

# Determination of integral antioxidants capacity in Syrian hawthorn fruits and flowers using photochemiluminescence assay

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## Summary

Syrian flora is very well known of its diversity and richness. It contains a large number of medicinal and aromatic species. There are many different hawthorn *Crataegus: sinaica, aronia, monogyna* and *azorolus* available in Syria which is mainly located in the western and southern part of the country. Most of these Syrian species are used in folk and in traditional medical care. They are taken in the form of herbal tea to contradict cough, flu and cold. There is no any scientific information available on the antioxidant properties of Syrian *hawthorn* medicinal plant. Therefore, the assessment of such properties remains an interesting and useful task, particularly for finding a new natural source of antioxidants available in Syria. Therefore, the integral antioxidants, IA of Syrian hawthorn fruits and flowers in five different sites as ascorbic acid equivalents have been carried out using photochemiluminescence, PCL assay of measurements for the first time.

By means of a PCL assay, it was possible to assess the integral antioxidant (IA) using this accurate and simple method, the highest antioxidant capacity values of hawthorn as ascorbic acid equivalents were found in the fruits of Bi'r Al-ajam and Al-Haffa sites which have values of 1444.82 and 483.44 (nmol/g), for *C. monogyna* and *C. aronia* cataegus, respectively. The highest fractions of antioxidant components are mainly due to the existence of catechin and flavonoids in both Syrian hawthorn fruit and flowers. Other chemical constituents like elemicin, sorbistat, polygalitol and homocatechol are found in Syrian hawthorn fruit and flowers. The measured values are considered to be the highest among countries of the region.

**Key words:** antioxidant capacity, ascorbic acid equivalents, photochemiluminescence, hawthorn *Crataegus sinaica, Crataegus aronia, Crataegus monogyna, Crataegus azorolus, medicinal plants*

## INTRODUCTION

A great number of aromatic, spicy, medicinal and other plants contain chemical compounds exhibiting antioxidant properties. Numerous studies were carried out on some of these plants, e.g. rosemary, sage, oregano etc. which resulted in a development of natural antioxidant formulations for food, cosmetic and other applications. [1]. Leaves, flowers and fruits of wild different hawthorn *Crataegus* in particular are used for production of pharmaceuticals with cardtonic, coronary vasodilatoric and hypotensive action. Many pharmacological studies suggested that hawthorn extract has considerable effect on the cardiovascular system including the reduction of blood pressure and total plasma cholesterol and the treatment of congestive heart failure. High amounts of flavonoids and phenolics are accumulated in leaves, flowers and fruit of hawthorn are important parameters of quality. Flavonoids and phenolic compounds have also many biological effects, including hepatoprotective, antibacterial and anticancer activities. The physiological advantages of phenolic compounds are in general due to their antioxidant and free radical scavenging properties. Chemical and biological diversity of aromatic and medicinal plants depending on various factors: cultivation area, climatic conditions, vegetation phase, genetic modifications and others of very important impetus to study flora present in different growing sites, countries and geographical zones. The genus *Crataegus*, *Hawthorn* is considered to be one of the oldest pharmaceutical plants and it is widely prescribed or used in medicine for production of pharmaceuticals with cardtonic, coronary vasodilatoric and hypotensive action as well as also many biological effects, including hepatoprotective, antibacterial and anticancer activities [2, 3-7].

Zhen-Yu Chen and co-workers characterized the antioxidants of hawthorn fruit and their effect on the oxidation of human low density lipoprotein (LDL) and  $\alpha$ -tocopherol. Eight pure compounds, namely ursolic acid, hyperoside, isoquercitrin, epicatechin, chlorogenic acid, quercetin, rutin and protocatechuic acid were separated [8]. All the previous isolated compounds are phenolics except ursolic acid. They were protective to human LDL from  $\text{Cu}^{+2}$ -mediated LDL oxidation. They were also effective of preventing the proxy free radical-induced oxidation of  $\alpha$ -tocophero in human LDL. The highest concentration of antioxidant was found in epicatechin with a concentration of  $178.3 \pm 6.6$  mg/100 g dry fruit [8].

Changjiang Guo *et. al.* determined the antioxidant activity of peel, pulp and seed fractions of 28 fruits consumed in China using the ferric reduction/antioxidant power assay (FRAP assay). Their results showed that hawthorn pulp had the highest FRAP value ( $13.42 \pm 0.74$  mmol/100g wet weight) among all fruit pulp [9]. It is concluded that peel and seed fractions of some fruits, such as pomegranate peel, grape seed, hawthorn peel longan and lychee seeds possessed relatively high antioxidant activity and might be rich sources of natural antioxidants [9].

The contents of total phenolic compounds of five plant materials native to Mediterranean area – olive tree (*Olea europaea*), St. John's wort (*Hypericum perfo-*

ratum), hawthorn (*Crataegus laevigata*), oregano (*Origanum vulgare*) and laurel leaf (*Lauris nobilis*) were determined by Zeljko Knez and co-workers using Folin-Ciocalteu method [10]. Antioxidant activities of apigenin, luteolin, kaempferol, myricetin and quercetin of plant extracts were examined. Antioxidative activities were studied in sunflower oil at 98°C, by measuring peroxide value, and in an aqueous emulsion system of  $\beta$ -carotene and linoleic acid by measuring the absorbance. The total phenols, proanthocyanidins and flavonoids of hawthorn were found at 160 g/kg, 40.6 g/kg and 245 mg/kg, respectively. The highest concentration of quercetin in hawthorn was found at 241 mg/kg [10].

The *Crataegus aroniasyn*, *azarolus*, the hawthorn possesses considerable antioxidant potential and is not cytotoxic. The therapeutic benefit of *Crataegus aronia* can be, at least in part, attributed to its effective inhibition of oxidative processes, efficient scavenging of  $O_2^{\cdot-}$  and possible increasing GSH biosynthesis [11]. Capillary Zone electrophoresis (CZE) was used to evaluate the influence of vegetation period on the extract qualitative composition and flavonoids quantities of hawthorn (*Crataegus monogyna* Jacq and f. *Rosaceae* juss.) in leaves and sprouts. The work was extended to investigate the effects of extract preparation, its storage conditions, raw material collection on the flavonoids composition in the extracts [12].

Antioxidant activity of the phenolic compounds of hawthorn pine and skullcap using AAPH assay has been carried out [13]. It has been found that the best effects were observed in the samples containing procyanidins of hawthorn at 6 and 12 ppm concentrations and they did not statistically differ from the antioxidative activity of trolox and BHT. The significantly worst results were observed in the samples containing 6 ppm of flavones of skullcap or procyanidins of pine [13].

Relative and total antioxidant capacity and cytoprotective activities of common herbs including hawthorn (*Crataegus pinnatifida*) have been carried out by Chang Yong Lee and co-worker. Total phenolics, total flavonoids, total antioxidant and DPPH of hawthorn were found at 817 mg GAE/100 g, 407.8 mg CE/100 g, 929.4 mg VCE/100 g and 84.5%, respectively [14].

A number of assays have been developed for the detection of both general and specific antioxidants action of complex mixtures [15]. Some of the following assays and many others were widely used: TEAC for long life radical anions [16], DPPH for measuring the antioxidants capacity in fruit and vegetable juices or extracts [17], TRAP for monitoring the antioxidant compounds interference as the results of the reaction between peroxy ( $ROO^{\cdot}$ ) radicals and the target probe [18] ORAC for measuring the antioxidant capacity in botanical samples [19] and FRAP for the antioxidant efficiency of the sample as a result of reduction of ferric to ferrous which give a blue intense blue color line at 595 nm with a reference of known  $Fe^{2+}$  concentration [20].

Syrian flora is very well known for its diversity and richness. It contains a large number of medicinal and aromatic species. There are many different hawthorn *Crataegus*: *sinaica*, *aronia*, *monogyna* and *azarolus* available in Syria which is mainly found in the western and southern part of the country. The *Crataegus* hawthorn

belongs to the Rosaceae family. It is considered to be one of the most important members of the Syrian flora. Most of these Syrian species are used in folk and in traditional medical care and is taken in the form of herbal tea to contradict cough, flu and cold.

There are no evaluations of antioxidant capacity of Syrian *hawthorn* medicinal plant. Therefore, the objective of this study is to find out and evaluate a new source of Syrian natural antioxidants *hawthorn* fruit and flowers available in Syria using photochemiluminescence, PCL assay.

## MATERIALS AND METHODS

### Samples collection and preparation of the extract

Two collections at ripening and flowering times of hawthorn each year (2006-2007) were carried out. The fruit were collected in the autumn while the flowers were collected in the spring from five different sites located in the coastal part of Syria (West of the country) and in the south. The sites were: Al-Haffa, Zabadani, Gota, As Suwayda and Bi'r Al-ajam which is very close to Golan Height. (tab. 1, 2).

Each category (flower or fruit) from the five different sites was separated, the four similar category samples from each site were washed and dried followed by being ground into machine powered by grinding and collected separately (fruit and flowers). After that, the samples were mixed thoroughly until the homogeneity then divided into portions and each portion was weighted 15 g of dried sample.

Similar extraction processes were carried out on the fruit and flowers samples as follows: 15 g of fruit or flowers samples powder were extracted three times with methanol (150 ml) for 24 hours at room temperature. The pooled filtrates materials were concentrated under reducing vacuum pressure.

The obtained brown solutions were filtered using a 0.45  $\mu\text{m}$  filter. The solvents were evaporated under vacuum (0.2 torr) using a rotavaporator leaving solid brown material and the yield of extraction was determined in wt% (60%). The solid extracts were stored in dry, dark and cool place for antioxidant measurements.

### Analysis of extracts and identifications

50 mg of the brown extract material was dissolved in 20 ml distilled water and 30 ml of pure methanol. After refluxing at 90°C for about three hours, the extract was cooled and the volume was completed to 50 ml.

The separated components were carried out using a JASCO- LC- 1500 semi preparative high performance liquid chromatograph, HPLC equipped with UV/VIS detector and ODS C18 preparative column. The following operation conditions

were: THF/Acetonitrile /H<sub>2</sub>O as a mobile phase, a flow rate of 1.3 ml per minute with the injected sample volume of 150 μl, and the analysis time was about 95 min. The used wave length was 205 nm. Retention times of some individual constituents were compared with those of available authentic samples in order to check the credibility of the determinations. The identification of all separated components from five collection sites were carried out using GC-MS (Agilent, 6869) under the following conditions: column HP5-MS, injection temperature 280°C, source temperature 230-280°C, fragment energy 70eV and the volume injection 1 μl. It should be pointed out here, that all the used chemicals were of HPLC grade and were purchased from Merck.

### Photochemiluminescence (PCL)

The PCL method was applied as described by Popov and Lewin [21]. The PCL assay is easy and rapid to perform and has many advantages over other assays. It does not require high temperatures to generate radicals and it is more sensitive (nanomolare range) to measure within few minutes (≤3 min.) the scavenging activity of antioxidants against the superoxide radical (O<sub>2</sub><sup>•-</sup>) which is one of the most reactive oxygen species occurring in human body [22]. While, most of the other methods (like TEAC, TRAP, DPPH, ORAC and FRAP) determine the antioxidant activity in micromolar range and it requires minutes or hours. In the previous methods, the measuring of antioxidant activity involves the generation of radical species and the presence of antioxidant causing the disappearance of these radicals. The PCL assay has been applied by many research groups for its advantages [23, 24]. The use of PCL assay for the measurement of integral antioxidant capacity in different herbs and medicinal plants is widely applied [15]. The water soluble antioxidant capacity of different teas by PCL assay was determined [23]. The antioxidant capacity of *Adansonia digitata* fruit pulp and leaves using PCL assay was also reported [24]. The evaluation of food antioxidant activity by modified method of photostoragechemiluminescence (PSCL) generated from photolyzed acridine and strong base was carried out [25].

The PCL principal is as follows: the photochemical generation of free radicals is combined with the sensitive detection using chemiluminescence's process. The PCL method differs from other procedures of antioxidant evaluation principally because it does not require oxidizing reagents for the production of the radical species. The PCL method is based on the photo-induced auto-oxidation inhabitation of luminol by antioxidants, mediated from the radical anion superoxide O<sub>2</sub><sup>•-</sup> and is suitable to measure the radical scavenging properties of single antioxidants as well as more complex systems in the nanomolare range. Therefore, the photochemical generation of free radicals is combined with sensitive detection method using chemiluminescence process. This reaction is induced by optical excitation (hν) of a photosensitizer S, the overall process is as follows:



The free radicals are visualized with a chemiluminescence detection reagent – luminol; this acts as photosensitizer as well as oxygen radical detection reagent. The antioxidant potential is measured by means of the lag phase at different concentrations, calculated according to ascorbic acid or Trolox calibration curve and expressed as mmol equivalents in antioxidant activity, AC with a reference compound (i.e. Trolox for lipid-soluble substances, ACL protocol and ascorbic acid for water-soluble substances, ACW protocol)

## Antioxidant measurements

The integral antioxidative capacity of water-soluble substances, ACW protocol has been carried out. The water soluble fraction antioxidants presented in *hawthorn* fruits and flowers have been measured. All the required reagent kits were purchased from Analytik-Jena, Germany. The water-soluble substances, ACW protocol) can be explained as follows: The first three reagents can be described as follows: reagent 1 (solvent), reagent 2 (water buffer solution, pH 10.5), while reagent 3 (photosensitizer). Working solution of reagent 3 (**3-WS**) has been prepared by taking reagent 3 stock solution and then diluted with 750 $\mu$ l of reagent 2. The working solution of reagent 4 (**4-WS**) has been prepared by taking reagent 4 stock solution and then adding to it 490 $\mu$ l of reagent 1 and mixed with 10 $\mu$ l of H<sub>2</sub>SO<sub>4</sub> with a concentration of 95-97% from Merck. The mixture was stirred for 30 seconds. From this mixture, 10 $\mu$ l was taken and diluted with 990 $\mu$ l of reagent 1 to obtain the working solution 4 (**4-WS**). All the procedures and volumes used in the analysis are given in table 3.

The ACW calibration and measurements were performed according to the standard kit protocol as mentioned in the above table and the measurements were done by Photochem® apparatus (Analytik-Jena, Germany). All used volumes were in microliters and the measurements were repeated two times. A light emission curve was recorded over 240 seconds, using inhibition as a parameter to evaluate antioxidant potential. The antioxidant capacity was determined using the integral under the curve and was expressed as mmol/l of ascorbic acid used as standard to obtain the calibration curve.

## RESULTS

Seventeen fractions from four different *Crataegus* categories were separated by HPLC-semi preparative and then identified using GC-MS and the results were summarized in Table 4 showing the percentage of each fraction. The accounting identification of *C. sinaica* was about 33.56% and 37.96% for flowers and fruit, respectively and the highest fraction percentage for flowers and fruit was for Catechin at about 6.96% and 8.31%, respectively. The accounting identification of *C.*

*aronia* was about 33.95% and 46.60% for flowers and fruit, respectively and the highest fraction percentage for flowers and fruit was for Catechin at about 7.21% and 9.54%, respectively. It seems, that the second highest account identification is presented in the fruit of *C. aronia*. The accounting identification of *C. monogyna* was about 34.10% and 46.84% for flowers and fruit, respectively and the highest fraction percentage for flowers and fruit was for Catechin at about 12.32% and 13.64 %, respectively. It seems that, the first highest account identification is presented in the fruit of *C. monogyna*. Note that, the highest catechin percentages are found in both flowers and fruit of *C. monogyna*. Finally, the accounting identification of *C. azorolus* was about 31.62% and 43.78 % for flowers and fruit, respectively and the highest fraction percentage for flowers and fruit was also for Catechin at about 10.86% and 12.33%, respectively. It should be mentioned here that the highest observed Catechin in all four categories is presented in the fruits as the result of its concentration at the end of ripening which is consistent with expectations. The second highest identified fractions in all four categories are in the form of flavones. The percentage of flavones varies in the ranges from 3.49% to 4.77%. Once again the first highest catechin fractions are shown in the fruit of all four categories: *C. sinarica*, *C. aronia*, *C. monogyna* and *C. azorolus* which have a value of 8.31, 9.54, 13.64 and 12.33%, respectively. The second highest flavones fractions are shown also in the fruit of all four categories: *C. sinarica*, *C. aronia*, *C. monogyna* and *C. azorolus* which have a value of 4.11, 4.77, 4.87 and 4.21%, respectively.

It is very interesting to see that both catechin and flavones fractions are presented in the fruit of *C. monogyna* category which have a value of 13.64 and 4.87%, respectively.

Table 4 summarizes all the identified fractions of hawthorn obtained by GC-MS measurements. Note that, the first total identified fractions are found in the fruit of *C. monogyna* which has a value of 46.84%. The second identified fractions are found in the fruit of *C. aronia* which has a value of 46.60% which is very close to the fruit of *C. monogyna* category. All the fractions identified using GC-MS technique have been summarized in table 4.

## DISCUSSION

As it was stated before, the reported work is aimed to quantify the total antioxidant capacity of hawthorn in the four categories: *C. sinarica*, *C. aronia*, *C. monogyna* and *C. azorolus*. Table 5 shows the total water-soluble antioxidant capacity, corresponding to the activity expressed as nmol equivalent of ascorbic acid for each gram of tested product.

As stated in table 5, the highest antioxidant capacity values of hawthorn as ascorbic acid equivalents were found in the fruits of Bi'r Al-ajam and Al-Haffa sites which have values of 1444.82 and 483.44 (nmol/g), respectively. Referring to table 1, the *C. monogyna* family has the highest fractions of antioxidant components

which are mainly due to existence of catechin and flavonoids in both hawthorn fruit and flowers. This observation is in consistent with the results reported in table 4.

Table 1.

The collected hawthorn *Crataegus* from five different sites

site	Hawthorn <i>Crataegus</i>	source
Al-Haffa	<i>C. aronia</i>	fruit
	<i>C. monogyna</i>	flower
Zabadani	<i>C. monogyna</i>	fruit
	<i>C. aronia</i>	flower
Gota	<i>C. monogyna</i>	fruit
	<i>C. azarolus</i>	flower
As Suwayda	<i>C. azarolus</i>	fruit
	<i>C. aronia</i>	flower
Bi'r Al-ajam	<i>C. monogyna</i>	fruit
		flower

Table 2.

Meteorological parameters for the five investigated sites

plant	site	annual average humidity (%)	annual average rainfall [mm]	atitude [m]
<i>hawthorn fruit and flowers</i>	Al-Haffa	50–90	1000	1100
	Zabadani	30–80	500	1200
	Gota	30–80	210	750
	As Suwayda	40–80	350	1100
	Bi'r Al-ajam	40–80	350	1039

Table 3.

Pipetting scheme for sample preparation measurements

reagent	1	2	3–WS	4–WS	sample
blank	1500 $\mu$ l	1000 $\mu$ l	25 $\mu$ l	0	0
calibration	1500 $\mu$ l-x	1000 $\mu$ l	25 $\mu$ l	x	0
measurements	1500 $\mu$ l-y	1000 $\mu$ l	25 $\mu$ l	0	y

x= 10, 15, 20  $\mu$ l, y= 10  $\mu$ l, WS – working solution



Table 4.

Fractions identified from four different hawthorn categories using GC-MS technique

<i>C. azarolus</i>		<i>C. monogyna</i>		<i>C. aronia</i>		<i>C. sinaica</i>		Hawthorn
fruit	flowers	fruit	flowers	fruit	flowers	fruit	flowers	active separated fractions (%)
12.33	10.86	13.64	12.32	9.54	7.21	8.31	6.96	catechin
4.21	3.65	4.87	4.23	4.77	4.39	4.11	3.49	flavones
1.23	0.96	1.66	1.23	1.73	0.21	1.33	1.11	butylated hydroxytoluene
1.98	0.98	2.01	1.12	2.98	2.01	1.94	2.31	crotonolactone
1.79	1.21	1.87	1.65	3.22	2.65	2.98	3.69	elemicin
3.54	2.65	2.39	1.76	2.92	3.25	2.14	1.33	sorbistat
–	1.65	2.79	1.69	3.67	2.66	1.03	2.67	polygalitol
–	0.13	–	0.26	0.15	0.11	0.18	0.14	phenol 2-methoxy
1.33	–	1.92	–	2.31	–	1.79	–	myristicin
2.39	2.54	2.14	1.69	1.88	1.36	1.92	1.97	hydroquinone
0.31	0.12	0.42	0.21	0.24	0.11	0.18	0.68	furfural
2.98	0.98	1.85	1.23	2.78	3.29	2.91	2.65	homocatechol
3.54	1.36	2.33	1.12	2.01	1.32	2.11	1.65	glucitol
1.36	–	1.78	–	1.47	–	1.05	–	1,4 anhydro-d-galactitol
2.14	1.54	2.67	2.01	2.37	1.57	2.46	1.96	eersol
1.67	0.76	1.49	0.69	1.54	0.22	1.97	1.22	Inoleric acid
2.98	2.23	3.11	2.89	2.92	3.59	2.17	1.11	digitoxose
43.78	31.62	46.84	34.10	46.60	33.95	37.96	33.56	total%

Table 5.

Presents the integral antioxidant capacity as ascorbic acid equivalent using PCL assay

site	hawthorn <i>Crataegus</i>	source <sup>a</sup>	integral antioxidant (IA) as ascorbic acid equivalents (nmol/g) <sup>**</sup>
Al-Haffa	<i>C. aronia</i>	fruit	483.44
	<i>C. monogyna</i>	flower	159.31
Zabadani	<i>C. monogyna</i>	fruit	12.73
	<i>C. aronia</i>	flower	11.37
Gota	<i>C. monogyna</i>	fruit	207.94
	<i>C. azarolus</i>	flower	167.10
As Suwayda	<i>C. azarolus</i>	fruit	412.55
	<i>C. aronia</i>	flower	115.68
Bi'r Al-ajam	<i>C. monogyna</i>	fruit	1444.82
		flower	112.25

<sup>a</sup>: 1 g of dry fruit and flower<sup>\*\*</sup>The value is the mean of three measurements  $\pm$ SD. The maximum relative standard deviation, RSD is at most 0.002–0.005 for all measurements

In order to be sure about the source of antioxidant fractions, the separated extracts of catechin and flavones using HPLC semi preparative were subject to direct antioxidants measurements of activity. It has been observed that, between 80–90% of the reported measurements in table 5 are mainly due to the catechin and flavones components in both fruits and flowers of Syrian hawthorn. Other chemical constituents like elemicin, sorbistat, polygalitol and homocatechol are found in Syrian hawthorn fruit and flowers which are the sources of antioxidants. The work is in progress to measure all the chemical constituents' fractions shown in Table 4 in order to precisely identify all possible antioxidants sources in the Syrian hawthorn fruits and flowers from Table 5, in general, all the hawthorn fruits in the five different sites have considerable amounts of antioxidants. Many pharmacological studies suggested that hawthorn extract has considerable effect on the cardiovascular system including the reduction of blood pressure and total plasma cholesterol, the treatment of congestive heart failure. It is recommended to have these fresh fruits for their valuable usefulness to human body as a first measure to increase the level of antioxidants in the body before going further to make extracts of these fruit including deep pharmaceutical research.

## CONCLUSION

It can be concluded that the reported results support the view that hawthorn flowers and fruits in particular is a promising source of natural antioxidant for its potent antioxidant properties and contains significant amounts of flavonoids and catechin compounds. It has been found that the highest antioxidant capacity values of hawthorn as ascorbic acid equivalents were found in the fruits of Bi'r Al-ajam and Al-Haffa sites which have values of 1444.82 and 483.44 (nmol/g), for *C. monogyna* and *C. aronia* cataegus, respectively .

The highest fractions of antioxidant components are mainly due to the existence of catechin and flavonoids in both Syrian hawthorn fruit and flowers. Other chemical constituents like elemicin, sorbistat, polygalitol and homocatechol are found in Syrian hawthorn fruit and flowers

It might be advised to take the flowers in the form of herbal tea for high antioxidant capacity but further biological investigations should be taken in advance. Also, the fruits can be taken without any restriction.

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## OZNACZANIE OGÓLNEJ ZDOLNOŚCI PRZECIWUTLENIAJĄCEJ W OWOCACH I KWIATACH GŁOGU Z SYRII PRZY UŻYCIU METODY FOTOCHEMILUMINESCENCYJNEJ.

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### Streszczenie

Flora Syrii wykazuje dużą różnorodność. W Syrii występuje wiele gatunków z rodzaju *Crataegus*: *sinaica*, *aronia*, *monogyne* i *azorolus*. Są one głównie spotykane w zachodniej i południowej części kraju. Wiele z syryjskich gatunków z rodzaju *Crataegus* jest używanych w medycynie ludowej i tradycyjnej w postaci herbatek ziołowych w leczeniu kaszlu, grypy i przeziębienia. Brak jest naukowych doniesień na temat właściwości przeciwutleniających syryjskich gatunków głogu. Z tego powodu badanie tych właściwości jest interesujące i użyteczne, zwłaszcza w celu znalezienia nowych źródeł przeciwutleniaczy dostępnych na terenie Syrii. W artykule przedstawiono oznaczenia sumy antyoksydantów (ang. Integral antioxidants, IA) w przeliczeniu na kwas askorbinowy, wykonane dla syryjskich głogów (owoców i kwiatów), zebranych z pięciu różnych stanowisk. Oznaczenia te po raz pierwszy wykonane były przy zastosowaniu metody fotochemiluminescencyjnej (ang. PCL assay). Stwierdzono, że najwyższa wartość zdolności przeciwutleniających w przeliczeniu na kwas askorbinowy została oznaczona dla owoców ze stanowisk Bi'r Al.-ajam i Al.-Haffa, dla których wartości te wyniosły odpowiednio 1444,82 i 483,44 (nmol/g). Otrzymane wartości można uważać za najwyższe w stosunku do wartości podawanych w innych państwach w tym regionie.

**Słowa kluczowe:** właściwości przeciwutleniające, metoda fotochemiluminescencyjna, głóg, *Crataegus sinica*, *Crataegus aronia*, *Crataegus monogyne*, *Crataegus azorolus*, rośliny lecznicze