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Assessment of the Antioxidant and Free Radical Scavenging Activities of Two Different Solvent Extracts of Potato Peels

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Abstract: In this study, total phenolic and flavonoid contents were determined in water and ethanol extracts of potato peels. The antioxidant activity of potato peel extracts was evaluated using different biochemical assays, including total antioxidant capacity, reducing power, DPPH radical scavenging, nitric oxide scavenging, hydroxyl radical scavenging and metal ion chelating activities. GC-MS analysis was performed to identify the phenolic compounds present in the ethanol extract. The results showed that water extract contained significantly (P<0.05) high amount of total phenolics (40.95±0.10 mg/g potato peels) while ethanol extract contained high content of flavonoids (15.63±1.71 mg/g potato peels). The ethanol potato peel extract (EPPE) showed higher antioxidative and radical scavenging activity in comparison with water potato peel extract (WPPE). Five phenolic compounds were identified in ethanol extract by GC-MS. The results indicated that potato peel extracts could be a potential source of natural antioxidants for food applications.

Key words: Antioxidant activity · Free radical scavenging · Potato peels · Phenolics · Flavonoids · GC-MS

INTRODUCTION

Major research interests have been focused on reactive oxygen species (ROS) and their likely involvement in human physiopathology from the health point over the last few decades. Oxidative stress, caused by an imbalance between antioxidant systems and the production of oxidants, including ROS, seems to be associated with many multifactorial diseases, especially cancers, cardiovascular diseases and inflammatory disorders [1]. Accumulative effects of tissue destruction caused by ROS coupled with damage induced by proteolytic metalloproteinases lead to the pathological conditions [2]. It has been reported that bioactive herb extracts with high levels of phenolic and flavonoid compounds exhibit strong antioxidant and anti-inflammatory activities. Therefore, fruits and vegetables which contain significant amounts of antioxidants are believed to have health beneficial effects by counteracting oxidative stress thus reducing the risk of chronic diseases [3]. These antioxidants mainly come from plants in the form of phenolic compounds (flavonoids, phenolic acids, stilbenes, tocopherols and tocotrienols), ascorbic acid and carotenoids. Recently, phenolic compounds have been received much attention due to their effective antioxidant properties and their beneficial effects. These activities could be attributed to their donating electrons, scavenging free radicals and reducing power [4]. From another point of view, natural antioxidants have the capacity to improve food quality and stability and can also act as nutraceuticals to terminate free radical chain reactions in biological systems and providing additional health benefits to consumers [5, 6].

Potatoes (*Solanum tuberosum*) are one of the most commonly consumed vegetables throughout the world. The global consumption of potatoes as food is shifting from fresh potatoes to value added processed products such as French fries, chips and puree. Peels are the major by-product of potato processing industries, which represent a major waste disposal problem for the industry concerned. Up-grading of this by-product to value added products is therefore of interest to the potato industry. Potato peel waste has been shown to be a good source of dietary fiber [7] and contains many phenolic compounds, some in free form and others that are bound. The reported phenolic components of potato skins include caffeic acid, chlorogenic acid, ferulic acid, coumaric acid, protocatechic

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acid, gallic acid and vanillic acid, which play major roles in the antioxidant activity of potato skins [8, 9]. Antioxidative compounds extracted from potato peel may therefore be potential value added products that can be utilized for the feed, food and health care concerns. The antioxidant property of potato peel extract has been reported in food systems [10-15].

The aim of this work was to evaluate the antioxidant activity of potato peel extracts, employing various *in vitro* assay systems, such as DPPH/nitric oxide/hydroxyl radical scavenging and iron ion chelation.

MATERIALS AND METHODS

Plant Material: Potato tubers (*Solanum tuberosum* cv. Diamond) were purchased from a local market at Giza, Egypt.

Chemicals: Ascorbic acid, 1,1-diphenyl-2-picrylhydrazyl (DPPH), sulfanilamide, N-(1-naphthyl) ethylenediamine dihydrochloride, 2-deoxyribose and ferrous sulphate were purchased from Sigma Chemical Co., USA. All other chemicals were of analytical reagent grade.

Preparation of Potato Peel Extracts: Two different extracts were prepared from potato peels using the procedure described by Singh and Rajini [16] with some modifications as follows: Potato tubers were washed with tap water and peeled manually using a kitchen vegetable peeler. The peels were air dried (in shade, 25-30°C) for one week and powdered by using blender. The potato peel powder (0.5 g) was macerated in 10 ml of distilled water or ethanol 80% for 24h at room temperature and was stirred three times. The mixture was centrifuged at 5000 rpm for 10 min. The supernatant was filtered through Whatman No.1 filter paper. The resulting filtrate was used as water potato peel extract (WPPE) or ethanol potato peel extract (EPPE). The total solids (%) in both extracts WPPE and EPPE were determined by the dry weights following drying at 100°C until constant mass was achieved. In all assays, concentrations of potato peel extracts (WPPE or EPPE) were calculated as potato peels equivalent.

Determination of Total Phenolics Content (TPC): TPC was determined spectrophotometrically in potato peel extracts using Folin-Ciocalteau method as described by Gao *et al*. [17] as follows: Potato peel extract (100µl) was mixed with 0.2 ml of Folin-Ciocalteu reagent, 2.0 ml of H_2O and 1.0 ml of 15% Na_2CO_3 solution. The developing color was measured at 765 nm after 2 h at room temperature using Jenway 6300 spectrophotometer. The concentration was calculated from the standard curve prepared using serial concentrations of standard gallic acid solution.

Determination of Total flavonoids Content (TFC): TFC was determined in potato peel extracts using the method described by Kumaran and Karunakaran [18] as follows: One milliliter of each potato peel extract was mixed with 1.0 ml of aluminium trichloride in ethanol (20 mg/ml) and a drop of glacial acetic acid then diluted with ethanol to 25 ml. The absorption at 415 nm was read after 40 min using Jenway 6300 spectrophotometer. Blank was prepared using 1.0 ml of potato peel extract and a drop of glacial acetic acid then diluted to 25 ml with ethanol. The absorption of standard quercetin solution (0.5 mg/ml in ethanol) was measured under the same conditions. The amount of total flavonoids content in potato peel extracts in quercetin equivalents (QE) was calculated by the following equation:

$$X = (A * m_0)/ (A_0 * m)$$

where: X is the flavonoids content (mg/mg potato peel extract in QE), A is the absorption of potato peel extract solution, A_0 is the absorption of standard quercetin solution, m is the weight of potato peel (mg) in potato peel extract and m_0 is the weight of quercetin in the solution (mg).

Determination of Total Antioxidant Capacity: Total antioxidant capacity of potato peel extracts was assayed by the phosphomolybdenum method as described by Kumaran and Karunakaran [18] as follows: Known volumes (0.1-0.3 ml) of each potato peel extract were added to test tube then completed to a constant volume (0.3 ml) with DW. 3.0 ml of reagent solution (0.6 *M* sulphuric acid, 28.0 m*M* sodium phosphate and 4.0 m*M* ammonium molybdate) were added to each tube and mixed well then incubated at 95°C for 90 min. Blank was prepared by the same procedure without potato peel extract. Ascorbic acid solution (0.03%, w/v) was used as positive control. After cooling to room temperature, the absorbance of the solution was measured at 695 nm using Jenway 6300 spectrophotometer against blank. Increased absorbance of the reaction mixture indicated increased total antioxidant capacity.

Determination of Reducing Power: The reducing power of potato peel extracts was determined by the method of Mathew and Abraham [19] as follows: In clean test tubes,

a serial of known volumes (0.2-0.8 ml) of each potato peel extract were added. The solutions were completed to 1.0 ml with DW. 2.5 ml of phosphate buffer solution (0.2 *M*, pH 6.6) and 2.5 ml of potassium ferricyanide solution (1%, w/v) were added to each tube then mixed well. The mixtures were incubated at 50°C for 20 min. After incubation, 2.5 ml of trichloroacetic acid solution (10%, w/v) were added to each mixture then centrifuged at 5,000 rpm for 10 min. A known volume (2.5 ml) of each clear solution obtained after centrifugation (supernatant) was taken in another clean test tube then 2.5 ml of DW and 0.5 ml of ferric chloride solution (0.1%, w/v) were added and mixed well. The absorbance was measured at 700 nm using Jenway 6300 spectrophotometer. Blank was prepared by the same procedure without potato peel extract. Ascorbic acid solution (0.03%, w/v) was used as positive control. Increased absorbance of the reaction mixture indicated increased reducing power.

Assay of DPPH Radical Scavenging Activity: The antioxidant activity of potato peel extracts, based on the scavenging activity of the stable DPPH free radical, was determined by the method described by Lee *et al*. [20] as follows: Known volumes (0.2-0.7ml) of potato peel extract were individually added to test tubes then completed to a known volume (1.0 ml) by DW. 1.0 ml of DPPH solution (0.2 m*M* in ethanol) was added to each tube then mixed well and incubated at room temperature for 30 min. Control was prepared by the same procedure without potato peel extract. Ascorbic acid solution (0.03%, w/v) was used as a positive control. The absorbance (A) of the solution was measured at 517 nm using Jenway 6300 spectrophotometer. Inhibition of DPPH free radical in percent (I%) was calculated from the following equation:

$$I\% = [(A_c - A_s)/A_c] \times 100$$

Assay of Nitric Oxide Scavenging Activity: The scavenging activity of nitric oxide by potato peel extracts was determined by the method described by Kumaran and Karunakaran [18] as follows: In clean test tubes, 0.5 ml of sodium nitroprusside solution (10 m*M* in 0.1 *M* phosphate buffer saline, pH 7.4) was mixed with different volumes of potato peel extract (0.15-0.50 ml) then DW was added to each tube to complete the solution to a known volume (1.0 ml). The test tubes were incubated at room temperature for 150 min then 0.5 ml of Griess reagent (1% sulfanilamide, 2% H_3PO_4 and 0.1% *N*-(1-naphthyl) ethylenediamine dihydrochloride) was added to each tube and mixed well. The absorbance (A) was measured at 546 nm using Jenway 6300 spectrophotometer. Control was prepared by the same procedure without extract. Ascorbic acid solution (0.03%, w/v) was used as positive control. Scavenging activity of nitric oxide was calculated from the following equation:

$$\text{Scavenging activity (\%)} = [(A_c - A_s)/A_c] \times 100$$

Assay of Hydroxyl Radical Scavenging Activity: The scavenging activity of hydroxyl radical by potato peel extracts was assayed by deoxyribose method as described by Nagai *et al*. [21] as follows: In a clean test tubes, 0.45 ml of sodium phosphate buffer solution (0.2 *M*, pH 7.0), 0.15 ml of 2-deoxyribose solution (10 m*M*), 0.15 ml of $FeSO_4$-EDTA solution (10 m*M* $FeSO_4$, 10 m*M* EDTA), 0.15 ml of H_2O_2 solution (10 m*M*) and potato peel extract (0.04-0.10 ml) were added. The solutions were completed to a final volume (1.5 ml) with DW then incubated at 37°C for 4h. After incubation, the reaction was stopped by adding 0.75 ml of trichloroacetic acid solution (2.8%, w/v) and 0.75 ml of thiobarbituric acid solution (1% in 50 m*M* NaOH solution) then the solutions were boiled for 10 min and cooled. The absorbance (A) of the solution was measured at 520 nm using Jenway 6300 spectrophotometer. Control was prepared by the same procedure without extract. Ascorbic acid solution (0.03%, w/v) was used as positive control. Inhibition of deoxyribose degradation in percent (I%) was calculated using the following equation:

$$I\% = [(A_c - A_s)/A_c] \times 100$$

Assay of Fe^{2+} Chelating Activity: The ability of potato peel extracts to chelate ferrous (Fe^{2+}) ion was determined using a modified method of Minotti and Aust [22] as described by Oboh *et al*. [23]. In a clean test tube, 150µl of freshly prepared ferrous sulphate solution (500 µ*M*) were added to a reaction mixture consisted of 168µl of Tris–HCl buffer solution (0.1 *M*, pH 7.4) and potato peel extract (9-20µl). The solution was completed by saline solution (0.9% NaCl, w/v) to a known volume (561µl). The reaction mixture was incubated for 5 min at room temperature before the addition 13µl of 1, 10-phenanthroline solution (0.25%, w/v). The absorbance (A) was measured at 510 nm using Jenway 6300 spectrophotometer. Control was prepared by the same procedure without extract. Ascorbic acid solution (0.03%, w/v) was used as positive control. The Fe^{2+} chelating activity (%) was calculated from the following equation:

Fe^{2+} chelating activity (%) = $[(A_c - A_s)/A_c] \times 100$

GC–MS Analysis: The GC-MS analysis of ethanolic extract of potato peels was performed using a GC (Agilent Technologies 7890A) interfaced with a mass-selective detector (MSD, Agilent 7000) equipped with an a polar Agilent HP-5ms (5%-phenyl methyl poly siloxane) capillary column (30 m × 0.25 mm ID and 0.25µm film thickness). The carrier gas was helium with the linear velocity of 1ml/min. The identification of components was based on a comparison of their mass spectra and retention time with those of the authentic compounds and by computer matching with NIST and WILEY library as well as by comparison of the fragmentation pattern of the mass spectral data with those reported in the literature.

Statistical Analysis: The results were analysed by an analysis of variance (P<0.05) and the means separated by Duncan's multiple range test. The results were processed by CoStat computer program (1986).

RESULTS AND DISCUSSION

Since the antioxidant compounds found in plants have different polarities, different solvents are used to isolate these compounds. Water, methanol, ethanol and acetone are solvents commonly used in extraction processes. The antioxidant activity of the extract and the yield depends on the selected solvent [24]. In this study, water and ethanol were preferred as solvents for the extracts to be prepared. A number of methods and modifications have been proposed to determine antioxidant activity. Total antioxidant activity, metal chelation, radical scavenging (DPPH) effects and reducing power as well as activities destructive to active oxygen species such as the superoxide anion radical, hydroxyl radical and hydrogen peroxide are widely used for this purpose [25]. In this study, total antioxidant activity, reducing power, radical scavenging effects, metal chelating activity and the amounts of phenolic compounds were determined.

Phenolic and Flavonoid Contents: Phenolics constitute one of the major groups of compounds acting as primary antioxidants or free radical terminators and hence the total amount of phenolics and the content of flavonoids in potato peel extracts were determined. Water extract contained significantly (P<0.05) higher quantity of total phenolics (40.95±0.10 mg/g potato peels) when compared to ethanol extract (27.15±2.97 mg/g potato peels). On the contrary, ethanol potato peel extract contained high amount of flavonoids (15.63±1.71 mg/g potato peels) in comparison with water potato peel extract (11.80±0.85 mg/g potato peels). Total solids of WPPE and EPPE were 21.67±0.17% and 10.47±0.29%, respectively (Table 1). This finding is in agreement with earlier study reported by Habeebullah *et al.* [14]. The high content of flavonoids in the ethanol extract might be due to higher solubility of certain phenolics in ethanol than in water. The phenolic content of the potatoes varies with variety, color, geographical origin, season and storage [26, 27]. The selection of solvent and the extraction methods also affect the concentration of total phenols. Samarin *et al*. [28] studied the total phenolics content of potato peel extracts of five different solvents and two solvent extraction methods. They found that the amount of phenolic compounds in the methanolic extract was highest and total phenolic concentrations in the five solvents were in the order: methanol > water > ethanol > acetone > hexane. Due to the toxicity of methanol, it is not a preferred solvent. In this study, distilled water and ethanol were used for the extraction.

Table 1: Total solids, phenolic and flavonoid contents of potato peel extracts

Potato peel extract	Total solids (%)	Phenolics (mg/g potato peels)	Flavonoids (mg/g potato peels)
Water extract	21.67^{a}±0.17	40.95^{a}±0.10	11.80^{a}±0.85
Ethanol extract	10.47^{b}±0.29	27.15^{b}±2.97	15.63^{a}±1.71
LSD 0.05	0.94	8.25	5.29

-Values are means of three replicates ± SE. Numbers in the same column followed by the same letter are not significantly different at P<0.05.

Table 2: Total antioxidant capacity of water potato peel extract (WPPE), ethanol potato peel extract (EPPE) and ascorbic acid.

Treatment	Concentration (mg/ml)	Total antioxidant capacity ($O.D_{695\ nm}$)
WPPE	1.5	0.021^{g}±0.001
	3	0.117^{e}±0.001
	4.5	0.170^{c}±0.001
EPPE	1.5	0.041^{f}±0.002
	3	0.126^{d}±0.002
	4.5	0.186^{b}±0.002
Ascorbic acid	0.03	0.734^{a}±0.003
LSD 0.05	-	0.0056

-Values are means of three replicates ± SE. Numbers in the same column followed by the same letter are not significantly different at P<0.05.

Total Antioxidant Activity: The total antioxidant activity is based on reduction of molybdate [VI] to molybdate [V] at acid pH and formation of a green phosphate complex, which can be quantified spectrophotometrically at 695 nm. In the present study, as shown in Table 2, total

antioxidant capacity of potato peel extracts and ascorbic acid was demonstrated. The results revealed that the antioxidant activity of the potato peel extracts increased with increasing concentration of the potato peel extract. The ethanol potato peel extract seemed to be having a higher capacity than water potato peel extract. The antioxidant activities of potato peel extracts and standard were in the following order: ascorbic acid > EPPE > WPPE at different concentrations.

Reducing Power: In reducing power assay, potential antioxidants reduce the Fe^{3+}/ferricyanide complex to its ferrous form which can then be monitored spectrophotometrically at 700 nm. Increased absorbance of the reaction mixture indicates increased reducing power. The antioxidant activities of natural components may have a reciprocal correlation with their reducing powers. Table 3 shows the dose response for the reducing power of all the extracts of potato peels. The reducing power values were found to be correlated with the concentration of each extract. The ethanol extract possessed higher reducing power than water extract. Significantly high reducing power (0.487±0.02) was observed for ethanol extract at 4.5 mg/ml, while it was 0.266±0.0003 and 0.947±0.001 for water extract and ascorbic acid, respectively.

DPPH Radical Scavenging Activity: The DPPH is a very stable organic free radical with deep violet color which gives absorption maxima within the 515-528 nm. Upon receiving proton from any hydrogen donnor, mainly from phenolics, it loses it chromophore and became yellow. As the concentration of phenolic compounds or degree of hydroxylation of the phenolic compounds increases DPPH radical scavenging activity increases and with it antioxidant activity [29]. The DPPH radical scavenging shown by the extracts was concentration dependent. With an increase in concentration, the radical scavenging activity increases in the extracts of potato peels as depicted in Table 4. It was observed that ethanol extract showed strong radical scavenging activity with percentage inhibition of 89.61±0.58% compared with water extract which showed 86.97±0.62% of radical scavenging activity at concentration of 17 mg/ml with respect to ascorbic acid which showed 99.41±0.09%.

Nitric Oxide Scavenging Activity: Nitric oxide (reactive nitrogen species), formed during their reaction with oxygen or with superoxides, such as NO_2, N_2O_4, N_3O_4, NO_3^- and NO_2^- are very reactive. These compounds are responsible for altering the structural and functional behaviour of many cellular components. Nitric oxide is also implicated for inflammation, cancer and other pathological conditions [30]. Incubation of sodium nitroprusside resulted in linear time-dependent nitrite production. Data as shown in Table 5 revealed that potato peel extracts have nitric oxide scavenging activity. In general, the ability of EPPE on nitric oxide scavenging activity was higher than that of WPPE. There was a positive correlation between the concentration of potato peel extract and scavenging activity against nitric oxide. As shown in Table 5, higher concentration of EPPE and

Table 3: Total reduction capability of water potato peel extract (WPPE), ethanol potato peel extract (EPPE) and ascorbic acid

Treatment	Concentration (mg/ml)	Total reduction capability ($O.D_{700\ nm}$)
WPPE	1.5	0.134^{e}±0.002
	3	0.165^{c}±0.001
	4.5	0.266^{d}±0.0003
EPPE	1.5	0.154^{e}±0.001
	3	0.363^{c}±0.02
	4.5	0.487^{b}±0.02
Ascorbic acid	0.03	0.947^{a}±0.001
LSD 0.05	-	0.036

-Values are means of three replicates ± SE. Numbers in the same column followed by the same letter are not significantly different at $P<0.05$.

Table 4: Scavenging activities of water potato peel extract (WPPE), ethanol potato peel extract (EPPE) and ascorbic acid against DPPH radical

Treatment	Concentration (mg/ml)	Scavenging activity (%)
WPPE	5	19.48^{g}±0.56
	10	57.26^{e}±0.48
	17	86.97^{c}±0.62
EPPE	5	23.18^{f}±0.11
	10	70.04^{d}±1.31
	17	89.61^{b}±0.58
Ascorbic acid	0.1	99.41^{a}±0.09
LSD 0.05	-	1.99

- Values are means of three replicates ± SE. Numbers in the same column followed by the same letter are not significantly different at $P<0.05$.

Table 5: Nitric oxide scavenging activities of water potato peel extract (WPPE), ethanol potato peel extract (EPPE) and ascorbic acid

Treatment	Concentration (mg/ml)	Scavenging activity (%)
WPPE	5	17.08^{e}±1.35
	10	18.54^{e}±0.45
	17	22.81^{d}±0.74
EPPE	5	38.77^{c}±0.51
	10	45.07^{b}±0.61
	17	65.48^{a}±0.62
Ascorbic acid	0.1	10.71^{f}±0.88
LSD 0.05	-	2.39

- Values are means of three replicates ± SE. Numbers in the same column followed by the same letter are not significantly different at $P<0.05$.

Table 6: Hydroxyl radical scavenging activities of water potato peel extract (WPPE), ethanol potato peel extract (EPPE) and ascorbic acid

Treatment	Concentration (mg/ml)	Scavenging activity (%)
WPPE	0.8	11.39^{g}±0.81
	1.3	23.50^{e}±0.75
	1.7	35.59^{d}±1.27
EPPE	0.8	65.08^{c}±0.81
	1.3	80.21^{b}±0.88
	1.7	83.33^{a}±0.56
Ascorbic acid	0.01	16.38^{f}±0.56
LSD 0.05	-	2.57

- Values are means of three replicates ± SE. Numbers in the same column followed by the same letter are not significantly different at $P<0.05$.

Table 7: Metal chelating activities of water potato peel extract (WPPE), ethanol potato peel extract (EPPE) and ascorbic acid.

Treatment	Concentration (mg/ml)	% Fe Chelation
WPPE	0.8	31.25^{e}±0.19
	1.3	52.17^{d}±0.45
	1.7	64.93^{b}±0.38
EPPE	0.8	31.41^{e}±0.19
	1.3	59.22^{c}±0.37
	1.7	67.55^{a}±0.16
Ascorbic acid	0.01	7.93^{f}±0.11
LSD 0.05	-	0.90

- Values are means of three replicates ± SE. Numbers in the same column followed by the same letter are not significantly different at $P<0.05$.

WPPE (17mg/ml) possessed nitric oxide scavenging activity 65.48±0.62 and 22.81±0.74%, respectively and more than that of 0.1mg/ml of ascorbic acid. Accordingly, potato peel extracts may have the potential to counteract the effect of NO formation and in turn may be of considerable interest in preventing the destructive effects of excessive NO generation in the human body. Further, the scavenging activity may also help to arrest the chain of reactions initiated by excess generation of NO that are detrimental to the human health.

Hydroxyl Radical Scavenging Activity: Hydroxyl radical scavenging activity was quantified by measuring the inhibition of the degradation of 2-deoxyribose by the free radicals generated by the Fenton reaction. The percentage of hydroxyl radical scavenging activity increased with the increasing concentration of extracts (Table 6). The maximum scavenging activity was observed with EPPE, 65.08±0.81%, 80.21±0.88 and 83.33±0.56% at concentrations of 0.8 mg/ml, 1.3 mg/ml and 1.7 mg/ml, respectively, followed by WPPE which showed 11.39±0.81%, 23.50±0.75 and 35.59±1.27% at 0.8 mg/ml, 1.3 mg/ml and 1.7 mg/ml, respectively. At concentrations of 0.01 mg/ml, the scavenging activity of ascorbic acid was found to be 16.38±0.56%. Scavenging activity was found in the following order: EPPE > WPPE > ascorbic acid.

Metal Chelating Activity: Ferrous ion can initiate lipid peroxidation by the Fenton reaction as well as accelerating peroxidation by decomposing lipid hydroperoxides into peroxyl and alkoxyl radicals [31]. 1, 10-phenanthroline can make complexes with ferrous ions. In the presence of chelating agents, complex (red colored) formation is interrupted and as a result the red color of the complex is decreased. Thus, the chelating effect of the coexisting chelator can be determined by measuring the rate of color reduction. The formation of the 1, 10-phenanthroline -Fe^{2+} complex is interrupted in the presence of potato peel extracts, indicating their chelating activity (Table 7). Chelating agents that form bonds with a metal are effective as secondary antioxidants because they reduce the redox potential and thereby stabilize the oxidized form of the metal ion [32]. Our study showed that potato peel extracts had a marked capacity for iron binding, suggesting the presence of polyphenols that have potent iron chelating capacity.

GC-MS Analysis: The phenolic compounds present in the ethanolic extract of potato peels were identified by GC-MS analysis. The active phenolics with their retention time (RT) and concentration (%) in the ethanolic extract of potato peels are presented in Table 8. Five compounds were identified in ethanol extract by GC-MS. The main phenolic compounds present in the ethanolic extract of potato peels were Chromone, 5-hydroxy-6, 7, 8-trimethoxy-2, 3-dimethyl (2.74%), Kampferol-3, 4'-dimethyl ether (10.66%), 3', 4', 7-Trimethylquercetin (24.54%), Lucenin 2 (16.15%) and [+]-10, 11-cis-Dihydro-10-isopropyl-4-propyl-6,6,11-trimethyl-2H, 6H, 12H-benzo [1, 2-b:3, 4:b', 5, 6-b''] tripyran-2, 12-dione (45.91%). The latter compound is the major component found in the ethanolic extract of potato peels. Due to the presence of above mentioned compounds in the ethanolic extract of potato peels, it can be used in various pharmaceutical and industrial applications.

Crude extracts of fruits, herbs, vegetables, cereals, nuts and other plant materials rich in phenolics are increasingly of interest in the food industry. The importance of the antioxidant constituents of plant materials in the maintenance of health and protection from coronary heart disease and cancer is also raising interest among scientists, food manufacturers and consumers [33]. In this study, the ethanol potato peel extracts showed strong antioxidant activity, reducing power, DPPH radical, hydroxyl radical scavenging, nitric oxide scavenging and metal chelating activities when compared to water potato peel extract. The antioxidative activity of potato peel

Table 8: Phenolic compounds identified in the ethanolic extract of potato peels by GC-MS

No.	RT (min)	Name of the compound	Peak area (%)
1	8.83	Chromone, 5-hydroxy-6,7,8-trimethoxy-2,3-dimethyl	2.74
2	16.11	Kampferol-3,4'-dimethyl ether	10.66
3	19.60	3',4',7-Trimethylquercetin	24.54
4	20.43	Lucenin 2	16.15
5	22.37	[+]-10,11-cis-Dihydro-10-isopropyl-4-propyl-6,6,11-trimethyl-2H,6H,12H-benzo[1,2-b:3,4:b',5,6-b"]tripyran-2,12-dione	45.91

extracts is attributed to their contents of phenolic components [28, 34]. The obtained results showed that the ethanol potato peel extract possessed higher antioxidative activity in comparison with water potato peel extract. This is may be due to the types of phenolic components especially flavonoids (Tables 1 and 8). Therefore, it seems obvious that the presence of phenolic compounds is fundamental for free radical scavenging activity. The activity of antioxidant has been assigned to various mechanisms such as prevention of chain initiation, binding of transition-metal ion catalysts, decomposition of peroxides, prevention of continued hydrogen abstraction, reductive capacity and radical scavenging [35].

CONCLUSION

Finally, it could be concluded that potato peel extracts can be effectively used as a new source of a natural antioxidative that may be used in food industry.

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