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EFFECT OF SOLAR AND ELECTRIC DRYING ON THE CONTENT OF THE PHENOLIC COMPOUNDS AND ANTIOXIDANT ACTIVITY OF THREE VARIETIES OF ONION (*Allium cepa* L)

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ABSTRACT

The present research aimed at evaluating the effect of drying on the antioxidant properties of three varieties of onion. Onion powders were prepared after solar or electric dryings. The total phenolic compounds (TPC), flavonoids, tannins, and vitamin C were assayed at time in the fresh and powdered samples of these varieties. The total reducing power (TRP) and scavenging capacity (ABTS and DPPH) were also evaluated. Results showed a significant

decrease ($P \leq 0.05$) in the parameters evaluated during drying and a significant positive correlation ($P \leq 0.05$) between ABTS and DPPH ($R^2 = 0.602$) and between TPC and TRP ($R^2 = 0.77$), and between TPC and the scavenging capacity ($R^2 = 0.88$, $R^2 = 0.71$ for ABTS and DPPH respectively). The Violet of Galmi variety appeared to have the strongest antioxidant activity even after drying. In general, drying reduced the antioxidant activity of onion.

Key words: Onion *(Allium cepa* L*)*, Drying, Antioxidant, Vitamin C

INTRODUCTION

Onion (*Allium cepa* L) is one of vegetable crops widely consumed in the world. In Cameroon, this vegetable has a place in the daily food menu of people and its annual consumption is about 90 000 tons/year. Despite the estimated production of 119,638 tons per year, Cameroon cannot always ensure its self-sufficiency in consumption of onions due to post-harvest losses that reach approximately 40% of total production **[1, 2, 3]**. These losses are due among others to the lack of infrastructure and appropriate technology for the conservation of onion, at its seasonal production and especially to its high perishability. In order to make the sector more efficient and reduce post-harvest losses, efforts could focus on the development of processing technology, on stabilization of onions such as onion powder, for the sale and consumption throughout the year. But several questions arise about the effects of drying on functional properties, including its influence on their antioxidant properties. Indeed, several prospective studies and epidemiological studies confirmed the antioxidant power of onion which reflected its ability to reduce the incidence of several types of diseases related to oxidative stress **[4-7]**.

Moreover, in recent years, several national research centers have focused their work in promoting and enhancing the therapeutic potential of many foods in the country **[8]**. In order to make our contribution to this vast research program, we have decided to conduct this study whose general objective was to evaluate the effect of drying on the antioxidant properties of three varieties of onion (*Allium cepa* L) grown in Maroua (Cameroon).

MATERIALS AND METHODS

Plant Material

The three varieties onion (*Allium cepa* L) bulbs used in the drying experiments were collected randomly from a research farm in market in Maroua, Far North region of Cameroon during december 2009. The experiment was conducted by the Institute Research Agronomy Development (IRAD),

Maroua. The bulbs samples without any cracking, breaking and other physical damages were considered. They were carried out to laboratory in polyethylene plastic bags. The varieties: "*Violet of Galmi*", "*White of Galmi*" and "*Goudami*" are an appropriate cultivar to be used in this region.

Figure 1: White of Galmi

Figure 2: Goudami

Figure 3: Violet of Galmi

Methods

Drying

Once transported to the laboratory, the onion bulbs were cleared of dry dandruff, roots and crown. Cleaning operation was done manually using a stainless steel knife. The bulbs were then trimmed and washed thoroughly cleaned from impurities (earth, fragments of dry dandruff). To facilitate drying, the bulbs were cut into thin strips of 0.25 cm to 0.3 cm thick and dried. All varieties were treated separately. Two types of drying were used: solar drying and electric drying. Solar drying was carried out on wooden racks manufactured in ENSAI of Ngaoundere, at an average temperature of 36°C for 6 days. Drying by ventilation was done in an electric turning dryer (brand Riviera & Bar) at room temperature (25 ° C) for 4 days. After drying, the dry onions were powdered using an electric grinder (Culatti, Polymix, France) through a 500µm sieve. The obtained powders were finally sealed in polyethylene bags for better and stored at 4 ° C until analysis.

Determination of Phenolics Compounds

Methanolic Extracts

Efficiency of extractions is an important factor for the comparison of antioxidant activity. Previous studies reported that relatively higher antioxidant activities were observed from methanolic extracts in grains compared to other solvents including n-hexane, diethyl ether, ethyl acetate, acetone and water **[9, 10, 11]**. For this reason, methanol was selected as the solvent of choice for extraction in this study **[12]**. Methanolic extracts were obtained from 20 mg/mL of ground spice sample. In brief, 250 mg of ground spice sample was extracted by stirring with 25 mL of methanol at room temperature for 2 h and filtered through Whatman No. 1 (Maidstone, England) filter

paper. Residues were re-extracted with additional 25 mL of methanol for a further 2 h and filtered as described. The volume of the combined extract was removed by evaporation and the lot stored in a sealed tube at 4° C until use.

Determination of Total Phenol Content

Total phenol content was determined using Folin–Ciocalteu colorimetric method as described by **[13]**. Plant extracts (20 µL) was mixed in a test tube with 0.2 mL of Folin–Ciocalteu reagent and 2 mL of distilled water and incubated at room temperature for 3 min. Following this, 1 mL l of 20 % sodium carbonate was added to the mixture, re-incubated for 2 h at room temperature. The absorbance of the resulting blue color was measured using a quartz cuvet at 765 nm. Gallic acid was used as standard and total phenols were expressed as gram gallic acid equivalents (GAE per 100 g of dry weight).

Determination of Flavonoids

Flavonoid content of the different samples was determined following the method of **[14]**. Essentially, 1g of each ground spice sample was homogenized with 20 mL of extracting solvent (methanol/water/acetic acid, 140/50/10, V/V) and filtered into volumetric flasks and its volume was adjusted to 100 mL by addition of extracting solvent. Aliquots of 2.5 mL were transferred into 50 mL volumetric flasks and their volumes made up of water (analyzed solutions). To each 10 mL of analyzed solution, 2 mL of water and 5 mL of $AlCl_3$ reagent (133 mg crystalline aluminum chloride and 400 mg crystalline sodium acetate were dissolved in 100 mL of extracting solvent) were added and absorbance recorded at 430 nm against a blank made of 10 mL of analyzed solution plus 5 mL of water. The amount of flavonoids was calculated from the calibration curve of rutin standard solutions and expressed as mg rutin/100 g of plant material.

Tannins

Tannin level in the spices was determined by the method of **[15]**. Following this method, 1g of sample was weighed in a 50 mL volumetric flask followed by the addition 25 mL of 1% HCl (in methanol). After 30 min of agitation, the mixture was centrifuged at 4000 rpm/min during 10 min and the supernatant collected and used for the assay of its tannin content. In short, 1 mL of extract was mixed with 5 mL of reactive reagent (50 g of vanillin and 4 mL of hydrochloric acid/in 100 mL distilled water) and the mixture incubated at 30°C for 20 min at ambient temperature, and the absorbance read at 500 nm. The amount of tannins was calculated from the calibration curve of tannic acid standard solutions, and

expressed as mg tannic acid /100g of plant material.

Antioxidant Activity

The scavenging capacity of radical 1,1-diphenyl-2-picrylhydrazyl (DPPH) was determined using the method described by **[16]**. 0.3 mL of solution of radical DPPH 10mM, 2.4 mL of ethanol at 99% and 0.3 mL of the sample extract were rigorously and quickly mixed. The scavenging capacity was evaluated by spectrophotometry at 517 nm. The trolox was used as positive control.

DPPH (%) = [(ODcontrol– ODassay)/ (ODinitial)] x 100

Ferric Iron Reducing Activity (FIRA)

The antioxidant potential of the different spice extracts was also evaluated by their ability to reduce iron (III) to iron (II) following the method of **[17]**. In this respect, 1 mL aliquot of each extract, dissolved in distilled water, was mixed with 2.5 mL of phosphate buffer (0.2 M, pH 6.6) and 2.5 mL of a 1% aqueous $K_3Fe(CN)_6$ solution and incubated for 30 min at 50°C. After this, 2.5 mL of 10 % TCA was added, and the mixture centrifuged for 10 min. 2.5 mL aliquot of the supernatant was mixed with 2.5 mL of distilled water and 0.5 mL of 0.1% aqueous $FeCl_3$, and the reducing activity was determined as ascorbic acid equivalents (mg ascorbic acid/g extract).

Determination of Free Radical-Scavenging Activity (FRSA): Free radical scavenging activity was determined by ABTS (2,2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid)) radical cation decolorization assay described by Re, Proteggente, Pannula, **[18]**. ABTS radical cation ($ABTS^+$) stock solution (7 mM) was prepared in a 2.45 mM potassium persulfate solution and kept in the dark at room temperature for 12–16 h before use. The radical was stable in this form for more than two days when stored in these conditions. For our study, the $ABTS^+$ solution was diluted with ethanol to an absorbance (ODinitial) of 0.70 (±0.02) at 734 nm and equilibrated at 30°C. A reagent blank reading was taken. After addition of 3.0 mL of diluted $ABTS^+$ solution to 30 µL of total phenol extracts, the absorbance reading (ODassay) was taken exactly 6 min after initial mixing. The results were corrected for dilution and expressed in mg trolox per 100 g dry weight (dw). The percentage of inhibition was calculated using the equation:

FRSA (%) = [(ODinitial – ODassay)/ (ODinitial)] x 100

Statistical Analysis

All the chemical analyses were done in triplicate. The results obtained were expressed as means ± standard deviation and also subjected to one way analysis of variance and Duncan multiple test range when there was a significant ($p < 0.05$) difference using the Statgraphics 3.0 **[19]** statistical software. Principal component

analysis was performed using the statistical package, Stat Box version 6.4 (Grimmer Logiciels, Paris) to group and classify the spices according to their phenols composition and antioxidant potential.

RESULTS AND DISCUSSION

Phenolic Compounds

Total Phenolics (TPC)

Table 1 shows the measured levels of total phenols using Folin-Ciocalteu method. Total phenols ranged from 280.11 ± 6.28 mg (White of Galmi) to 982.03 ± 5.57 mg (violet) per 100 g dry matter (DM) for the fresh varieties, 208.92 ± 6.02 mg (White of Galmi) to 948.42 ± 3.20 mg (violet) per 100 g DM for varieties dried by electrical ventilation and 312.42 ± 14, 12 mg (White of Galmi) to 852.75 ± 9.20 mg (violet of Galmi) per 100 g dry matter for varieties dried under sun. In general, the analysis of variance shows a significant decrease ($P \leq 0.05$) in total phenolic content of purple varieties (Violet of Galmi and Goudami) after drying, this decline was more pronounced with solar drying. In fact, during drying, the temperature favors decomposition (enzymatic and chemical) reactions in the food resulting by loss of some phenolic compounds by volatilization and thermal decomposition. This mechanism might be the main reason that could explain the decrease in total polyphenol content during drying, as suggested by **[20]** in his work on grain fruit drying. Moreover, with the variety White of Galmi, there is a significant decrease ($P \leq 0.05$) in total phenolic content during drying by ventilation. But a significant increase ($P \leq 0.05$) during the solar drying was observed. This increase could be due to the formation of phenolic compounds by the reactions of non-enzymatic browning (NEB) during drying. Indeed, the chemical composition of the plant and the drying temperature could be important factors contributing to the increase in total polyphenol obtained during drying **[20]**.

Flavonoids

The levels of flavonoids measured ranged from 67.67 ± 2.45 mg (White Galmi) to 358.60 ± 0.31 mg (violet) per 100 g DM for the fresh varieties **(Table 1)**. The varieties Violet of Galmi and Goudami were the richest in flavonoids and this could be linked to their strong coloration. Indeed, the color of certain fruits and vegetables is attributed to flavonoids and intensity of this coloration is strongly correlated with the flavonoid content **[21]**. Analysis of variance shows a significant decrease ($P \leq 0.05$) of the flavonoid content in all varieties after drying. This decline was more discernible during drying under the sun for violet of Galmi but was not significant for Goudami

($P > 0.05$). Similarly, in the variety White of Galmi, there is a significant decrease ($P \leq 0.05$) of the flavonoid content during drying and this decrease is more pronounced during drying by ventilation. The decrease in flavonoid content observed during drying could be explained by the degradation reactions of bioactive compounds that would have occurred during the drying process **[20]**.

Tannins

The amount of tannins determined by the method using vanillin varied significantly ($P \leq 0.05$) between varieties of onion bulbs. The values ranged from 13.28 ± 0.43 mg (Goudami) and 22.52 ± 0.50 mg (violet of Galmi) per 100 g DM **(Table 1)**. After drying, there is a decrease in tannin content in the varieties Goudami, Violet of Galmi dried under the sun and in the White of Galmi dried by ventilation. This decrease was not significant in the variety Goudami whatever the treatment. The temperature rise during drying can lead to a deterioration of tannins **[22]**. Similarly, hydrolysis and oxidation of tannins **[23]** that may occur during drying justify the decrease in tannin content observed in the onion powder. However, the increasing quantity of tannins found in varieties of white and violet of Galmi dried under the sun and by electrical ventilation respectively may be due to the hydrolysis of tannins complexed. In effect, the tannins come in two forms in foods: a free form and complexed form with other polymers. It should be noted that enzymes can still stay active during the drying and cause several reactions including the hydrolysis reactions **[22]**.

Vitamin C

Vitamin C is an antioxidant whose role is crucial in the fight against stress **[24]**. **Table 1** shows the levels of vitamin C samples of onion powdered. The values oscillated from 29.22 ± 13.77 mg (Goudami) to 45.07 ± 0.00 mg (violet of Galmi) per 100 g DM for fresh samples. Note that drying causes significant losses ($P \leq 0.05$) in vitamin C. But these are not significant according to the method of drying used. In fact, the observed losses are due to oxidation of vitamin C during drying, oxidation promoted by light, heat and the presence of salts **[25].** Similar results were obtained by **[26]** in his work done on the influence of drying conditions of *D. schimperiana*.

Table 1: Effect of Type of Drying on the Phenolic Compounds

Type of drying	Effect of Drying on the Quantity of Total Phenolic Compounds (mg/100 g DM)		
	Varieties of onion bulbs		
	White of Galmi	Goudami	Violet of Galmi
Fresh	280, 11 ± 6,28[b]	620,47 ± 9,64[b]	982,03 ± 5,57[c]
Ventilation	208,92 ± 6,02[a]	652,45 ± 8,31[b]	948,42 ± 3,20[b]
Solar	312,42 ± 14,12[c]	579,00 ± 13,48[a]	852,75 ± 9,20[a]
	Effect of drying on the flavonoid content (mg/100 g DM)		
	White of Galmi	Goudami	Violet of Galmi
Fresh	67,67 ± 2,45[c]	200,89 ± 5,64[b]	358,60 ± 2,17 [c]
Ventilation	12,86 ± 0,62[a]	41,51 ± 0,32[a]	63,84 ± 0,31[b]
Solar	20,26 ± 2,20[b]	39,34 ± 1,50[a]	51,44 ± 0,89[a]
	Effect of drying on the level of tannins (mg/100 g DM)		
	White of Galmi	Goudami	Violet of Galmi
Fresh	16,52 ± 0,57[b]	13,28 ± 0,43[a]	22,52 ± 0,50[b]
Ventilation	13,14 ± 0,21[a]	12,78 ± 2,71[a]	28,17 ± 0,65[c]
Solar	23,74 ± 0,65[c]	10,81 ± 1,04[a]	20,35 ± 0,41[a]
	Effect of drying on the level of vitamine C (mg/100 g DM)		
	White of Galmi	Goudami	Violet of Galmi
Fresh	38,11 ± 17,96[c]	29,22 ± 13,77[c]	45,07 ± 0,00[b]
Ventilation	4,87 ± 2,29[b, c]	10,07 ± 0,00[c]	14,55 ± 2,28[a]
Solar	3,26 ± 0,00[a]	6,22 ± 0 ,00[a]	12,39 ± 0,00[a]

Note: The values presented are averages of three determinations; values on the same column with the same alphabetical letters are not significantly different (P ≤ 0.05)

Table 2: Effect of Type of Drying on Total Reducing Power (mg de vit C/100 g DM)

Type of drying	Varieties of Onion Bulbs		
	White of Galmi (WG)	Goudami (G)	Violet of Galmi (VG)
Fresh	0,09 ± 0,00[a]	0,33 ± 0,01[a]	0,50 ± 0,01[b]
Ventilation	0,13 ± 0,00[b]	0,38 ± 0,00[b]	0,33 ± 0,00[a]
Solar	0,30 ± 0,00[c]	0,39 ± 0,00[b]	0,66 ± 0,00[c]

Note: The values presented are averages of three determinations; values on the same column with the same alphabetical letters are not significantly different (P ≤ 0.05)

Evaluation of Antioxidant Strength

Total Reducing Power (TRP)

It is the ability of an antioxidant to transfer electrons to Fe^{3+} ions. **Table 2** displays the total reducing power of various extracts from powdered samples of onions bulbs, the total reduction potential is considered to reflect the measurement of antioxidant capacity. From this table it appears that the reducing power of extracts of the varieties of onions ranged from 0.09 ± 0.00 mg to 0.50 ± 0.01 mg of vitamin C per 100 g DM. The Violet of Galmi (0.50 ± 0.01 mg), the Goudami (0.33 ± 0.01 mg) present the largest values and the White of Galmi (0.09 ± 0.00 mg) of the value lower. This property is due to the high number of hydroxyl groups they contain in their aromatic constituents **[27]**. Recent studies conducted in Cameroon **[12, 28]** have shown that certain herbs and spices also have a strong reducing power. Drying causes a significant increase ($P \leq 0.05$) in total reducing power, especially sun drying. This increase is seen more in varieties of white of Galmi and violet of Galmi. The same results were obtained by **[29]** in their work on the drying of garlic and could be explained by the appearance of aromatic compounds responsible for the strong smell of products derived from non-enzymatic browning and have antioxidant properties **[30]**.

Scavenging Activity

Scavenging activity was measured by two methods, one using the DPPH and the other ABTS. **Table 3** expresses the results of the radical-scavenging activity (ABTS) in mg Trolox equivalent samples of onion bulbs. From this table it appears that scavenging activity of methanol extracts of the varieties of onions ranged from 56.74 ± 0.24 mg (White of Galmi) to 416.43 ± 12.41 mg (violet of Galmi) of Trolox per 100 g DM.

After this drying process, there is a decrease of scavenging activity in varieties Goudami, and Violet of Galmi dried under the sun and the White of Galmi dried by electric ventilation. This decrease is not significant in the variety Goudami whatever the treatment. This decrease of scavenging activity can be explained by the sharp decrease in total phenolic compounds observed during drying. In effect, there is a very good correlation ($R^2 = 0.994$) between phenolic compounds and scavenging activity in the fresh samples **(Table 5)**. The work of **[31]** on potatoes led to similar results ($R^2 = 0.87$) and those of **[32]** on "oxisoup." The decrease in phenolic compounds during drying could be responsible for the decrease of the scavenging power.

Table 3: Effect of Type of Drying on Scavenging Activity Using (ABTS) (mg de Trolox/100 g DM) and (DPPH) (mg de trolox/100 g DM).

Type of drying	Varieties of onion bulbs		
	White of Galmi (WG)	Goudami (G)	Violet of Galmi (VG)
Effect of Drying on Scavenging Activity Using (ABTS)			
Fresh	56,74 ± 0,24[b]	266,18 ± 14,56[b]	416,43 ± 12,41[c]
Ventilation	49,99 ± 0,12[a]	75,80 ± 0,13[a]	347,94 ± 0,63[b]
Solar	68,05 ± 2,56[c]	70,01 ± 0,00[a]	322,18 ± 0,60[a]
Effect of Drying on Scavenging (DPPH) (mg de Trolox/100 g DM).			
Fresh	54,23 ± 4,43[b]	72,84 ±10,10 [b]	136,64 ± 19,96[b]
Ventilation	26,13 ± 4,58[a]	49,04 ± 0,63[a]	60,10 ± 1,15[a]
Solar	26,54 ± 4,80[a]	51,73 ± 2,00[a]	62,25 ± 1,45[a]

Note: The values presented are averages of three determinations; values on the same column with the same alphabetical letters are not significantly different (P ≤ 0.05)

Table 4: Correlation Between Antioxidant Activity and Phenolic Compounds

Variables	TPC	FL	TN	VITC	TRP	$ABTS^+$	DPPH*
TPC	1						
FL	0,539	1					
TN	0,457	0,177	1				
VITC	0,300	0,816	0,131	1			
TRP	0,778	0,317	0,238	-0,011	1		
$ABTS^+$	0,881	0,694	0,586	0,487	0,643	1	
DPPH*	0,712	0,945	0,248	0,798	0,482	0,780	1

Note: In bold are significant values at 5% level. TCP: Total phenolic compounds; FL : flavonoids ; TN : tannins ; VITC : vitamin C ; TRP : Total reducing power; $ABTS^+$: 2,2'-azino-bis (3-ethylbenzothiazoline-6- sulphonic acid) diammoniun salt radical; DPPH*: N,N-diphenyl-N'-picrylhydrazyl radical

Multivariate Analysis

The Principal Component Analysis (PCA) is one of the most used for multivariate analysis. This analysis was conducted for the purpose of the linkages between the elements analyzed: antioxidant potential and radical-scavenging activity of onion samples determined by different methods. **Table 4** shows the Pearson correlation that allowed better appreciation of the possible relationships between different variables. With this, it appears that the methods used to determine the antioxidant capacity correlated positively and significantly. There is a correlation between ABTS and TRP (R^2 = 0.643, P ≤ 0.05), DPPH and PRT (R^2 = 0.542, P ≤ 0.05). These results are consistent with those of **[12]** who have found a good correlation between the TRP and ABTS methods (R^2 = 0.93, P ≤ 0.05), DPPH and

TRP (R^2 = 0.89, P ≤ 0.05), as well as **[33]** that in their study, observed a correlation between the TRP and ABTS. This strong correlation is due to the fact that these methods have the same mechanism of action. It can also be observed clearly from this table a good correlation between the TRP assay methods, ABTS and total phenolic compounds of methanol extracts of onion samples (R^2 = 0.778 and R^2 = 0.881, P ≤ 0.05, respectively). This confirms the observations made by several researchers **[34, 35, 36]** by which total phenolic compounds play a very important antioxidant role. A good correlation is observed between flavonoids and total phenolics (R^2 = 0.539, P ≤ 0.05) which confirms the fact that flavonoids constitute one of the largest groups of total phenolic compounds **[37]**.

The PCA can also better visualize individuals (powdered samples of onions) on a shaft, which can be in the map reproduced in this plane axis, a sample relative to another. For this, samples presented with similar variables will be located very close together, unlike those who are different. **Figure 1** shows the mapping of samples of onions in terms of F1 and F2 axis which explains 82.65 % of the results. Axis F1 alone explains 61.65 % of the results expressed, and the axis F2 explains 21.00 %. On this map, we can observe that the samples of onions VGS (violet of Galmi dried in sun) and VGV (violet of Galmi dried in the electrical ventilation) are close; it could mean they have similar variables. This reconciliation is also observed for samples of onions Gs (Goudami dried in the sun), Gv (Goudami dried in the electric ventilation) and BGs (White of Galmi dried in the sun). On the other hand, figure 2 brings out the correlation between the different variables analyzed. We can note the proximity of the variables between TN, TRP, ABTS and TPC and between Vit. C, FL, and DPPH. This closely materializes their inter-correlation. Furthermore, these variables analyzed are strongly correlated with the F1 axis and explains 61.65 % of our results.

Table 5 and **Figures 4 and 5** were used to highlight the contribution of each sample on different axes (F1 and F2). Only samples with at least 11.11% of contribution of each axis are considered significant. However, it appears from this table that the samples BGV (94%), BGs (40.20%) and contribute more negatively to the construction of the F1 axis, in contrast to VGF samples (75.60%), VGV (33.20%) which are contributing positively. On the F2axis, the samples were BGF (62.10%) and Gf (58.80%) and contribute more negatively

when VGs (56.40%), Gs (32.40%) and Gv (32%) are in a positive way.

Table 5: Contribution of Onion Samples on the Main Axis.

	F1	F2	F3	F4	F5	F6	F7
WGf	**0,276**	**0,621**	**0,034**	**0,019**	**0,050**	**0,000**	**0,000**
Gf	**0,120**	**0,588**	**0,227**	**0,003**	**0,034**	**0,029**	**0,000**
VGf	**0,756**	**0,232**	**0,002**	**0,006**	**0,001**	**0,003**	**0,000**
WGs	**0,402**	**0,026**	**0,360**	**0,205**	**0,000**	**0,006**	**0,000**
Gs	**0,305**	**0,324**	**0,349**	**0,006**	**0,000**	**0,012**	**0,003**
VGs	**0,350**	**0,564**	**0,018**	**0,018**	**0,029**	**0,021**	**0,000**
WGv	**0,940**	**0,012**	**0,001**	**0,000**	**0,037**	**0,010**	**0,000**
Gv	**0,272**	**0,320**	**0,327**	**0,013**	**0,006**	**0,056**	**0,006**
VGv	**0,332**	**0,279**	**0,298**	**0,085**	**0,006**	**0,000**	**0,000**

Note : WG : White of Galmi ; VG : Violet of Galmi ; G : Goudami ; v : Ventilate ; s : Solar ; f : Fresh ; F : Axis.

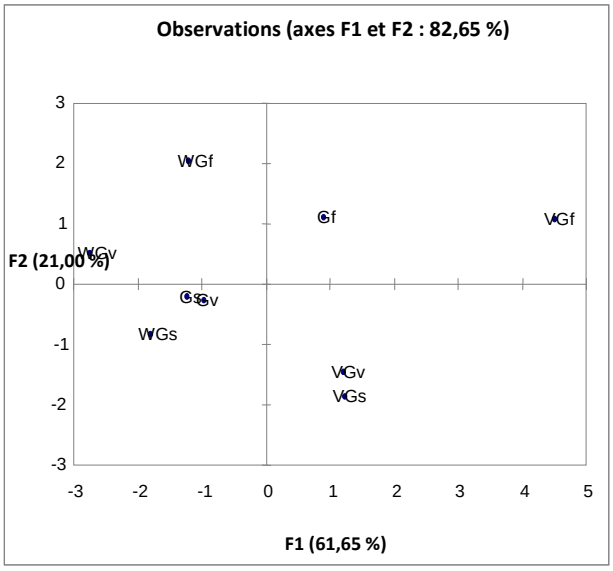

Figure 4: Two Dimensional Plots of Onion Bulb Samples Coordinates on Varimax Rotated F1xF2 Axes

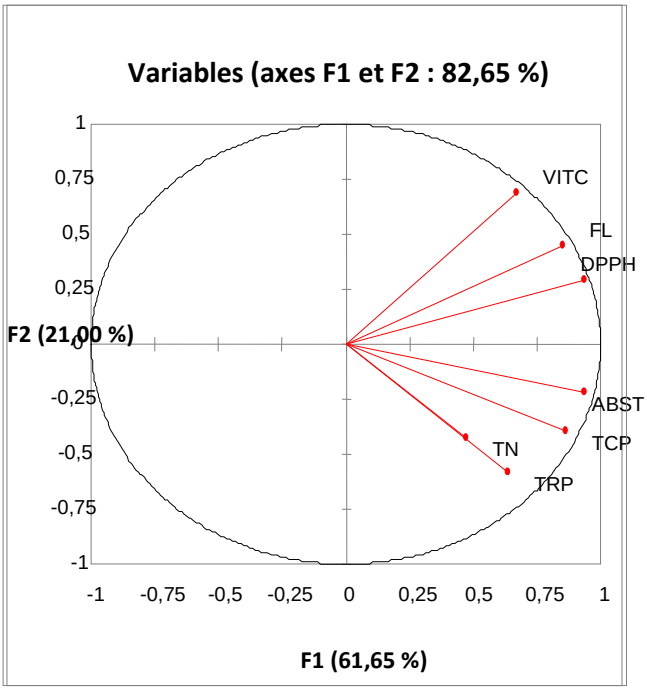

Figure 5: Correlation Circles of the Phenols and Antioxidant Variables on Varimax Rotated F1xF2 Plans

CONCLUSION

This study was aimed at evaluating the effect of drying on the antioxidant properties of three varieties of onion (*Allium cepa* L) grown in Maroua. It appears from this study that the antioxidant power varies from one variety of onion to another; White of Galmi showed the lowest power while Violet of Galmi showed the highest. We also noted that the drying of onion lowers its antioxidant *in vitro*, but the variety of Violet of Galmi better preserves the antioxidant activity after drying. However, despite the loss of certain bioactive compounds found during the drying, onion powder continues to have a significant antioxidant activity. As a result, onion powder would then be able to assist us in preventing the harmful effects of free radicals. Given these results, several efforts could be made in the popularization of cultivation of the onion Violet of Galmi which presented a strong antioxidant activity compared to the other two varieties of onions studied. Similarly, other studies need to be undertaken to complete this work and encourage the development of an efficient processing technology of onion drying in order to significantly reduce post-harvest losses.

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