GAE/g) and old leaves (OL) (29.75 ± 1.22 mg GAE/g); the peels (PE) are half as rich in polyphenols (19.87 ± 0.26 mg GAE/g) as the young leaves. Unlike V1, the residue of defatted seeds (DS) of Red Lady variety (V2) is less rich in polyphenols (9.61 ± 3.81 mg GAE/g) than all other parts of the plant; young leaves are richer (55.24 ± 3.14 mg GAE/g), followed by old leaves (53.24 ± 3.02 mg GAE/g) and peels (15.53 ± 5.93 mg GAE/g) remaining poor. In Sunrise variety (V3), the old leaves are richer in polyphenols (41.77 ± 0.96 mg GAE/g) while the peels are the poorest (23.64 ± 1.28 mg GAE/g); the defatted seeds and the young leaves have comparable polyphenol levels (38.28 ± 1.34 and 38.56 ± 1.61 mg GAE/g). It is observed that the defatted seeds of V1 are twice as rich in polyphenols as V3 ones and that it is three times richer than that of V2 which is poor in polyphenols. In V2 the polyphenols are found in the leaves whereas in V1 the seeds contain almost as many polyphenols as all the other parts of the plant combined. For V3 the polyphenols are fairly homogeneously distributed in the leaves and seeds. It should be noted that for varieties V2 and V3 the total polyphenol content (TPC) of young leaves and the old leaves are comparable contrary to V1 for which the TPC of the young leaves is higher than the TPC of the old leaves. The three varieties studied in this work have a TPC that is higher than *Carica* studied by Vuong *et al.* [32]. Leaves of a variety of *C. papaya*, cultivated in Pakistan [39], give TPC value of 49.94 ± 0.60 mg AeE/g which is less than the values found for OL and YL of V2 and higher than those for OL and YL of V1 and V3. The TPC (32.23 ± 0.64 mg AeE/g) of the peels of the Pakistan's variety is greater than those of the three varieties used in this study while the seeds' TPC (27.94 ± 0.09 mg AeE/g) is very low compared to the TPC value of the DS of V1 and V3.

For all three varieties, flavonoid levels are low (Table 1). This can be explained

Table 1. Total phenolic and total flavonoid content of three varieties of *Carica papaya*.

	Total phenolic content (mg GAE/g)			
	OL	**YL**	**PE**	**DS**
V1	29.75 ± 1.22^{a}	38.03 ± 1.18^{b}	19.87 ± 0.26^{c}	72.56 ± 3.16^{d}
V2	53.24 ± 3.02^{e}	55.24 ± 3.14^{e}	15.53 ± 5.93^{f}	9.61 ± 3.81^{g}
V3	41.77 ± 0.96^{h}	$38.56 \pm 1.61^{b,h}$	23.64 ± 1.29^{j}	38.28 ± 1.34^{b}
	Total flavonoid content (mg QE/g)			
	OL	**YL**	**PE**	**DS**
V1	1.11 ± 0.077^{a}	1.01 ± 0.009^{a}	0.34 ± 0.050^{b}	0.22 ± 0.010^{b}
V2	1.46 ± 0.047^{c}	1.39 ± 0.014^{d}	0.23 ± 0.004^{e}	0.36 ± 0.013^{e}
V3	1.39 ± 1.970^{d}	0.99 ± 0.010^{g}	0.23 ± 0.006^{h}	1.01 ± 0.030^{i}

Legend: Ordinary (V1), Red Lady (V2) and Sunrise (V3). OL: Old leaves, YL: Young leaves; PE: Peels and DS: defatted seeds. Values with different letters in superscript in column showed the significant differences at the significance level of p-value of 0.05 or 0.001*.

by the low solubility of flavonoids in water which is a very polar solvent. Indeed, the flavonoids which are low polar molecules are more soluble in the organic solvents and little and medium polar solvents. For all varieties, flavonoid levels of OL and YL are comparable and range between 1.10 mg QE/and 1.50 mg QE/g. These values are lower than the value reported in the literature (3.33 mg/g) for young leaves of the papaya variety which growth in Malaysia [40]. The TFC of aqueous extracts of defatted seeds (0.22 mg QE/g - 1.01 mg QE/g) are greater than the TFC of aqueous extract of the seeds of the Malaysian variety [40]. The TFC of PE are between 0.23 mg QE/g and 0.35 mg QE/g and are higher than the value reported (0.056 mg/g) for the *Carica papaya* L. var solo 8 variety that is cultivated in Ivory Coast [41].

3.3. Saponins Content of Three Varieties of *Carica papaya*

The peels (PE) and defatted seeds (DS) of sunrise variety (V3) are the richest in saponins 194.03 ± 15.78 and 102.92 ± 26.77 mg AeE/g respectively (**Table 2**). The same observation is noticed for ordinary variety (V1) but with lower values: 87.07 ± 6.08 mg AeE/g for PE and 74.87 ± 11.77 mg AeE/g for DS. For the lady variety (V2), young leaves contain more saponins (65.88 ± 5.70 mg AeE/g) than all the other studied parts of the plant whereas the OL are the poorest saponins content (49.73 ± 0.92 mg AeE/g) unlike to the other two varieties (**Table 2**). This is consistent with the fact that saponins are slightly polar are more compatible with solvents which are less polar than water. These results are in accordance with those reported for the *Carica* studied by Vuong *et al.* [32].

3.4. Proanthocyanidins Content of Aqueous Extracts

Owing to their low polarity the proanthocyanidins extraction yields in water are low (**Table 3**). The proanthocyanidins content of OL of the three varieties are comparable and are in the range 2.19 - 2.51 mg CE/g and are slightly greater than those found for YL (1.57 - 2.33 mg CE/g). Peels (PE) and defatted seeds (DS) of V1 are the richest in proanthocyanidins: 2.53 ± 0.34 mg CE/g and 2.50 ± 0.08 mg CE/g respectively. For V2, PE and DS are poor with lower values: 1.68 ± 0.16 mg CE mg/g for PE and 1.23 ± 0.05 mg CE/g for DS. For V3 the DS contains much less proanthocyanidins (1.45 ± 0.11 mg CE/g) than all the other studied

Table 2. Saponins content in different organs of three varieties of *Carica papaya*.

	Content of Saponins mg AeE/g			
	OL	**YL**	**PE**	**DS**
V1	38.31 ± 5.58^{a}	66.38 ± 3.36^{b}	87.07 ± 6.08^{c}	$74.87 \pm 11.77^{b,c}$
V2	49.73 ± 0.92^{a}	65.88 ± 5.70^{b}	55.61 ± 7.41^{d}	51.79 ± 1.34^{d}
V3	66.61 ± 1.97^{b}	56.35 ± 12.39^{d}	194.03 ± 15.78^{e}	102.92 ± 26.77^{f}

Legend: Ordinary (V1), Red Lady (V2) and Sunrise (V3). OL: Old leaves, YL: Young leaves; PE: Peels and DS: defatted seeds. Values with different letters in superscript in column showed the significant differences at the significance level of p-value of 0.05 or 0.001*.

Table 3. Proanthocyanidins content in different organs of three varieties of *Carica papaya*.

	Content of Proanthocyanidins mg CE/g			
	OL	**YL**	**PE**	**DS**
V1	$2.23 \pm 0.15^{a,b}$	$2.10 \pm 0.10^{b,g}$	$2.53 \pm 0.34^{a,h}$	2.50 ± 0.08^{a}
V2	$2.51 \pm 0.03^{a,c,h}$	$2.33 \pm 0.12^{a,c,g}$	1.68 ± 0.16^{d}	1.23 ± 0.05^{e}
V3	2.19 ± 0.06^{a}	1.57 ± 0.18^{f}	1.50 ± 0.08^{f}	1.45 ± 0.11^{f}

Legend: Ordinary (V1), Red Lady (V2) and Sunrise (V3). OL: Old leaves, YL: Young leaves; PE: Peels and DS: defatted seeds. Values with different letters in superscript in column showed the significant differences at the significance level of p-value of 0.05 or 0.001*.

parts of the plant For V1 the proanthocyanidins quantities are regularly distributed between the different parts of the plant: 2.23 ± 0.15 mg CE/g - 2.53 ± 0.34 mg CE/g (Table 3).

3.5. Antioxidant Capacity and IC50

Since phenolic compounds are known for their ability to trap free radicals a study of their antioxidant activity and IC50 was carried out for the three varieties of *C. papaya*. Table 4 summarizes their results.

DPPH·, which is a stable radical, is widely used to evaluate free radical scavenging ability [42] [43]. Globally, the results show that V2 has a better antioxidant capacity than V1 and V3 which antioxidant's activities seem similar. The trend can be seen with OL and YL but not with PE and DS. The antioxidant capacity is slightly higher in OL than YL for V2 and V3 (8.92 ± 0.21 mg TrE/g for OL and 8.39 ± 0.08 mg TrE/g for YL of V2); (5.58 ± 0.42 mg TrE/g for OL and 4.01 ± 0.09 for YL of V3), while inverted tendency is noticed for V1 (5.20 ± 0.20 mg TrE/g for YL versus 3.85 ± 0.04 mg TrE/g for OL). For V2, the antioxidant capacities are not significantly different ($p > 0.05$), whereas in V1 and V3 these values are significantly different ($p < 0.05$).

The trend we observe with OL and YL is not the same with PE and DS. The higher antioxidant capacity for PE is for V3 with 3.69 ± 0.14 mg TrE/g followed by V1 with 2.47 ± 0.09 mg TrE/g and V2 with 1.96 ± 0.15 mg TrE/g. It can be noted that for DS, the antioxidant capacities of the three varieties are comparable with a p-value of 0.001 and are in the range 4.06 - 4.57 mg TrE/g. The lowest value corresponds to V3 with 4.06 ± 0.12 mg TrE/g while the variety V1 has the highest DS antioxidant capacity (4.57 ± 0.11 mg TrE/g).

The IC50 cannot be determined with the DPPH·s method neither in all organs from V1, V3 nor PE and DS from V2. On the other hand, OL and YL from V2 have a good IC50; OL is better than YL with 0.072 mg/ml against 0.080 mg/ml.

With the ABTS assay, we determined an IC50 for the different extracts of each variety (Table 4). For variety V2 the different organs studied have highest IC50 values of 0.376 TrE/ml (OL), 0.400 TrE/ml (YL), 0.446 TrE/ml (PE) and 0.351 TrE/ml (DS). Leaves and peels of variety V1 have low IC50 values in the range

Table 4. The antioxidant capacity (DPPH and ABTS) and IC50 in different organs of three varieties of *Carica papaya*.

Variety	Organ	DPPH·			ABTS		
		mg TrE/g	IC50 (mg/ml)	% Inb max after 2 h 30	mg TrE/g	IC50 (mg/ml)*	% Inb max after 2 h 30
V1	OL	3.85 ± 0.04[a]	n/a	39.45	46.70 ± 2.66	0.256[a]	77.87
	YL	5.20 ± 0.20[b]	n/a	48.22	57.26 ± 3.10	0.252[a]	70.57
	PE	2.47 ± 0.09[c]	n/a	35.15	27.89 ± 0.75	0.218[a]	97.57
	DS	4.57 ± 0.11[d]	n/a	40.12	83.21 ± 2.67	0.274[a]	69.63
V2	OL	8.92 ± 0.21[e]	0.072	61.02	113.84 ± 3.80	0.376[b]	69.56
	YL	8.39 ± 0.08[e]	0.080	69.96	114.95 ± 0.32	0.400[b]	68.30
	PE	1.96 ± 0.15[f]	n/a	23.32 (after 1 h 30)	73.44 ± 3.16	0.446[b]	98.36
	DS	4.30 ± 0.05[d]	n/a	30.26 (after 1 h 30)	46.71 ± 1.77	0.351[b]	63.82
V3	OL	5.58 ± 0.42[g]	n/a	48.76	56.83 ± 4.61	0.293[a]	71.68
	YL	4.01 ± 0.09[h]	n/a	35.14	47.97 ± 0.86	0.281[a]	72.43
	PE	3.69 ± 0.14[i]	n/a	32.41	39.60 ± 1.19	0.238[a]	98.49
	DS	4.06 ± 0.12[d]	n/a	27.34	49.26 ± 1.13	0.269[a]	66.87

Values with different letters in superscript in column showed the significant differences at the significance level of p-value of 0.05 or 0.001*.

0.256 TrE/ml - 0.218 mg TrE/g, with the smallest IC50 for PE. The IC50 values of variety V3 are comparable to the values obtained for V2 and its PE has the smallest value of IC50. However, the antioxidant capacity does not reflect the IC50. Indeed, V2 which has the highest IC50 values has the best antioxidant capacity values for OL, YL and PE with respectively 113.84 ± 3.80, 114.95 ± 0.32 and 73.44 ± 3.16 mg TrE/g. Indeed, several types of compounds can contribute to the antioxidant capacity of plant materials, including tocopherols, carotenoids and polyphenol compounds. The variation in the antioxidant capacity of the papaya may be due to its geographical origin and to climatic and environmental factors such as temperature, humidity, soil composition, sunlight, and harvesting and storage conditions [44]. The mechanisms involved in the process and the conditions under which reactions with DPPH or ABTS occur may also explain these observations [45] [46].

For DS, V1 has the highest antioxidant capacity with 83.21 ± 2.67 mg TrE/g while V2 and V3 varieties have comparable antioxidant activities of 46.71 ± 1.77 mg TrE/g and 49.26 ± 1.13 mg TrE/g respectively. On the other hand for OL and PE, the values are different with respectively 46.70 ± 2.66 mg TrE/g and 27.89 ± 0.75 mg TrE/g for V2, 56.83 ± 4.61 mg TrE/g and 39.60 ± 1.19 mg TrE/g for V3. The lowest antioxidant capacity value for YL was found for V3 with 47.97 ± 0.86 mg TrE/g versus 57.26 ± 3.10 mg TrE/g for V1. In previous studies, the antioxidant activities of *Carica papaya* extracts reported are lowest than our results

[32]. Other organic solvents such as the extracts of n-hexane, dichloromethane, n-butanol, ethyl acetate, methanol and ethanol showed a significant difference in scavenging activity between the different parts of *Carica papaya* [32] [39]. According to study of Asghar *et al.* [39], leaf ethanol extract shows the highest free radical scavenging of DPPH compared to seed and peel extracts. Extracts of n-hexane and n-butanol give the lowest DPPH free radical scavenging probably due to the difference in polarity of the solvents and extracted compounds.

Owing to the quantitative presence of polyphenols and flavonoides in the aqueous extracts of the different studied parts of the plant and the antioxidant activities presented by these extracts, it is conceivable to make formulations in the form of infusion for human consumption. Indeed polyphenols are good substrat for protection against oxidative stress. All these parts of the papaya plant considered as waste can find in this sector a potential valuation at low cost.

4. Conclusion

In Senegal, *Carica papaya* is a widespread tree and several varieties are grown in various regions during all seasons. While only the papaya pulp is consumed in Senegal, this work shows that polyphenols, flavonoids, proanthocyanidins and saponins are present in other organs such as seed, leaves and peels. Their optimal aqueous extraction conditions are reminiscent of the conditions for obtaining infusions. These observations offer interesting prospects for the development of new product in food and nutrition area.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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