DOI: 10.2478/agr-2024-0001

THE ANNALS OF "VALAHIA" UNIVERSITY OF TARGOVISTE

PHYTOCHEMICAL STUDY OF THE THREE MAIN ONION VARIETIES (ALLIUM CEPA L.) GROWN IN ALGERIA

Fatima Zohra El Kadi*[1], Hamza Belkhodja[2], Fatima Zohra Labbaci[3], Houaria Lebga[1], Manel Tefiani[1], Farah Snouci[1]

[1]Laboratory of Molecular Microbiology Health and Proteomics, Biology Department, Faculty of Natural Sciences and Life, Djillali Liabés University of Sidi-Bel-Abbés, Algeria
[2]Laboratory of Bioconversion, Microbiology Engineering and Health Safety, Department of Biology, Faculty of Nature and Life Sciences, University of Mustapha Stambouli, Mascara, Algeria
[3]Department of Biology, Faculty of Nature and Life Sciences, University of Mustapha Stambouli, Mascara, Algeria
*Corresponding author e-mail address: elkadifatimazohra@yahoo.fr

Abstract

Three species of Allium cepa (red, purple, yellow) were evaluated for their secondary metabolite content, free radical scavenging activity (DPPH), and ferric reducing ability (FRAP). Our findings confirm that the dry matter content in all varieties ranged from 12.3% to 18.1%, rendering them suitable for extended storage. The ethanolic extract of red onion (EERO) displayed the highest yield (3.86%). Similarly, the levels of total phenols (TPC), total flavonoid content (TFC), hydroxycinnamic acid (HTC), and cysteine-containing peptide (CTC) varied between 0.14 and 0.27 mg/g GAE, 0.20 and 0.29 mg/g QE, 0.25 and 0.29 mg/g GAE, and 0.015 and 0.102 mg CE/g DW, respectively." Furthermore, ethanolic extract of yellow onion (EEYO) demonstrated a significant iron reduction capacity (0.75 ± 0.06 mM Fe2+) and an IC50 of 0.159 ± 0.18 mg/ml, indicating enhanced antioxidant potential.

Keywords: Allium Cepa L – variety – secondary metabolites – DPPH - FRAP

1. INTRODUCTION

Originating in Central Asia, the onion (Allium cepa L.) is cultivated as an agricultural crop for its foliage and bulbs (Pitrat & Foury [1]). It is a fundamental ingredient in recipes worldwide (Mégroz & Baumgartner [2]). The bulb, typically spherical or pear-shaped, with a wide array of features, serves as a nutrient reserve organ supporting the vegetative propagation of the species (Bhattacharjee et al. [3]). The major onion bulb producers in the western region of Africa encompass Niger, Nigeria, Senegal, and Burkina Faso (Schmelzer & Gurib-Fakim [4]). Allium cepa bulbs are a well-planted variety and an essential component of many African condiments and sauces. It's one of the world's most prized veggies.

Nutritionally, it provides all sorts of vitamins (B vitamins, vitamin C, provitamin A), inorganic salts (potassium, sodium, zinc, iron, phosphorus, selenium, magnesium, manganese, calcium), fats, proteids, carboids, essential oils, organic acids, fibers (Ciqual [5]). Therapeutically, multiple studies have revealed that systematic intake of fresh onions influences blood coagulation, protects against serious metabolic health problems (hypocholesterolemic, hypolipidemic, antithrombic effects), colorectal, stomach and prostate cancers (Bianchini & Vainio; You & Li; Graf et al. [6-8]).

The preventive effect relies on organosulfur compounds (thiosulfinates), taht impede carcinogenic effects. (Corzo-Martínez et al. [9]). In this context, our research focuses on assessing the antioxidant properties through Ferric Reducing Antioxidant Power and 2,2-diphényl-1-picrylhydrazyle tests, alongside quantifying secondary metabolites in three various cultivars (red, purple and yellow) widely cultivated in Algeria -Sidi Bel Abbès-.

2. MATERIALS AND METHODS

Biological material

Three Allium cepa varieties - red (Rd), yellow (Ylw), and violet (Prl) - were selected. Freshly harvested bulbs, uniform and flawless, were stored at 4ºC before analysis. In the lab, bulbs were cleaned, peeled, diced, and oven-dried (Ecocell) at 40°C for 4 days. Subsequently, they were ground using an electric grinder (IKA), and the powder was collected after sieving.

Non-biological materials

The Folin-Ciocalteu reagent (99.8% purity), quercetin (99%), ascorbic acid (99%) and DPPH (92%) are sourced by Sigma Chemical Co (St. Louis, MO, USA), while the high-purity chemicals (>98%) are by Merck (Darmstadt, Germany)".

Physical and chemical analyses

Determination of dry matter

5gr of onion slices were weighed in baskets before and after oven drying at 105°C overnight (16-18 h).

The overall solid content was calculated by subtracting the water content.

Ash content

For ash determination, 5 g of onion slices were calcined in a muffle furnace at 550°C for 30 minutes.

Acidity

Thirty milliliters of 95% ethanol were mixed with five grams of ground onion, and the combination was agitated at 25°C for an hour. Subsequently, it was centrifuged for five minutes at 3500 rpm. For qualitative

phytochemical screening, 20 milliliters of the resulting supernatant were titrated with 0.1N NaOH, employing a color indicator (Trease and Evans, 1987 [10]).

Phytochemical screening (qualitative)

To extract, 5 grams of each sample powder were boiled in 100 ml of water. After a 15-minute, the suspension was filtered to obtain 100 cc of filtrate (Trease & Evans [10]).

Hydrolysable tannins test

5 ml of 5% infusion from each sample was placed in a glass container, followed by the addition of 1 ml of 1% $FeCl_3$. The emergence of a greenish or blue-black color indicates reactivity.

Condensed tannins test

To assess condensed tannins, 1 ml concentrated hydrochloric acid was mixed with 5 ml infusion of each sample and boiled for 10 minutes. The presence of a red precipitate, soluble in amyl alcohol, is a sign of responsiveness.

Anthocyanins test

Ammonium hydroxide (NH4OH) and sulfuric acid (5 ml each) were added to 5 ml of infusion of each sample. The coloration is enhanced by acidity when anthocyanins are present, and in a basic medium, the coloration changes to purplish blue.

Free quinones test

Add 0.1 milliliter of 1% NaOH to 1 milliliter of extract from all of the samples. There are free quinones exist when the color turns yellow, red, or purple.

Anthraquinone

To 1ml of extract of each sample, 1ml of ammonia (NH_4OH 10%) is added. After shaking, the purple coloration indicates their presences.

Saponosides

Samples (1%) were decocted by boiling 1 g of powder in 100 ml water for 15 minutes. The filtered suspension (1-10 ml) was added incrementally to ten test tubes filled with water. The tubes were vigorously shaken horizontally for 15 seconds, and foam height was measured after 15 minutes. For each tube, the foam height was evaluated.

Quantification of different compounds

Producing the alcohol-based extract

10 g onion powder of each species was soaked in ethanol and stirred for 24 h at ambient conditions (Majhenic et al. [11]). The solution was treated on evaporation equipment (Heidolph instruments). The extract was then dried in an oven: the three extracts resulting EERO: ethanolic extract of red onion; EEYO: ethanolic extract of yellow onion; EEPO: ethanolic extract of purple onion, these extracts were skept at 4°C until required.

Total polyphenols content (TPC)

0.2 ml of each extract was added to a solution consisting of 1 ml diluted Folin-Ciocalteu reagent and 0.8 ml 7.5% Na_2CO_3, according to Singleton et al. [12] process.

The reading was taken at 765 nm with Gallic Acid as reference. Values were reported in milligrams of gallic acid equivalents (GAE) per gram of dry extract, calculated from the equation of the calibration curve ($y = 46.41 x + 0.063$; $R2= 0.988$).

Total flavonoids content (TFC)

The AlCl3 colorimetric method involves diluting 0.5 ml of each extract in 2 ml of distilled water, then successively adding 0.15 ml of 5% NaNO2, 0.15 ml of 10% AlCl3 and 2 ml of 4% NaOH. The volume was adjusted to 5 ml with distilled water. Absorbance at 510 nm was read after 15 minutes of incubation (Kanazawa et al. [13]). Quercitrin served as the reference for the calibration curve. Results, calculated using the curve's equation ($y = 46.41 x + 0.063$; $R2= 0.988$), were expressed as mg quercitrin equivalent per gram of dry extract (mg QE/g DE).

Hydrolysable tannins content (HTC)

For Hydrolysable Tannins Content (HTC) involved mixing tannin extract with FeCl3, creating a red-purple complex via Fe3+ ion interaction. A solution containing FeCl3 (0.01M) and HCl (0.001M) (v/v) was combined with each extract. Absorbance was read at 660 nm after 15 seconds (Mole & Waterman [14]). HTC calculation

$$HT\% = OD.\frac{M.V}{Emoles.SW} \quad (1)$$

HT%: percentage of hydrolysable tannins; OD: optical density; M : 300 ; V : volume of extract used ; Emoles: 2169 d'acide gallique ; SW: sample weight.

Condensed tannins content (CTC)

Three milliliters of 4% vanillin were mixed with volumes of each sample ranging from 0.1 to 0.5 milliliters. 1.5 cc of HCl was swiftly introduced and thoroughly shaken after the initial vigorous shaking. After 20 minutes of incubation, absorbance was taken at 500 nm (Julkunen-Titto [15]). The outcomes were presented to be mg of catechin equivalent per gram of dry extract (mg CE/g DE) utilising a calibration curve with catechin as a reference under comparable conditions.

Antioxidant activity via DPPH free radical scavenging

DPPH radical scavenging was assessed following Benhamou et al.'s method [16]. Five distinct concentrations were made available and 50 µl of samples was introduced into 1.95 ml of freshly made methanolic DPPH solution (0.0025 g/l). A negative control was created similarly using 50 µl of methanol with DPPH. After incubation in darkness for 30 minutes at ambient conditions, readings were taken at 515 nm.

Ferric reducing antioxidant power (FRAP)

FRAP test, as outlined by Oyaizu et al. [17], utilized 0.25 ml of individual extract concentrations. These were mixed with 0.625 ml of 0.2 M phosphate buffer (pH: 6.6) and 0.625 ml of 1% K3Fe(CN)6 solution. After 20 minutes at 50°C, 0.625 ml of 10% TCA halted the reaction. Subsequently, the supernatant (0.625 ml) was blended with 0.625 ml distilled water and 0.125 ml of a 0.1% FeCl3 solution. Measured at 700 nm using ascorbic acid as the reference.

Statistical analysis was conducted via Microsoft Excel 2010. Feedings were reported as mean ± standard

deviation, with significance set at $p < 0.05$. All measurements were performed in triplicate.

3. RESULTS AND DISCUSSIONS

Physico-chemical characteristics

The outcomes concerning the physical and chemical characteristics of the three onion types are detailed in Table 1.

Table 1. Physicochemical parameters of the different varieties of *Allium cepa*

Parameters (%)	RO	YO	PO
DM	17.6±0.0	12.3±0.0	18.1±0.0
Ashes	1.9±0.005	2 ±0.006	1.1±0.006
Acidity	3,33±0,15	3,23±0,15	3,1±0,2

DM: Dry matter; RO: Red onion; YO: Yellow onion; PO: Purple onion

Based on our findings, the three varieties have DM contents that vary between (12.3 to 18.1%), these values remain comparable to those reported by (Stadlmayr [18]) (12 to 13%) and (Konate et al. [19]), (9.63 ±0.38 to 17.97±0.45%). Several studies indicate that the levels of dry matter (DM) typically fluctuate between 7% and 18% of fresh weight based on the onion variety (Abhayawick et al. [20]). Interestingly, a positive relationship has been established between an onion's capacity for long-term storage and the dry matter content within the bulbs (Ko et al. [21]).

Onions containing higher levels of dry matter tend to exhibit greater firmness, thus offering increased resistance during transportation and handling, reducing susceptibility to damage (Silué et al. [22]).

Such damages, if incurred, could serve as entry points for parasites or microorganisms, ultimately leading to bulb rot. Consequently, the varieties under investigation demonstrate characteristics suggesting they possess significant potential for extended storage.

Regarding ash content, the onion varieties exhibited variations ranging from 1.1% to 2%. These findings differ from those reported by Nwinuka et al. [23] and Konate et al. [19], where ash content was reported to range from 4.8±0.15% to 2.50% to 6.64%, respectively.

The acidity levels among the various varieties appear comparable, ranging from 3.1 to 3.3%.

Nevertheless, these readings are notably higher compared to those documented by Konate et al. [19], which ranged from 0.27 to 0.40%. This discrepancy might arise from the abundance of acid (propanethial-S-oxide) in our varieties. When this compound is exposed to ocular moisture, it transforms into sulfuric acid.

Phytochemical screening (qualitative)

The findings from the phytochemical examination of the three onion varieties are depicted in Table 2.

Table 2. Phytochemical screening of different varieties of *Allium cepa L* (Mean ± SD; n=3).

Phytochemical substances	RO	YO	PO
Total tannins	+++	-	++
Condensed tannins	+++	+++	+++
Flavonoids /Anthocyani	-	-	-
Anthraquinone	+++	++	++
Quinones	++	+++	++
Saponosides Foam height (cm) Foam index	 <1 <100	 <1 <100	 <1 <100

RO: Red onion; YO: Yellow onion; PO: Purple onion ; Very positive: +++ ; moderately positive: ++; positive: +; negative: -

Our findings indicate the existence of distinctive secondary constituents including tannins, anthracene derivatives and saponins, which are distinctive of onions. These outcomes align with research conducted by Mangambu et al. [24] and Arora et al. [25]. Likewise, Oyewusi et al. [26] upheld the presence of flavonoids, alkaloids, tannins and saponins in the methanolic extract of onions Allium cepa L. However, anthocyanins, known for their antioxidant properties beneficial for UV protection and plant health, were undetected in our extracts.

Phytochemical screening (quantitative)

Table 3 shows the quantification of the various secondary metabolites of the three onion varieties.

Table 3. Secondary metabolites of various *Allium cepa L.* extracts (Mean ± SD; n=3)

Parameters	EERO	EEYO	EEPO
TPC mg EAG/g DM	0.23± 0.005	0.14± 0.03	0.27± 0.02
TFC mg QE /gr DM	0. 29± 0.02	0. 20 ± 0.01	0. 25± 0.01
HTC mg EAG/g de DM	0.29 ± 0.002	0.25 ± 0.021	0.26± 0.031
CTC mg CE/g DM	0.015 ± 0.008	0.078± 0.007	0.102± 0.012
Yield (%)	3.86	0.61	3.79

EERO : ethanolic extract of red onion ; EEYO : ethanolic extract of yellow onion ; EEPO : ethanolic extract of purple onion ; CE: Catechin equivalent; GAE: Gallic acid equivalent; QE: Quercetin equivalent; TFC: Total flavonoid content; TPC: Total phenolic content; HTC : Hydrolysable tannins content ; CTC: Condensed tannins content

The Total Phenolic Content (TPC) among the three extracts exhibited a range from 0.14 to 0.27 mg, with a maximum of 0.27 ± 0.02 mg EAG/g DM, consistent with findings by Benkeblia [27], who reported levels ranging from 0.18 to 0.20 mg/g fresh weight in red onions. Similarly, the concentration of total phenolic compounds varied notably in Allium extracts, spanning from 0.84 to 2.07 mg/g DM, surpassing our recorded results (Nuutila et al. [28]).

Flavonoids, renowned for their anti-inflammatory and analgesic properties in medicinal plants such as onions (Aliyu et al. [29]), exhibit varying contents in our findings, measuring approximately (0.29 ± 0.02 vs 0.20 ± 0.01 vs 0.25± 0.01) for EERO, EEYO, and EEPO, respectively. Tannins, widely prevalent across numerous plant species, serve as a defense against predation and potentially function as pesticides, contributing to growth regulation.

The present study confirms the existence of Hydrolysable Tannins (HT) in all three extracts, reaching a peak of 0.29± 0.002 in EERO, while EEPO displayed the highest concentration of Total Tannins (TC) at 0.102± 0.012 mg EC/g DM. The variations observed in bioactive compounds within the three extracts likely stem from variances in genetic makeup, notably the cultivar (Bajaj et al. [30]).

Regarding antioxidant activity, the DPPH test serves as a rapid screening method for identifying antioxidant molecules within plant extracts. Similarly, the assessment of antioxidant potency through iron reduction presents as a facile and reproducible method, widely employed to discern the most active extracts (Rodríguez-Bonilla et al. [31]). The results derived from the DPPH and FRAP tests conducted on the three alcoholic extracts of Allium cepa L. are delineated in Table 4.

Table 4. Free radical-scavenging activities and ferric reducing ability of ascorbic acid and ethanolic extracts of different *Allium cepa L* (Mean ± SD; n=3).

Extract	DPPH IC50*(mg/ml)	FRAP** (mM Fe^{2+})
EERO	0.204 ±0.017	0,48 ± 0,09
EEYO	0.159 ±0.18	0,75 ± 0,06
EEPO	0.265 ±0.014	0,66 ± 0,05
Vit C	0.132 ±0.002	1,37 ± 0,07

*Values were the means of three replicates ± standard deviation. *IC50 value (mg/ml of extract), inhibitory concentration 50%; DPPH radicals were scavenged by 50%; **Determined at 1 mg/ml ; EERO : ethanolic extract of red onion ; EEYO : ethanolic extract of yellow onion ; EEPO : ethanolic extract of purple onion.*

These two trials validate EEYO's superior antioxidant potential, showcasing an IC50 of (0.159 ±0.18 mg/l) and Ferric Reducing Capacity (0.75 ± 0.06 mM Fe2+), trailed by EERO (0.204 ±0.017 mg/l vs 0.48 ± 0.09 mM Fe2+) and EEPO (0. 265 ±0.014 mg/l vs 0.66 ± 0.05 mM Fe2+). This underscores the impact of onion variety on Alliums' antioxidant prowess. However, the antioxidant performance of Alliums is contingent upon phenolic and sulfur compounds (Miller et al. [32]), cultivation techniques, and extraction procedures (Prakash et al. [33]). Moreover, the varying sensitivity of reagents utilized in the antioxidant assessment methods (DPPH, FRAP) may elucidate the disparities observed among the studied extracts.

CONCLUSIONS

This investigation underscores the secondary metabolite richness within Algeria's primary onion varieties. The evaluation of antioxidant potential through diverse methodologies demonstrates a convergence in outcomes.

REFERENCES

[1] Pitrat M., Foury C. Histories of vegetables: their origins at the start of the 21st century. *Histories of vegetables: their origins at the start of the 21st century* 2003.
[2] Mégroz N., Baumgartner A. The onion, good to taste and the eye. *A Loupe* 2000; 2: 1-4.
[3] Bhattacharjee S., Sultana A., Sazzad M. H., Islam M.A., Ahtashom M., Asaduzzaman M. Analysis of the proximate composition and energy values of two varieties of onion (*Allium cepa L.*) bulbs of different origin: A comparative study. International Journal of Nutrition and Food Sciences 2013; 2(5): 246-253.
[4] Schmelzer G. H., Gurib-Fakim A. Medicinal Plants, vol. 11. *Wageningen, The Netherlands: Plant Resources of Tropical Africa (PROTA)*.
[5] Ciqual. 2020. National Agency for Food, Environmental and Occupational Health Safety. Table of nutritional composition of foods. Accessed on 14/09/2020.
[6] Bianchini F., Vainio H. Allium vegetables and organosulfur compounds: do they help prevent cancer? Environmental health perspectives 2001; 109(9): 893-902.
[7] You WC, Li JY. Etiology and prevention of gastric cancer: a population study in a high risk area of China. Chin. J. Dig Dis 2005; 6(4): 149-154.
[8] Graf BA., Milbury PE., Blumberg JB. Flavonols, flavones, flavanones and human health: epidemiological evidence. J Med Food 2005; 8(3):281-90.
[9] Corzo-Martínez M., Corzo N., Villamiel M. Biological properties of onions and garlic. Trends in food science & technology 2007; 18(12): 609-625.
[10] Trease GE., Evans WC. Pharmacology 11th Ed. Bailliere Tindall Ltd, London 1978; 60-75.
[11] Majhenič L., Škerget M., Knez Ž. Antioxidant and antimicrobial activity of guarana seed extracts. Food chemistry 2007; 104(3):1258-1268.
[12] Singleton VL., Orthofer R., Lamuela-Raventós R. M. Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. In Methods in enzymology 1999; 299:152-178.
[13] Kanazawa K., Hashimoto T., Yoshida S., Sungwon P., Fukuda S. Short photoirradiation induces flavonoid synthesis and increases its production in postharvest vegetables. Journal of agricultural and food chemistry 2012; 60(17): 4359-4368.
[14] Mole S., Waterman P.G. A critical analysis of techniques for measuring tannins in ecological studies. Oecologia 1987; 72(1): 137-147.
[15] Julkunen-Titto R . Phenolic constituents in the levels of northern willows: methods for precursors of clarified apple juice sediment. J. Food Sci 1985; 33 : 254-257.
[16] Benhammou N., Atik Bekkara F., Kadifkova P.T. Antioxidant activity of methanolic extracts and some bioactive compounds of *Atriplex halimus*. Comptes Rendus Chimie 2009; 12 (12): 1259-1266.
[17] Oyaizu M. Studies on products of browning reactions: Antioxidative activities of product of browning reaction prepared from glucosamine. Japanese Journal of Nutrition and Dietetics 1986; 44(6): 307-315.

[18] Stadlmayr B. West African food composition table/table de composition des aliments d'Afrique de l'Ouest 2012.
[19] Konate M., Parkouda C., Tarpaga V., Guira F., Rouamba A., Sawadogo–Lingani H .Evaluation des potentialités nutritives et l'aptitude à la conservation de onze variétés d'oignon (*Allium cepa L.*) bulbe introduites au Burkina Faso. International Journal of Biological and Chemical Sciences 2017; 11(5) : 2005-2015.
[20] Abhayawick L., Laguerre J.C., Tauzin V., Duquenoy A. Physical properties of three onion varieties as affected by the moisture content. Journal of Food Engineering 2002 ; 55(3) : 253-262.
[21] Ko S.S ., Huang J.W., Wang J.F., Shanmugasundaram S., Chang W. N. Evaluation of onion cultivars for resistance to *Aspergillus niger*, the causal agent of black mold. Journal of the American Society for Horticultural Science 2002; 127(4) : 697-702.
[22] Silué S., Fondio L., Coulibaly M.Y., Magein H. Sélection de variétés d'oignon (*Allium cepa L.*) adaptées au nord de la Côte d'Ivoire. Tropicultura 2003; 21(3):129-134.
[23] Nwinuka N. M., Ibeh G. O., Ekeke G. I. Proximate composition and levels of some toxicants in four commonly consumed spices 2005.
[24] Mangambu M. D. D., Mushagalusa, K. F., Kadima N.J . Contribution à l'étude photochimique de quelques plantes médicinales antidiabétiques de la ville de Bukavu et ses environs (Sud-Kivu, RD Congo). Journal of Applied Biosciences 2014; 75: 6211-6220.
[25] Arora E., Sharma V., Khurana A., Manchanda A., Sahani D., Abraham S., Chiru L. Phytochemical analysis and evaluation of antioxidant potential of ethanol extract of *Allium cepa* and ultra-high homoeopathic dilutions available in the market: A comparative study. Indian Journal of research in homoeopathy 2017, 11(2): 88-96.
[26] Oyewusi J.A., Saba A. B., Olukunle J. O. Phytochemical, elemental and acute toxic effects of methanol extract of onion (*Allium cepa*) bulbs in Wistar albino rats experimentaly pre-exposed and rested for a week. Vom Journal of Veterinary Science 2015; 10 : 65-74.
[27] Benkeblia N. Phenylalanine ammonia-lyase, peroxidase, pyruvic acid and total phenolics variations in onion bulbs during long-term storage. LWT-Food Science and Technology 2000; 33(2): 112-116.
[28] Nuutila A.M., Puupponen-Pimiä R., Aarni M., Oksman-Caldentey K.M. Comparison of antioxidant activities of onion and garlic extracts by inhibition of lipid peroxidation and radical scavenging activity. Food chemistry 2003; 81(4): 485-493.
[29] Aliyu A. B., Musa A. M., Oshanimi J. A., Ibrahim H. A., Oyewale A.O. Phytochemical analyses and mineral elements composition of some medicinal plants of Northern Nigeria. Nigerian Journal of Pharmaceutical Sciences 2008; 7(1):119-125.
[30] Bajaj K.L., Kaur G., Singh J., Gill S.P.S .Chemical evaluation of some important varieties of onion (*Allium cepa L.*). Plant Foods for Human Nutrition 1980; 30:117-122.
[31] Rodríguez-Bonilla P., Gandía-Herrero F., Matencio A., García-Carmona F., López-Nicolás J. M. Comparative study of the antioxidant capacity of four stilbenes using ORAC, ABTS+, and FRAP techniques. Food Analytical Methods 2017; 10: 2994-3000.
[32] Miller H. E., Rigelhof F., Marquart L., Prakash A., Kanter M. Antioxidant content of whole grain breakfastcereals, fruits and vegetables. J. Am. Coll. Nut 2000; 19: 1-8.
[33] Prakash D., Singh B. N., Upadhyay G. Antioxidant and free radical scavenging activities of phenols from onion (*Allium cepa*). Food chemistry 2007; 102(4): 1389-1393.