Agriculture and Food Sciences Research
Vol. 5, No. 2, 73-78, 2018
ISSN(E) 2411-6653/ ISSN(P) 2518-0193
DOI: 10.20448/journal.512.2018.52.73.78

Influence of Agro-Ecological Areas on the Antioxidant Capacity of Onion Varieties Grown in Burkina Faso

Virginie Marie Dakéné[1]
Abdoulaye Sérémé[2]
Moumouni Koala[3]
Marius K. Somda[4]
Hagrétou Sawadogo – Lingani[5]
Alfred S. Traoré[6]


(✉ Corresponding Author)

[1]*National Laboratory of Public Health; 09 BP 24 Ouagadougou 09; Burkina Faso*
Email: virginieyougbar@yahoo.fr
[2]*Natural Substances Department / IRSAT / CNRST, 03 BP 7047 Ouagadougou 03; Burkina Faso*
[3]*Department of Medicine and Traditional Pharmacopoeia / IRSS / CNRST, 03 BP 7047 Ouagadougou 03; Burkina Faso*
[4]*Food Technology Department / IRSAT / CNRST, 03 BP 7047 Ouagadougou 03; Burkina Faso*
[5,6]*Department of Biochemistry-Microbiology; University Ouaga I Pr Joseph KI-ZERBO; 03 BP 7021 Burkina Faso*

Abstract

Colored onion bulb is an important source of antioxidants. Some ecological factors can significantly influence the content and quality of these substances. The aim of the present study is to determine the antioxidant and total polyphenol content of fresh bulbs of five (05) varieties of onion (*Galmi Violet*, *Damani Violet*, *Prema*, *Safari* and a *Local variety-LV*) grown in Burkina Faso, and to evaluate also the influence of agro-ecological parameters on the antioxidant content of the most cultivated variety (*Galmi violet*) of them. Samples of onion bulb for analysis were collected in the six agro-ecological areas of Burkina Faso under the same cultivation conditions. Antioxidant activities were evaluated using the method of *Ferric Reducing Antioxidant Power*. The evaluation of the total polyphenol contents was carried out using the *Folin-Ciocalteu method*. The results showed that antioxidant activities for the 5 varieties tested vary between 0.125 ± 0.001 and 0.149 ± 0.004 mg TE / g, and total polyphenol contents from 0.172 ± 0.011 to 0.272 ± 0.003 mg EAG/g. Results on the assessment of the effect of ecology on the antioxidant content of *Galmi violet* variety revealed significant variations in antioxidant content from 0.144 ± 0.002 to 0.155 ± 0.001 mg TE / g, and total polyphenols from 0.208 ± 0.014 to 0.292 ± 0.012 mg EAG / g depending on the ecological cultivation area.

Keywords: Agrarian, Cultivation.

Citation | Virginie Marie Dakéné; Abdoulaye Sérémé; Moumouni Koala; Marius K. Somda; Hagrétou Sawadogo – Lingani; Alfred S. Traoré (2018). Influence of Agro-Ecological Areas on the Antioxidant Capacity of Onion Varieties Grown in Burkina Faso. Agriculture and Food Sciences Research, 5(2): 73-78.
History:
Received: 12 October 2018
Revised: 21 November 2018
Accepted: 17 December 2018
Published: 7 January 2019

Contribution/Acknowledgement: All authors contributed to the conception and design of the study.
Funding: This research project was supported by a grant from the West Africa Agricultural Productivity Program/National Center of Specialization - Fruits and Vegetables (WAAPP / NCS-FV).
Competing Interests: The authors declare that they have no conflict of interests.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study was reported; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained.
Ethical: This study follows all ethical practices during writing.

Contents

1. Introduction

Air pollution, ionizing radiation, radioactive radiation (UV, X or ɣ) consequences of industrialization and urbanization, as well as tobacco and alcohol, are among the main risk factors responsible for diseases, related to oxidative stress. These diseases pose an increasingly serious public health problem [1]; [2]. Indeed, diseases related to oxidative stress are the increasingly important causes of disability and premature death in both developed and developing countries such as Burkina Faso. In 2001, they were responsible for about 60% of the 56.5 million deaths worldwide, and 46% of the global burden of morbidity [1]. The same source indicates that this morbidity rate will rise to 57% in 2020, and diseases that are linked to oxidative stress will be responsible for nearly 3/4 of deaths worldwide. In developing countries deaths from these diseases dominate in mortality statistics [3]. One of the main causes of these diseases is the action of free radicals, chemical molecules naturally produced in the body during different reactions of metabolism.

Antioxidants are chemical molecules that not only fight against free radicals, but also repair the damage they cause. They therefore play a leading role in the prevention of diseases caused by oxidative stress [4]; [5]; [6]. Synthetic antioxidants exist but are inaccessible to consumers because of their cost. In addition, at high doses, these synthetic antioxidants could become pro-oxidants potentially dangerous for health Defraigne and Pincemail [7]; Edeas [8]; Favier [9]. Pincemail, et al. [10] pointed out that many studies show that a high level of antioxidants obtained through a diet rich in fruits and vegetables can reduce safely the relative risk of mortality due to oxidative stress. Food and nutrition are therefore important factors in determining the prevention of oxidative stress related illnesses [3]. Several foods are used as natural sources of antioxidants, but their antioxidant abilities are not well known generally, hence the present investigation on onion (*Allium cepa* L.). Because of its composition, onion is a plant with many nutritional and antioxidant properties. Indeed, many studies attribute it properties to fight against certain diseases related to oxidative stress such as cancer, cardiovascular disease, diabetes, aging-related diseases [11]; [12]; [13]; [14]; [15]. Burkina Faso is one of the largest producers of onion in West Africa where it ranks fourth after Nigeria, Niger and Senegal [16]. Onion bulb ranks first among market gardening. It is a consumer product both in urban centers and in rural areas. In 2012 the production was 329319 tons, and this production continues to grow [16]. The onion bulb produced in Burkina Faso is exported to the countries of the sub-region, particularly in Côte d'Ivoire, Ghana, Togo and Benin [16]; [17]. Its use as a natural source of antioxidants could therefore allow populations, and particularly vulnerable ones such as children, pregnant women and the elderly, to prevent diseases related to oxidative stress. However, some factors such as culivation techniques, environmental conditions, have an impact on the biosynthesis of antioxidant compounds in plants [18]; [19]; [20]; [21]; [22].

The aim of the present study is to check antioxidant and total polyphenol content of five (05) varieties of onion bulb (*Galmi Violet*, *Damani Violet*, *Prema*, *Safari* and *LV*) grown in Burkina Faso, and to determine the influence of agro-ecological factors on the antioxidant content of *Galmi Violet*, the most cultivated variety.

2. Material and methods

2.1. Sampling

The study is focused on the following five varieties: *Galmi violet*, *Damani Violet*, *Prema*, *Safari* and a *LV*. Samples of each variety of onion bulb were collected in six regions of Burkina Faso: Mouhoun, High Basins, North, Central, West Central and East, for laboratory analyzes. Sampling was done randomly for each variety. Since the cultivation techniques are identical for the six areas, two (02) batches each consisting of a 50 kg bag of bulb were collected by variety. Varieties collected by region are presented in Table 1. A total of twenty (20) lots of 05 onion varieties were collected for this study (Table 1). The batches were kept at room temperature, in a ventilated place, away from solar, heat and light.

Table-1. Varieties collected and number of lots by region

Region	Number of lots	Varieties collected
Mouhoun	02	*Galmi Violet*
Central	02	*Galmi Violet*
West central	06	*Galmi Violet*, *Prema*, *LV*
East	04	*Damani Violet*, *Safari*
High Basins	02	*Galmi Violet*
North	04	*Galmi Violet*, *Safari*

Source: Field work data.

2.2. Methods of Analysis

The determination of the antioxidant activities and the total polyphenol contents on fresh extracts of onion bulb concerned all the five varieties. The evaluation of the effect of the agro-ecological areas on the concentration of antioxidants and total polyphenols is done on the *Galmi violet* variety only.

2.2.1. Sample Preparation and Extraction of Antioxidants

For each variety, three (3) bulbs from each batch are taken randomly. The outer peel (dried flake) were removed and then cut into pieces using a stainless steel knife and crushed using a porcelain mortar. Then, 2 grams of the fresh onion raw material was immediately weighed in a glass beaker and mixed with 3 ml of solvent consisting of a mixture: acetone, water, acetic acid (AWA) in the proportions of 70: 29.5: 0.5 (v / v). After homogenization with the vortex mixer, the mixture was macerated for 24 hours under cold conditions (4 °C.). After filtration using Whatman N° 1 filter paper, the filtrate was stored at 4 °C protected from light in amber flasks for further analysis. This extraction operation was repeated three times in succession in order to ensure the total extraction of the sample.

2.2.2. Evaluation of the Antioxidant Activity of the Varieties Collected

The FRAP method (Ferric ion Reducing Antioxidant Power) [23] was used to evaluate the antioxidant activity of the collected samples. The principle is to evaluate the effectiveness of an antioxidant by its ability to reduce iron (transition from ferric form, Fe^{3+} to ferrous form, Fe^{2+}). The oxidant used for this purpose is a ferric salt, Fe (III) $(TPTZ)_2Cl_3$ (TPTZ = 2,4,6-tripyridyl-s-triazine) which goes from colorless to intense blue when reduced. The absorbance of the solution is measured at 595 nm [24]. The procedure was as follows: a volume of 20 µl of extract was introduced into 30 µl of distilled water and then 200 µl of FRAP solution which is prepared by mixing 1 ml of TPTZ, 10 ml of a buffer solution of acetate of sodium (pH = 3.6) and 1ml of Fe (III), H_2O solution. A blank consisting solely of 250 µl of the extraction solvent was also prepared. The whole was incubated at 37°C for 10 minutes after homogenization. Absorbance was then read at 595 nm with a spectrophotometer (MP96, SAFAS) for each sample. A calibration curve was established using *Trolox* as a reference (antioxidant). The results were determined from the equation ($Y = 28.67 x + 0.066$, $R^2 = 0.999$) of the standard curve and were expressed in mg of *Trolox* Equivalent (TE) per gram of fresh plant material. An average of the contents for each variety was calculated.

2.2.3. Evaluation of the Phenolic Compounds Content of the Varieties Collected

The evaluation of the content of phenolic compounds was made using the method of Folin-Ciocalteu (R-FC) [25] whose principle is to react on the sample (the extract), the reagent of Folin-Ciocalteu (diluted 10 times) and absorbance measured at 765 nm. The procedure was as follows: a volume of 60 µl of extract was mixed with 60 µl of the Folin-Ciocalteu reagent diluted 10 times. The mixture was left at room temperature for 8 minutes to allow complete reaction of the reagent on the oxidizable compounds or on the phenolates. Then, 120 µl of 7.5% (w / v) aqueous sodium carbonate solution (Na_2CO_3) was added to neutralize the residual reagent. After 30 minutes of incubation at 37 °C, the absorbance of the extracts was measured at 765 nm with the MP96 spectrophotometer, SAFAS (96 well quartz microplates). A blank is made with 60 µl of R-FC and 120 µl of sodium carbonate solution. A calibration curve was established using gallic acid as a reference. The results were determined using the equation ($Y = 46.41x + 0.063$, $R^2 = 0.998$) of the calibration curve. They were expressed as mg Gallic Acid Equivalent (GAS) per gram of fresh plant material. All measurements were made in triplicate.

2.2.4. Statistical Analysis of the Results

The statistical analysis of the results was carried out using the Genstat version 14 software. The comparison between the varieties was also performed by the multivariate analysis of Genstat version 14.

3. Results

3.1. Antioxidant Activities (AAO) of Onion Bulb Varieties Collected in the 6 Production Areas

The results of the antioxidant activity of the extracts of the 05 varieties of onion bulb collected in the Mouhoun, High Basins, North, Central, West Central and East regions are presented in the Table 2. Significant differences ($P < 0.05$) between the antioxidant activities (AAO) of different varieties of fresh bulb are observed. These contents range from 0.125 ± 0.001 to 0.149 ± 0.004 mg TE / g fresh material. The varieties with the highest levels of antioxidants are *LV*, *Galmi Violet* and *Damani Violet*, with contents respectively 0.149 ± 0.004; 0.147 ± 0.004 and 0.139 ± 0.000 mg TE / g fresh material. However, it is noted that the levels are substantially equivalent for the *Galmi violet* (0.147 ± 0.004 mg TE / g fresh material) and *LV* (0.149 ± 0.004 mg TE / g fresh material) varieties. *Prema* and *Safari* have lower levels (0.125 ± 0.001 and 0.132 ± 0.002 mg TE / g fresh material).

Table-2. Antioxidant Activity of the 5 varieties of onion bulb collected

Variety	Antioxidant Activity (AAO) (mg TE / g MF)
Galmi Violet	0,147 ± 0,004^{c}
LV	0,149 ± 0,004^{c}
Damani Violet	0,139 ± 0,000^{b}
Safari	0,132 ± 0,002^{ab}
Prema	0,125 ± 0,001^{a}

Note: All assay results are expressed as mean contents ± standard deviation. The averages affected by the same letter are not significantly different.

3.2. Total Polyphenol (TPP) Content of Onion Bulb Collected in Production Areas

The results of the total polyphenol contents of the extracts of the 05 varieties of onion bulb collected in the Mouhoun, High Basins, North, Central, West Central and East regions are shown in Table 3. The results show a significant variation ($P < 0.05$) from one variety to another. The contents range from 0.220 ± 0.013 to 0.272 ± 0.003 mg EAG / g fresh material for the five varieties. The highest levels are obtained with *Galmi Violet*, *Prema* and *Damani Violet* varieties, with respectively 0.272 ± 0.003; 0,270 ± 0,014 and 0,254 ± 0,017 mg of EAG / g of fresh material. The *Safari* variety has the lowest content (0.172 ± 0.011 mg EAG / g fresh material). However, *Galmi Violet* and the *Prema* have almost the same level of polyphenol.

Table-3. Total Polyphenol Content of the 5 onion bulb collected

Variety	Total polyphenol (TPP) content (mg EAG / g MF)
Galmi Violet	0,272 ± 0,003^{c}
LV	0,220 ± 0,013^{b}
Damani Violet	0,254 ± 0,017^{bc}
Safari	0,172 ± 0,011^{a}
Prema	0,270 ± 0,014^{c}

Note: All assay results are expressed as mean contents ± standard deviation. The averages affected by the same letter are not significantly different.

No significant correlation was observed between AAO and TPP for the different varieties (R^2 = 0.069) (Figure 1)

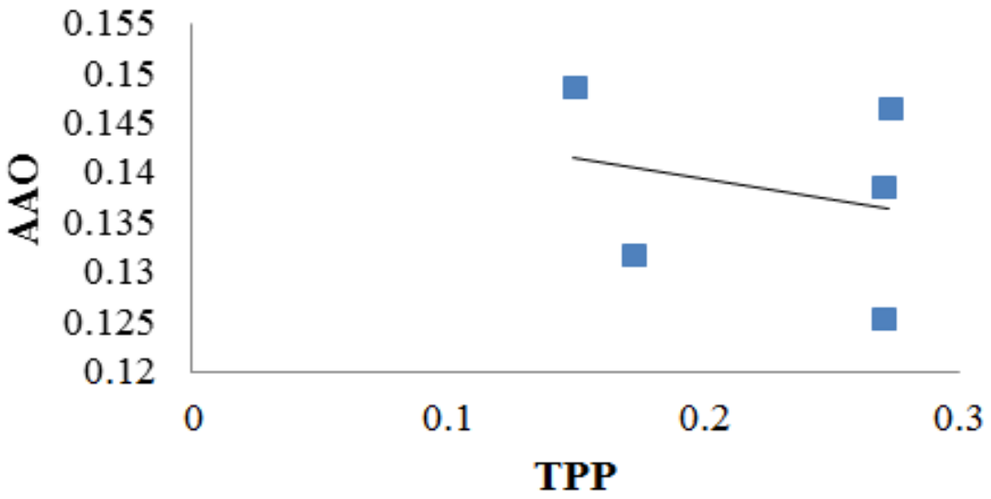

Figure-1. Correlation between AAO and TPP of 5 varieties of onion collected in the production areas

3.3. Effect of the Agro-Ecological Areas of Burkina Faso on the Antioxidant and Polyphenol Contents of Galmi Violet Variety

The results of the effect of the agro-ecological areas in Burkina Faso on the antioxidant and total polyphenol contents of the variety *Galmi violet* are presented in Table 4. Two batches of fresh onion bulb were collected by region, the results are an average of the data obtained from the two lots. These results show that, there is a significant variation ($P < 0.05$) of antioxidants and polyphenols contents from one ecological region to another. For AAO and TPP these levels respectively range from 0.144 ± 0.002 to 0.155 ± 0.001 mg TE / g fresh material, and from 0.208 ± 0.014 to 0.292 ± 0.012 mg EAG / g fresh material (Table 4).

The highest levels of antioxidants are obtained with the Mouhoun samples (0.155 ± 0.001 mg TE / g fresh material). The North (0.152 ± 0.003 mg TE / g MF), West Central (0.152 ± 0.006 mg TE / g MF) and High Basins (0.147 ± 0.004 mg TE / g MF) have equivalent levels. Central samples show the lowest levels (0.144 ± 0.002 mg TE / g fresh material).

The highest levels of total polyphenols are obtained with North Region (0.292 ± 0.012 mg EAG / g fresh material), Central Region (0.289 mg EAG / g fresh material), West Central Region (0.280 ± 0.002mg EAG/g fresh matter) and Mouhoun Region (0.265±0.006 mg EAG / g of fresh material). These 4 regions have substantially equal contents. High Basins presented the lowest levels (0.208 ± 0.002 mg of EAG / g of fresh material).

Table-4. Antioxidant and total polyphenol content of *Galmi violet* by locality

Region	AAO (mg of TE / g of fresh material)	TPP (mg of EAG / g of fresh material)
Central	0,144 ± 0,002^{a}	0,289 ± 0,000^{b}
West Central	0,152 ± 0,006^{ab}	0,280 ± 0,002^{b}
North	0,152 ± 0,003^{ab}	0,292 ± 0,012^{b}
Mouhoun	0,155 ± 0,001^{b}	0,265 ± 0,006^{b}
High Basins	0,147 ± 0,004^{ab}	0,208 ± 0,014^{a}

Note: All assay results are expressed as mean contents ± standard deviation. The averages affected by the same letter are not significantly different.

4. Discussion

4.1. Antioxidant Activities (AAO) and Total Polyphenol Content (TPP) of Onion Varieties Collected in Production Areas: Mouhoun, High Basins, North, Central, West Central and East

The results obtained are in agreement with those of the literature concerning the variation of the concentrations of antioxidants and total polyphenols between varieties of the same species as pointed out by Causse [26] whose researches have shown the existence of a wide range of variation of the concentrations of antioxidants and total polyphenols between varieties of the same species of fruits and vegetables, ranging from single to double. In fact, Jeffery, et al. [20] showed, by comparing the β-carotene content of 50 varieties of broccoli, which could be 6 times greater from one variety to another. Kurilich, et al. [27] showed a 5 times increase in total antioxidant capacity between eight (08) varieties of the same plant according to ecological areas.

Several factors would be responsible for the variation in antioxidant levels between varieties of the same species. Indeed, as Causse [26]. Benbrook [28] these variations are physiological, genetical, agronomical (cultivation techniques, production method), or environmental (radiation, temperature, region of culture). To our knowledge very little work has been done on the antioxidants and polyphenols of onion bulb varieties grown in Burkina Faso.

The variations observed in the case of onion bulb varieties of our research, could be explained by the combined effect of these factors. One could thus think that the equivalence of the levels observed between the varieties of *Galmi violet* and the *LV* for the antioxidants, and between the varieties of *Galmi violet* and *Prema* for the polyphenols, would be the fact of genetic factors, since the cultivation conditions (agronomic and environmental) were the same for these varieties. R^2 = 0.069 indicating that only 06.9% of the antioxidant capacity of the extracts is due to the contribution of the phenolic compounds. In other words, the richest extract of phenolic compounds is not necessarily the one which has the highest antioxidant activity. These results clearly show that polyphenols are not the only compounds responsible for the antioxidant activity of onion bulb extracts. Similar results have been

previously reported by other authors. Indeed, Dabiré [29]; Psarra, et al. [30] showed a weak correlation between antioxidant power and phenol content by working on extracts of *Tridax procumbens* species and wine samples. Carotenoids are also compounds with very high antioxidant activity contained in the onion. Koala, et al. [31] showed a good correlation between total carotenoid levels and the antioxidant activities of eight (08) orange fleshed sweet potato varieties. We could therefore think that carotenoids would be the compounds that would contribute, to a large extent, to the antioxidant activities of the onion bulb varieties collected.

4.2. Effect of the Agro-Ecological Areas of Burkina Faso on the Antioxidant and Polyphenol Contents of Galmi Violet Variety

The results of the effect of the agro-ecological areas of Burkina Faso on the levels of antioxidants and total polyphenols of *Galmi violet* variety, show that the contents of these compounds vary according to the agro-ecological areas, especially between Central, Mouhoun, and the other 3 regions (West Central, North and High Basins) for antioxidants, and between the High Basins and the other 4 regions (West Central, North, Central, Mouhoun) for polyphenols. This shows that the areas have an influence on the concentration of these compounds in onion bulb grown in Burkina Faso. Similar results have been observed by other authors. Indeed, as pointed out by Mauget [32] important differences in polyphenol and carotenoid contents are observed for the same variety of fruit or vegetable grown in different geographical areas. This has been confirmed by Koala, et al. [31] which showed a 30% variation in polyphenol levels as a function of agro-ecological areas, working on orange-fleshed sweet potato (OFSP). As Dragovic-Uzelac, et al. [19] pointed out, that, without climatic characterization of the region, it is difficult to attribute these variations to any factor of the air or edaphic environment. The nature of the soils in the areas concerned is practically identical because the type of dominant soils in these areas is ferruginous soils, but the morphological characteristics (structure, texture, depth, thickness, color, porosity, etc.) and the analytical characteristics differ from an area to another BUNASOLS (National Office of Soils) [33]; BUNASOLS [34]; BUNASOLS (National Soil Bureau) [35]; BUNASOLS (National Soil Bureau) [36]. Schreiner [22] has shown that in some vegetables, radiation and temperature play a more important role than water or fertilizer. Variations in antioxidant and polyphenol levels from one area to another for the same variety of onion could therefore be explained by the effect of these factors, and the morphological and chemical composition differences observed at the soil level. The equivalence of concentrations noticed between the areas of West Central, North and High Basins, for the antioxidant content, on one hand, and West Central, North, Central and Mouhoun for the content of polyphenols in other hand, could be explained by the existence in these areas of similar climatic and / or edaphic conditions.

5. Conclusion

The results of this work show that onion bulb varieties cultivated in Burkina Faso are rich in antioxidants, and concentrations vary from one agro-ecological area to another. The onion bulb could therefore be used as natural sources of antioxidants, and could thus contribute to the prevention of oxidative stress related diseases which today constitute a real public health problem in Burkina Faso and around the world. This onion bulb rich in antioxidant and others micronutrients makes it a vegetable that could help improve the nutritional status of vulnerable groups such as children, pregnant women and the elderly. However, for the future it is necessary that much further research studies based on the precise determination of the influence of the individual parameters of the ecological areas on the antioxidant content of the bulbous onion be carried out. This could lead to a better understanding of the impact of these parameters on the antioxidant concentration of onion bulbs and consequently to optimize the antioxidant biosynthesis of the bulbous onion produced in Burkina Faso. Other studies could be focused on the determination of the carotenoids level in the bulb in order to determine the existence or not of a correlation between AAO and total carotenoid content (TCT). This will make it possible to know the contribution of these compounds to the antioxidant activity of the onion bulb grown in Burkina Faso, and consequently to optimize their biosynthesis within the plant.

References

[1] WHO (World Health Organization), "Diet, nutrition and chronic disease prevention," Technical Report Series No. 9162003.

[2] I. Young and J. Woodside, "Antioxidants in health and disease," *Journal of Clinical Pathology*, vol. 54, pp. 176-186, 2001.

[3] WHO (World Health Organization), "Reducing risks and promoting healthy living," World Health Report. Geneva Switzerland2002.

[4] M. N. Diaz, B. Frei, J. A. Vita, and J. F. Keaney Jr, "Antioxidants and atherosclerotic heart disease," *New England Journal of Medicine*, vol. 337, pp. 408-416, 1997.Available at: https://doi.org/10.1056/nejm199708073370607.

[5] S. C. Renaud, R. Guéguen, and H. J. D. Schenker, "Alcohol and mortality in middle-age men from Eastern France," *Epidemiology*, vol. 9, pp. 184-188, 1998.Available at: https://doi.org/10.1097/00001648-199803000-00014.

[6] J. K. Willcox, S. L. Ash, and G. L. Catignani, "Antioxidants and prevention of chronic disease," *Critical Reviews in Food Science and Nutrition*, vol. 44, pp. 275-295, 2004.

[7] J. O. Defraigne and J. Pincemail, "Oxidative stress and antioxidants: Myths and realities," *Medical Journal of Liège*, vol. 63, pp. 10-19, 2008.

[8] M. Edeas, "Anti-oxidants, controversies and perspectives: How to explain the failure of clinical studies using antioxidants," *Médecine & Nutrition*, vol. 46, pp. 19-29, 2010.

[9] A. Favier, "Oxidative stress: Conceptual and experimental interest in understanding the mechanisms of diseases and therapeutic potential," *Journal of Chemical News, France*, pp. 108-115, 2003.

[10] J. Pincemail, F. Degrune, S. Voussure, C. Malherbe, N. Paquot, and J.-O. Defraigne, "Effect of a diet rich in fruits and vegetables on plasma levels of antioxidants and markers of oxidative damage," *Clinical Nutrition and Metabolism*, vol. 21, pp. 66-75, 2007.

[11] K. T. Augusti, "Therapeutic and medicinal values of onions and garlic," *Onions and Allied Crops*, vol. 3, pp. 93-108, 1990.

[12] F. Bianchini and H. Vainio, "Allium vegetables and organosulfur compounds: Do they help prevent cancer?," *Environmental Health Perspectives*, vol. 109, p. 893, 2001.Available at: https://doi.org/10.1289/ehp.01109893.

[13] N. Mégroz and A. Baumgartner, "The onion, good to taste and the eye," *A Loupe No. 2*, pp. 1-4, 2000.

[14] World Cancer Research Fund, *Food, Nutrition and the Prevention of Cancer: A Global Perspective*. Washington, DC: American Institute for Cancer Research, 1997.

[15] W. C. You, J. Y. Li, L. Zhang, M. L. Jin, Y. S. Chang, MA, J. L. Kai, and F. PAN, "Etiology and prevention of gastric cancer: A population study in a high risk area of China," *Chinese Journal of Digestive Diseases*, vol. 6, pp. 149-154, 2005.Available at: https://doi.org/10.1111/j.1443-9573.2005.00222.xw.

[16] PAFASP (Agro Sylvo Pastoral Support Program), "Onion. Bulletin of the Ministry of Agriculture of Burkina Faso," p. 2, 2014.
[17] APEX (Agency for the Promotion of Exports of Burkina), "Products: The Burkina onion," *Newsletter, November 19*, p. 25, 2014.
[18] O. Daniel, M. S. Meier, J. Schlatter, and P. Frischknecht, "Selected phenolic compounds in cultivated plants: Ecologic functions, health implications, and modulation by pesticides," *Environmental Health Perspectives*, vol. 107, pp. 109-114, 1999.Available at: https://doi.org/10.2307/3434477.
[19] V. Dragovic-Uzelac, B. Levaj, V. Mrkic, D. Bursac, and M. Boras, "The content of polyphenols and carotenoids in three apricot cultivars depending on stage of maturity and geographical region," *Food Chemistry*, vol. 102, pp. 966-975, 2007.Available at: https://doi.org/10.1016/j.foodchem.2006.04.001.
[20] E. Jeffery, A. Brown, A. Kurilich, A. Keck, N. Matusheski, B. Klein, and J. Juvik, "Variation in content of bioactive components in broccoli," *Journal of Food Composition and Analysis*, vol. 16, pp. 323-330, 2003.Available at: https://doi.org/10.1016/s0889-1575(03)00045-0.
[21] Z. Premuzic, A. Garate, and I. Bonilla, "Production of lettuce under different fertilization treatments, yield and quality," *Acta Horticulturae*, pp. 65-72, 2002.Available at: https://doi.org/10.17660/actahortic.2002.571.6.
[22] M. Schreiner, "Vegetable crop management strategies to increase the quantity of phytochemicals," *European Journal of Nutrition*, vol. 44, pp. 85-94, 2005.Available at: https://doi.org/10.1007/s00394-004-0498-7.
[23] I. F. Benzie and J. J. Strain, "The ferric reducing ability of plasma (FRAP) as a measure of "antioxidant power": The FRAP assay," *Analytical Biochemistry*, vol. 239, pp. 70-76, 1996.Available at: https://doi.org/10.1006/abio.1996.0292.
[24] R. L. Prior, X. Wu, and K. Schaich, "Standardized methods for the determination of antioxidant capacity and phenolics in foods and dietary supplements," *Journal of Agricultural and Food Chemistry*, vol. 53, pp. 4290-4302, 2005.Available at: https://doi.org/10.1021/jf0502698.
[25] V. L. Singleton and J. A. Rossi, "Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents," *American Journal of Enology and Viticulture*, vol. 16, pp. 144-158, 1965.
[26] M. Causse, "The sources of variability of the nutritional qualities of fruits and vegetables. Sources of biological variation of physiological and genetic order. In: Fruits and vegetables in food, Issues and determinants of consumption," Report of Collective Expertise, INRA2007.
[27] A. C. Kurilich, E. H. Jeffery, J. A. Juvik, M. A. Wallig, and B. P. Klein, "Antioxidant capacity of different broccoli (Brassica Oleracea) genotypes using the oxygen radical absorbance capacity (ORAC) assay," *Journal of Agricultural and Food Chemistry*, vol. 50, pp. 5053-5057, 2002.Available at: https://doi.org/10.1021/jf025535l.
[28] C. Benbrook, *Increasing the antioxidant content of foods through organic agriculture and food processing: State of the science report*. Washington, DC: The Organic Center for Education and Promotion Inc, 2005.
[29] M. C. Dabiré, "Chemical composition and antioxidant activities of essential oils of some aromatic plants of Burkina Faso," PhD Thesis. University of Ouagadougou, 2011.
[30] E. Psarra, D. P. Makris, S. Kallithraka, and P. Kefalas, "Evaluation of the antiradical and reducing properties of selected Greek white wines: Correlation with polyphenolic composition," *Journal of the Science of Food and Agriculture*, vol. 82, pp. 1014-1020, 2002.Available at: https://doi.org/10.1002/jsfa.1124.
[31] M. Koala, A. Hema, K. Somé, E. Palé, A. Sérémé, J. Belem, and M. Nacro, "Evaluation of eight orange fleshed sweetpotato (OFSP) varieties for their total antioxidant, total carotenoid and polyphenolic contents," *Journal of Natural Sciences Research*, vol. 3, pp. 67-72, 2013.
[32] J. C. Mauget, "The sources of variability of the nutritional qualities of fruits and vegetables; sources of biological variations of agronomic and environmental order In: Fruits and vegetables in food, Issues and determinants of consumption," Report of Collective Expertise. INRA2007.
[33] BUNASOLS (National Office of Soils), "Morpho-pedological study of the provinces of Houet and Tuy. Scale 1/5 500 000," Technical Report No. 126. Burkina Faso2002.
[34] N. S. B. BUNASOLS, "Morpho-soil study of West Central Province. Scale 1/100 000," Technical Report No. 124. Burkina Faso2003a.
[35] BUNASOLS (National Soil Bureau), "Morpho-pedological study of the provinces of Kossi and Banwa. Scale 1/100 000," Technical Report No. 130. Burkina Faso2003b.
[36] BUNASOLS (National Soil Bureau), "Morpho-pedological study of provinces of Yatenga, Loroum and Zondoma provinces. Scale 1/100 000," Technical Report No. 122. Burkina Faso2004.