Assessment of antioxidant contents of vegetarian extracts, cucumber, daikon and turnip by HPLC

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Abstract:

The Cucurbitaceae vegetables family contains a wide range of horticultural crops that constitute a major part of diets worldwide. The aim of this study was to investigate the total phenolic content and antioxidant activity of some the whole vegetables extracts of cucumber, turnip, and daikon. The results showed that the methanol extract of daikon exhibited higher total phenolic and flavonoid contents and antioxidant activities than those other vegetables. Among the whole vegetables, daikon (26.5 ±0.5 and 245.13±1.13) showed the highest phenolic contents where cucumber was the lowest. Also, the antioxidant activity of daikon showed the highest radical scavenging activity (91%) and (IC_{50} of 21.8 µg/mL) compared to other vegetables extracts. HPLC profile was investigative 14 phenolic compound (Pyrogallol, Gallic, 3-OH Tyrosol, Catechol, 4-Aminobenzoic, Catechein, Chlorogenic, P-OH-benzoic, Caffeic, Vanillic, Caffeine, Ferulic, Ellagic, Coumarin), the daikon extract has the highest phenolic and flavonoids contents. The findings of this study suggest that the tested Cucurbitaceae whole vegetables and vegetarians are a good dietary source of phenolic compounds with appreciable antioxidant potential. Thus, the study imagery Cucurbitaceae whole vegetables conserved a good source of phenolic and flavonoid compounds that can be consumption for nutritional diets daily.

Keywords: Phenolic, Flavonoids, , Vegetables, Anti-oxidants.

1. Introduction

Plant origin foods, especially vegetables, are sources of vitamins, minerals, fibers, carbohydrates and bioactive compounds, such as

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polyphenols, a group of phytochemicals acknowledged as the most plentiful in our diet. Phenolics and flavonoids are essential vegetables constituents which exhibit antioxidant activity by preventing the conversion of hydroperoxides into free radicals or inactivating lipid free radicals (Fatemeh et al.,2012).

Vegetables play a key role in the diet of humans because of their support in the normal functioning of different body systems. It is well-known that the consumption of vegetables could reduce the risk of various chronic diseases in humans (Bjorkman et al., 2011; Vale et al., 2014). Vegetables contain several health-promoting nutrients and bioactive compounds, including polyphenolics, vitamins, carotenoids, minerals, and fiber. In particular, phenolic compounds are recognized as having valuable health benefits, because of their remarkable antioxidant properties (Moreno et al., 2006; Wei et al., 2011). Dietary phenolics can reduce the risk of various chronic diseases, such as cardiovascular disease, inflammation, cancers, and diabetes, by suppressing the production of free radicals (Kowalska et al., 2014).

In recent times, the role of Brassicaceae and Cucurbitaceae vegetables in the diet of humans has gained attention because of their high nutritional value and rich bioactive metabolite contents (Vale et al., 2014). Turnip, cucumber, and daikon have various pharmacological properties, such as antioxidant, gastroprotective, anti-inflammatory, and anti-obesity activities. These vegetables can be used in different forms, including raw, cooked, fried, baked, and fermented (Samec et al., 2017). In addition, the whole vegetables have received considerable attention over the past decades because of their low-fat level, which contributes to the improvement of human health (Li et al., 2018). These plants are grown worldwide their good environmental adaptation. The studied vegetables have great global economic importance. The consumption of Cucurbitaceae vegetables also significantly regulates metabolic activity in the body (Cartea et al., 2011). Flavonoids (flavonols and anthocyanins) and hydroxycinnamic acids (*p*-coumaric, sinapic, and ferulic acids) are the most widespread group of polyphenolic compounds in Brassicaceae vegetables (Olsen et al., 2009; Vale et al., 2015).

Edible vegetables possess higher nutritional profiles than those of vegetable products, according to several studies (Martinez-Villaluenga et al., 2008; Yuan et al., 2010). Some Brassicaceae and Cucurbitaceae members, such as broccoli, cabbage, radish, and cucumber are rich sources of various antioxidant compounds. These whole vegetables are particularly recommended as the best sources of polyphenols, glucosinolates, fiber, carotenoids, vitamins, and minerals (Nicola et al., 2013). Some health-promoting bioactive components, such as glucosinolates, are found in almost 10 times higher quantities in whole vegetables than in vegetarian (Wei et al., 2011; Yuan et al., 2010). Previous studies found that the breakdown products of glucosinolates (isothiocyanates) have the potential to reduce the risk of different types of cancers (Nicola et al., 2013; Vale et al., 2015). Further, the consumption of whole vegetables stimulates the immune system activation, alleviates vitamin and mineral deficiencies, and prevents several serious illnesses (Wezyk and Kazepilko, 2012). whole vegetables are an important alternative to increasing the consumption of seeds in human nutrition. However, there have been no comparative studies in relation to the phytochemical analysis antioxidant activity and antimicrobial activity of Brassicaceae and Cucurbitaceae whole vegetables and their commercial vegetables. Hence, this study aimed to evaluate the total phenolic content and antioxidant activity of selected Cucurbitaceae members (turnip, cucumber, and daikon).

Materials and Methods

Materials, chemicals and reagents

Fresh mature vegetables (Cucumber, Daikon and Turnip**)** were purchased from the local market in Cairo of Abo-Ahmed company.

1,1-diphenyl-2-picryl hydrazyl (DPPH), ascorbic acid, 2,2'-azinobis (3-ethylbenzothiozoline-6-sulfonic acid) diammonium salt (ABTS), potassium persulfate, Folin–Ciocalteu phenol reagent, sodium nitrite, catechin, aluminum chloride, sodium hydroxide, sodium carbonate, polyvinyl polypyrrolidone (PVPP), and gallic acid were purchased from Sigma-Aldrich (St. Louis, MO, USA).

Bacterial strains was the gram negative strains, *Clostridium clostridiiforme* (ATCC 25537), *Listeria monocytogenes* (ATCC 19116), *Shigella sonnei* (ATCC 25931), *Salmonella typhi* (ATCC 19430), *Escherichia coli* (ATCC25922). These strains was brought in Microbiological Resources Center (MIRCEN), Ain Shams University, Faculty of Agriculture Egypt. by MERSN and stored strains to can be used.

2.1. Sample preparation

The fresh vegetables (**Cucumber, Daikon and Turnip)** they were carefully selected and were cleaned under running tap water and were separated damage the parts. The vegetables samples were and a portion was sliced and dried in oven drying at 40˚C for 3 days and ground into fine powder to preparing the extracts. The vegetables samples were extracted with 100 mL of 80% (v/v) methanol. The extracts were filtered by Whatman No. 2 filter paper and samples were dried using a rotary vacuum evaporator. All the extracted samples were stored at 20 °C until other analysis.

2.2. Antioxidant contents estimation

2.2.1. Determination of total phenolic content

Total phenolic contents were determined with Folin-Ciocalteu technique with small modifications according to Bhatti *et al.*, (2015). The total phenolic content was expressed as mg of gallic acid (mg GAE/g extract). The absorbance was recorded at 750 nm by spectrophotometer (Visiscan 167, Sytronics).

2.2.2. Determination of total flavonoids content

Total flavonoid content of extracts was determined by aluminum chloride colorimetric method with some modifications according to. 2 mL of various extracts (4 mg/mL) were combined with 100 µL of aluminum chloride solution (10%), The absorbance of the tested samples was measured by spectrophotometer at 510 nm against reagent as blank. The concentrations of flavonoids flavonoid were expressed as mg of catechin equivalent per gram of extract (mg CE/g extract).

2.3. Antioxidant activity:

DPPH (1,1-diphenyl-2-picryl-hydrazyl) radical scavenging activity

Extracts were prepared from fresh vegetables by using one mL of the extracts for several concentrations and mixed with 1 mL of 0.1 mM of DPPH solution in methanol (Faller and Fialho, 2009). The absorbance was measured using a Spectrophotometer at 517nm. The percentage of the radical scavenging activity was calculated as follows

% Radical scavenging activity = (Abs control − Abs sample/Abs control) × 100.

2.4. Phenolic and flavonoid profile of extracts by HPLC

The HPLC analysis was presented as Ferreres *et al.*, (2006) by conjunction of column heating device set at 30 _C, and an ion exclusion column, Nucleogel_ Ion 300 OA (300 _ 7.7 mm). The detection was performed with an UV detector, at 214 nm. Organic acids quantification was achieved by the absorbance recorded in the chromatograms relative to external standards, and the peaks in the chromatograms were integrated using a default baseline construction technique.

2.5. Antibacterial activity

The antibacterial activity of the extracts (Cucumber, Daikon and Turnip**)** was investigated by the well diffusion method (Langfield *et al.*, 2004). Selective media was prepared according to the standard procedure and 25 mL was poured into the plates and was allowed to solidify. The standard inoculum suspension was streaked over the surface of the media using sterile cotton swab to ensure the confluent growth of the organism and the plates were allowed to dry for 5 minutes. Discs of filter paper were saturated with 30µl of different antioxidant extract (800 µg/mL) and placed on Petri dishes containing agar media contaminated with pathogenic bacteria. Then, measured the inhibition zone diameters (mm). A disc saturated with distilled water was a negative control and levofloxacin was a positive control. Finally, the inoculated plates were incubated for 24 hours at 37ºC for bacteria. The zone of inhibition was measured and noted. That technique procedure in Department Food Science, Faculty of Agriculture, Zagazig University.

2.6. Statistical analysis

The data means were analyzed by one way ANOVA at probability level of 5%, the means were compared for significant differences by LSD.

3. Results

3.1. Total phenols and flavonoids contents of extracts vegetables.

Results in Table (1) showed that the significant differences were found in total phenolic content between all cucumber, daikon and turnip extracts. The highest level was noticed in daikon extract (245.13 mg GAE/g) followed by turnip extract (205±1 mg GAE/g) and cucumber extract (185.2 mg GAE/g). The data indicated possibility presence of high antioxidant capacity compounds in these vegetables studied. Also, the value of TFC reported here for daikon extract (26.5 mg GAE/g) was higher than the value in cucumber extract (11.52 mg GAE/ g). Cucumber extracts showed lower ratios of total flavonoid content 11.52 ±0.5 mg CE/100 g. The defensive the vegetables have connected the antioxidant vitamins such as ascorbic acid, carotene, although a great portion of these vegetables antioxidant activity conversion from phenolic compounds **(Singh *et al.*, 2006).** Vegetables compounds have phenolics and flavonoid exhibit antioxidant activity by stopping the conversion of hydroperoxides into free radicals or deactivating lipid free radicals**.** The previous studies reported that the phenolic and flavonoid contents with vegetables are antioxidative capacities due to medicinal significance in the management of various disorders **(Fatemeh *et al.*, 2012)**.

Table (1) Total phenols and flavonoids contents of vegetarian extracts (Cucumber, Daikon and Turnip).

Samples	TPC (mg GAE/100g)	TFC (mg GAE/100g)
Cucumber	185.2±1.2[c]	11.52 ±0.5[a]
Daikon	245.13±1.13[a]	26.5 ±0.5[c]
turnip	205±1[b]	13.45±0.4[b]

The lowercase letters in the same column indicate significant differences

3.2. DPPH radical scavenging activity of vegetarian extracts(cucumber, daikon, turnip)

The DPPH radical scavenging are presented in table (2). All extracts exhibited concentration-dependent increases in radical scavenging. The daikon extract (91.24 %) presented better radical scavenging activity followed turnip extract (88.12 %) then cucumber extract (82.5). **Sushant *et al.*, (2019)** who showed that DPPH is a stable free radical, which has been widely used in phytomedicine for the assessment of scavenging activities of bioactive fractions.

Table (2) DPPH radical scavenging activity of vegetarian extracts (Cucumber, Daikon and Turnip).

Samples	DPPH % or (_g/mL)	IC_{50}
Cucumber	82.5±0.5[c]	25.81±0.8[a]
Daikon	91.24±1.2[a]	21.82±0.8[c]
Turnip	88.12±1.1[b]	24.5±0.5[b]

The lowercase letters in the same column indicate significant differences.

3.3. HPLC profile of phenolic content in vegetables extracts

The HPLC analysis of the phenolic compounds for vegetarian extracts was presented in Table (3). Analysis of HPLC was selected by investigative the several compositions of different and identified in 14 compound (Pyrogallol, Gallic, 3-OHTyrosol , Catechol, 4-Aminobenzoic , Catechein, Chlorogenic , P-OH-benzoic , Caffeic , Vanillic , Caffeine , Ferulic , Ellagic, Coumarin), was found in all vegetarian extracts. The results obtained that the major phenolic compounds for vegetarian extracts found in Catechol by daikon (487.19 ppm) followed cucumber (278.67 pm) and turnip (265.55 ppm), and then compound Catechein in daikon (181.50 ppm) and turnip (174.96 ppm), while cucumber was 125.39 ppm. The lowest phenolic compounds for vegetarian extracts were observed in the Coumarin by cucumber (2.40 pm) , then daikon(5.41ppm) and turnip (5.41ppm).

Daikon extract is characterized by the highest contents of flavonoids where higher contents of Naringin and Quercetrinrutin were detected in daikon (39 and 35 ppm) and medium contents of kampferol 3-2-P-coumaroylglucose (16.7 and 11.4 ppm) where the other flavonoids in lower contents, followed by turnip and cucumber extracts

Table 3. Phenolic compounds profile.

Phenolic compounds	phenolic compounds of vegetarian extracts (ppm)		
	Cucumber	Daikon	Turnip
Pyrogallol	143.26	146.87	163.46
Gallic	42.35	58.88	25.94
3-OHTyrosol	6.83	9.66	8.22
Catechol	278.67	487.19	265.55
4-Aminobenzoic	2.70	4.72	6.31
Catechein	125.39	181.50	174.96
Chlorogenic	42.87	49.16	42.19
P-OH-benzoic	17.74	26.02	14.36
Caffeic	30.95	54.70	40.25
Vanillic	90.15	163.88	89.02
Caffeine	18.03	23.83	38.67
Ferulic	13.10	70.11	48.46
Ellagic	92.12	29.00	50.24
Coumarin	2.40	5.41	5.41
Flavonoids compounds	Flavonoids compounds of vegetarian extracts (ppm)		
Rutin	2.31	16.73	6.19
Naringin	13.18	39.05	31.03
Rosmarinic	1.35	2.33	1.49
Quercetrin	10.02	35.14	6.90
Apignin 7-glucose	3.47	2.26	3.79
Quercetin	2.66	8.21	21.62
Naringenin	1.84	3.11	3.02
Kampferol 3-2-P-coumaroylglucose	2.33	11.84	21.61
Kampferol	0.61	4.62	5.13
Apignin	0.42	0.21	2.09

3.4. Antimicrobial activity

Table 4 showed that daikon and turnip extracts the best activity against all tested microorganisms producing the widest inhibition zones ranged from 5 to 30 mm, followed by cucumber extracts with inhibition zones ranged from 5 to 26 mm respectively. On the other hand extracts daikon and turnip showed variable antimicrobial activity, alcoholic extracts of daikon and Turnip exhibit good activity but weak activity against fungal species. All extracts from all tested plants were less active against fungal species than bacterial species.

Table (4) Antimicrobial activity of vegetables extracts.

Samples	Microorganisms					
	Asperigillus niger (mm)	***Clostridium*** *Clostridiiforme* (mm)	***Listeria*** *Monocytogenes* (mm)	***Shigella*** *Sonnei* (mm)	***Salmonella*** *Typhi* (mm)	***E. colI*** (mm)
Cucumber	5	25	18	26	26	26
Daikon	8	27	30	28	27	30
Turnip	5	27	28	27	30	30

4. Discussion

Brassicaceae vegetables are one of the most important groups of low-carbohydrate foods. These vegetables are consumed by people worldwide, and are considered the main food crops in China, Korea, Japan, India, and many European countries. *B. oleracea* is the major vegetable species, and its cultivars include cabbage, broccoli, kohlrabi, cauliflower, and others (Cartea et al., 2011). Recently, the development of antioxidant-rich foods has gained considerable attention for the purpose of health promotion and disease prevention. The health-promoting effects of Brassicaceae vegetables are mainly ascribed to their complex mixture of bioactive metabolites, which have strong antioxidant potential (Vale et al., 2014). The antioxidant potential of Brassicaceae vegetables is associated with their phenolic content. Brassicaceae whole vegetables are richer in phenolic compounds than their respective commercial vegetables (Pajak et al., 2014). Hence, a comparison of the phytochemical composition and antioxidant activities of Cucurbitaceae whole vegetables with those of their commercial vegetables is key to developing new functional foods (Nicola et al., 2013).

The results of DPPH and ABTS scavenging activities in the present investigation of Cucurbitaceae whole vegetables and their commercial vegetables were compared and correlated with each other. The total phenolic content exhibited a strong correlation with total flavonoid (R^2 = 0.9487) and moderate correlation with DPPH (R^2 = 0.4983) and ABTS (R^2 = 0.5032). Further, there was a close correlation between ABTS and DPPH (R^2 = 0.9831). However, there was no significant correlation between tannin content and antioxidant activity.

In this study, we determined the total phenolic, flavonoid, and tannin contents of Brassicaceae and Cucurbitaceae whole vegetables (Cucumber, Daikon and Turnip) and their respective vegetables. Additionally, we investigated the antioxidant activity of whole vegetables and vegetables using DPPH and ABTS assays. The whole vegetables of all three plants contained higher total phenolic and flavonoid contents than their commercial vegetables, except for taste whole vegetables. Polyphenolic compounds are involved in a variety of biological functions. It is well-known that phenolic components, including phenolic acids, flavonoids, anthocyanins, and proanthocyanidins, may regulate numerous signaling pathways involved in the survival, growth, and differentiation of cells (Cartea et al., 2011).

DPPH and ABTS radical scavenging activities have been extensively used to examine the antioxidant activity of plant products, mainly to assess the ability of chemicals as free radical scavengers or hydrogen donors (Sowndhararajan and Kang, 2013). In this study, all whole vegetables scavenged the DPPH and ABTS radicals more effectively than did their respective vegetables, with the exception of the tatsoi vegetable, which provided a better scavenging effect than its whole vegetables. Among the different whole vegetables, those of red radish showed the highest DPPH and ABTS scavenging activities. The IC_{50} values of DPPH and ABTS assays were 358–1,053 and 413–870 µg/mL for whole vegetables, and 616–8,989 and 578–8,304 µg/mL for vegetables, respectively. Among different vegetables, pink cabbage registered the lowest total phenolic and flavonoid contents and antioxidant activities. However, we found higher levels of total phenolic and flavonoids in pink cabbage whole vegetables, as well as considerable antioxidant activity. As well as their high total phenolic and flavonoid (known for their antioxidant capacity) contents, the whole vegetables showed higher DPPH and ABTS radical scavenging activities.

There are several studies that evaluate the phytochemical composition and biological activities of Brassicaceae whole vegetables (Baenas et al., 2012; De Nicola et al., 2013; Samec et al., 2018; Vale et al., 2014; 2015; Wei et al., 2011). In a recent study, Samec et al. (2018) investigated the phytochemical composition and the activity of endogenous enzymes in five Brassicaceae whole vegetables: white cabbage, kale, broccoli, Chinese cabbage, and arugula. In their study, white cabbage whole vegetables showed the highest amount of polyphenols (18.34 mg GAE/g dry weight [DW]) and glucosinolates, as well as a strong antioxidant activity, followed by kale whole vegetables. In another study, Vale et al. (2014) studied the total phenolic content and antioxidant activity of *B. oleracea* whole vegetables such as broccoli, Portuguese Galega kale, Portuguese Tronchuda cabbage, and red cabbage using DPPH, hydroxyl, and peroxyl radical scavenging and ferrous ion chelating ability assays. These four *B. oleracea* whole vegetables exhibited significantly different antioxidant activity; red cabbage grown under light cycles exhibited the highest antioxidant activity. The authors found that the antioxidant capacity of whole vegetables declined with sprouting and increased in the presence of light. Baenas et al. (2012) performed the phytochemical profiling of Brassicaceae varieties such as broccoli, kohlrabi, red cabbage, rutabaga, turnip, turnip greens, radish, garden cress, and white mustard. They found that the levels of glucosinolates in seeds were significantly higher than those in whole vegetables, and considered eight-day-old whole vegetables as optimum for consumption. Whole vegetables from red cabbage and radish presented the highest total glucosinolate and total phenolic contents, biomasses, and antioxidant capacities.

Heimler et al. (2006) investigated the radical scavenging activity and total phenolic, flavonoid, and total condensed tannin contents of seven Brassicaceae vegetables (Italian kale, broccoli, Savoy cabbage, white cabbage, cauliflower, green cauliflower, and Brussels whole vegetables). The results showed that the EC_{50} values ranged from 81.45 (broccoli) to 917.81 (cauliflower) mg sample/mg DPPH, and the total phenolic content ranged from 4.30 (Savoy cabbage) to 13.80 (Italian kale) mg GAE/g DW. Further, Jaiswal et al. (2011) investigated the total phenolic content, antibacterial and antioxidant potentials of 60% ethanol, acetone, and methanol extracts of *B. oleracea* vegetables (broccoli, Brussel whole vegetables, and white cabbage). The results revealed that the methanol (60%) extract registered the highest polyphenolic content for broccoli (23.6 mg GAE/g extract), Brussels whole vegetables (20.4 mg GAE/g extract), and white cabbage (18.7 mg GAE/g extract). In this study, the total phenolic content in the ethanol (95%) extracts of broccoli whole vegetables and vegetables were 25.750 and 20.293 mg GAE/g extract, respectively. The solvent used for extraction also plays a major role in the total phenolic content and antioxidant activity. Whole vegetables , which can be consumed in their fresh form in all seasons, are an excellent substitute for plant foods. Further, whole vegetables are inexpensive, easy to grow, and fast growing. The results of this study also confirmed that whole vegetables from edible plants are a good source of antioxidants.

Conclusion

This study found highly varied total phenolic and flavonoid contents and antioxidant activity of Cucurbitaceae whole vegetables. The results of our investigation indicated that three Cucurbitaceae whole vegetables (daikon, turnip, and cucumber) contained higher levels of polyphenolic components with appreciable antioxidant properties than did commercial vegetables. We concluded that Cucurbitaceae whole vegetables are a rich source of natural antioxidants and can be used as plant-based foods.

References

- Asma S., Muhammad S. M., Abdul Haleem S.R., Sheikh Z.-U. and Samina A. (2019). Assessment of total phenolic and flavonoid contents of selected fruits and vegetables. Indian Journal of Traditional Knowledge. Vol 18(4), 686-693.

- APHA.(1976): American public Health Association of Methods for the Microbiological Examination of Foods (1976). Speck, M. L. ed., Washington, D. C., USA.
- Baenas, N., Moreno, D. A. and García-Viguera, C. (2012). Selecting sprouts of Brassicaceae for optimum phytochemical composition. J. Agric Food Chem. 60,11409-11420.
- Bhatti M. Z., Ali A, A., and Saeed A. A., and Malik S.A.,(2015). Antioxidant and phytochemical analysis of Ranunculus arvensis L. extracts, *BMC Res Notes*, 8, 279.
- Bjorkman, M., Klingen, I., Birch, A. N., Bones, A. M., Bruce, T. J., Johansen, T. J., Meadow, R., Mølmann, J., Seljåsen, R., Smart, L. E., and Stewart, D. (2011). Phytochemicals of Brassicaceae in plant protection and human health-influences of climate, environment and agronomic practice. Phytochemistry 72:538-556.
- Cartea, M. E., Francisco, M., Soengas, P. and Velasco, P. (2011). Phenolic compounds in Brassica vegetables. Molecules 16:251-280.
- De Nicola, G. R., Bagatta, M., Pagnotta, E., Angelino, D., Gennari, L., Ninfali, P., Rollin, P., and Iori, R. (2013).Comparison of bioactive phytochemical content and release of isothiocyanates in selected brassica sprouts. Food Chem 141:297-303.
- Difco-Manual, (1984). Dehydrated culture media and reagents microbiological and clinical laboratory procedures. Pub-Difco-LabDetroits Michigan, USA.
- Faller, A.L.K. and Fialho, E. (2009). The Antioxidant Capacity and Polyphenol Content of Organic and Conventional Retail Vegetables after Domestic Cooking. *Food Research International*, 42, 210-215. http://dx.doi.org/10.1016/j.foodres.2008.10.009.
- Fatemeh S.R., Saifullah R, A., and Azhar M.E., (2012). Total phenolics, flavonoids and antioxidant activity of banana pulp and peel flours: influence of variety and stage of ripeness, *Int Food Res J,* 19 (3), 1041-1046
- Ferreres, F., Sousa, C., Vrchovska, V., Valenta˜o, P., Pereira, J. A., and Seabra, R. M.,. (2006). Chemical composition and antioxidant activity of tronchuda cabbage internal leaves. Eur. Food Res. Technol. 222, 88–98.

- Fu, R., Zhang, Y., Guo, Y., and Chen, F. (2014) Antioxidant and tyrosinase inhibition activities of the ethanol-insoluble fraction of water extract of *Sapium sebiferum* (L.) Roxb. Leaves. South African Journal of Botany 93:98-104.
- Heimler, D., Vignolini, P., Dini, M. G., Vincieri, F. F., and Romani, A. (2006) Antiradical activity and polyphenol composition of local Brassicaceae edible varieties. Food Chem 99:464-469.
- Herald, T. J., Gadgil, P., and Tilley, M. (2012). High-throughput micro plate assays for screening flavonoid content and DPPH-scavenging activity in sorghum bran and flour. J Sci Food Agric 92:2326-2331. 10.1002/jsfa.563322419130
- Jaiswal, A. K., Abu-Ghannam, N., and Gupta, S. (2011). A comparative study on the polyphenolic content, antibacterial activity and antioxidant capacity of different solvent extracts of *Brassica oleracea* vegetables. Int J Food Sci Technol 47:223-231.
- Kowalska, I., Pecio, L., Ciesla, L., Oleszek, W.,and Stochmal, A. (2014). Isolation, chemical characterization, and free radical scavenging activity of phenolics from *Triticum aestivum* L. aerial parts. J Agric Food Chem 62:11200-11208.
- Langfield R.D., Scarano F.J, Heitzman M.E., Kondo M., Hammond G.B., and Neto C.C., (2004). Use of a modified microplate bioassay method to investigate antibacterial activity in the Peruvian medicinal plant Peperomia galiodes. Journal of Ethno pharmacology 94(2-3): 279-281.
- Li, Z., Lee, H. W., Liang, X., Liang, D., Wang, Q., Huang, D., and Ong, C. N., (2018) Profiling of phenolic compounds and antioxidant activity of 12 cruciferous vegetables. Molecules 23:1139.
- Makkar, H. P. S., (2003). Quantification of tannins in tree and shrub foliage: A laboratory Manual. Dondrecht. The Netherlands: Kluwer academic publishers. 10.1007/978-94-017-0273-7
- Martinez-V. C., Frias, J., Gulewicz, P., Gulewicz, K., and Vidal-Valverde, C. (2008). Food safety evaluation of broccoli and radish sprouts. Food Chem. Toxicol. 46:1635-1644.

- Mokrani, A., Krisa, S., Cluzet, S., Costa, G. D., Temsamani, H., Renouf, E., Merillon, J.M., Madani, K., Mesnil, M., Monvoisin, A., and Richard, T. (2016) Phenolic contents and bioactive potential of peach fruit extracts. Food Chem 202:212-220.
- Moreno, D. A., Carvajal, M., Lopez-Berenguer, C., and Garcia-Viguera, C. (2006) Chemical and biological characterization of nutraceutical compounds of broccoli. J Pharm Biomed Anal 41:1508-1522.
- Mouradov, A., and Spangenberg, G.(2014). Flavonoids: A metabolic network mediating plants adaptation to their real estate. Front. Plant Sci. 5, 620.
- Nicola, G. R. D., Bagatta, M., Pagnotta, E., Angelino, D., Gennari, L., Ninfali, P., Rollin, P., and Iori, R (2013). Comparison of bioactive phytochemical content and release of isothiocyanates in selected brassica sprouts. Food Chemistry 141:297-303.
- Olsen, H., Aaby, K., and Borge, G. I. (2009). Characterization and quantification of flavonoids and hydroxycinnamic acids in curly kale (*Brassica oleracea* L. Convar. *acephala* Var. *sabellica*) by HPLC-DAD-ESI-MSn. J Agric Food Chem 57:2816-2825.
- Pajak, P., Socha, R., Galkowska, D., Roznowski, J., and Fortuna, T. (2014) Phenolic profile and antioxidant activity in selected seeds and sprouts. Food Chem 143:300-306.
- Samec, D., Pavlović, I., Redovniković, I. R., and Salopek-Sondi, B. (2018). Comparative analysis of phytochemicals and activity of endogenous enzymes associated with their stability, bioavailability and food quality in five Brassicaceae sprouts. Food Chem. 269:96-102.
- Samec, D., Pavlović, I., and Salopek-Sondi, B. (2017). White cabbage (*Brassica oleracea* var. *capitata* f. *alba*): Botanical, phytochemical and pharmacological overview. Phytochem Rev 16:117-135.
- Singh, J., Upadhyay, A.K., Bahadur, A., Singh, B., Singh, K.P. and Rai, M. (2006) Antioxidant Phytochemicals in Cabbage (*Brassica oleracea* L. var. capitata). *Scientia Horticulturae*, 108, 233-237.
- Sowndhararajan, K., and Kang, S. C., (2013). Free radical scavenging activity from different extracts of leaves of *Bauhinia vahlii* Wight & Arn. Saudi J Biol Sci 20:319-325.

- Sushant A., Manoj K. B., Krisha D., Puspa K., Roshani G., and Niranjan K. (2019).Total Phenolic Content, Flavonoid Content and Antioxidant Potential of Wild Vegetables from Western Nepal. Plants 8, 96.
- Tachakittirungrod, S., Okonogi, S., and Chowwanapoonpohn, S. (2007) Study on antioxidant activity of certain plants in Thailand: Mechanism of antioxidant action of guava leaf extract. Food Chem 103:381-388.
- Vale, A. P., Santos, J., Brito, N. V., Marinho, C., Amorim, V., Rosa, E., and Oliveira, M. P. (2015). Effect of refrigerated storage on the bioactive compounds and microbial quality of *Brassica oleracea* sprouts. Postharvest Biol. Technol. 109:120-129.
- Vale, A.P., Cidade, H., Pinto, M., and Oliveira, M. P. (2014). Effect of sprouting and light cycle on antioxidant activity of *Brassica oleracea* varieties. Food Chemistry 165:379-387.
- Wei, J., Miao, H., and Wang, Q. (2011) Effect of glucose on glucosinolates, antioxidants and metabolic enzymes in *Brassica* sprouts. Sci Hortic 129:535-540.
- Wezyk, I. Z., and Krzepilko, A. (2012). Comparison of the antioxidant properties of selected edible sprouts from the Cruciferae family. Ecol. Chem. Eng A 19: 921-929.
- Yuan, G., Wang, X., and Wang, Q. (2010). Effect of salt stress on phenolic compounds, glucosinolates, myrosinase and antioxidant activity in radish sprouts. Food Chem 121:1014-1019.

تقدير المركبات المضادة للأكسدة للمستخلصات النباتية (الخيار والفجل واللفت) بواسطة *HPLC*

الملخص العربي:

تعتبر العائلة الخضرية الجزرية من المحاصيل الحقلية الاكثر انتشارا والتي لها اهميه اساسيه وضرورية بالوجبات الغذائية في العالم. تهدف الدراسة الحالية لتقدير المركبات الفينوليه الكلية ومضادات الاكسدة لبعض انواع من مستخلصات الخضروات (الخيار والفجل واللفت) . اوضحت النتائج ان المستخلص الميثانولي للفت كان اعلى محتوى للمركبات الفينوليه والفلافونويد والنشاط المضاد للأكسدة عن الخضروات الاخرى وبالنسبة للفجل أوضح اعلى القيم للمركبات الفينوليه ٢٤٥,١٣ملجم جالك / ١٠٠جم و ٢٦,٥ ملجم جالك /١٠٠جم بينما كان الخيار اقلهم . ايضا النشاط المضاد للأكسدة للفجل اوضح اعلى قيمه٢١,٨ ميكروجرام لكل ملم بنسبه ٩١٪ مقارنه بمستخلصات الخضر الاخرى. بالتعرف على المركبات الفينوليه بواسطه HPLC تم التعرف على ١٤ مركب وهى (بيروجالك و جالك و ٣ او اتش تيروسول وكاتشول و ٤ امينوبنزوك و كاتاشين و كلوروجينك وبى او اتش بنزويك و كافييك وفانبلليك وكافايين و فيروليك والاجيك و كيومريك) لمستخلص الفجل الذى امتلك اعلى المركبات الفينوليه والفلافونويد. الدراسة الحالية تهدف الى استخدام كل العائلة الجزرية والخضرية لكل الخضروات لأنها مصدر جيد للمركبات الفينوليه بالوجبة الغذائية لما تحتويه من مضادات اكسده. لذلك يمكن التوصية بان كل الخضروات الجزرية تعتبر مصدر غني للمركبات الفينوليه والفلافونويد لذلك يجب الحرص على تناولها يوميا في الوجبة الغذائية.

الكلمات المفتاحيه : الفينولات- الفلافونويد - الخضروات - النشاط المضاد للأكسدة.