Antioxidant Activity and Antiproliferative Effects of Lycium barbarum’s (Goji berry) Fractions on Breast Cancer Cell Lines

Kaloyan D. Georgiev1, Iliya J. Slavov1, Ivan A. Iliev2

1 Department of Pharmaceutical Technologies, Faculty of Pharmacy, Prof. Paraskev Stoianov Medical University, Varna, Bulgaria
2 Institute of Experimental Morphology, Pathology and Anthropology with Museum, Bulgarian Academy of Sciences, Sofia, Bulgaria

Correspondence:
Kaloyan Georgiev, Prof. Paraskev Stoianov Medical University, Department of Pharmaceutical Technologies, 55 Marin Drinov Str., 9002 Varna, Bulgaria
E-mail: kalgeorgiev@hotmail.com
Tel: +359898343274

Received: 15 June 2018
Accepted: 23 Sept 2018
Published Online: 22 Oct 2018
Published: 31 Mar 2019

Key words: Lycium barbarum, goji berry, polysaccharide, antioxidant, growth inhibition, breast cancer

Citation: Georgiev KD, Slavov IJ, Iliev IA. Antioxidant activity and antiproliferative effects of Lycium barbarum’s (Goji berry) fractions on breast cancer cell lines. Folia Med (Plovdiv) 2019;61(1):doi: 10.2478/fomed-2018-0053

Background: Lycium barbarum has gained immense popularity over the past decade because of its antioxidant properties. There are many reports of observed health benefits of juice consumption, including prophylaxis in neoplastic disease and treatment of tumors.

Materials and methods: In this study, we isolated three fractions of Lycium barbarum fruits – total water, pectin-free and polysaccharide, and determined their antioxidant activity by ORAC and HORAC assays. We investigated the antiproliferative effects of Lycium barbarum’s pectin-free and polysaccharide fraction on three different breast cell lines - MCF-10A (non-tumorigenic epithelial breast cell line), MCF-7 (breast cancer cell line, estrogen, progesterone receptors +, HER2-), and MDA-MB-231 (breast cancer cell line, triple negative), by the MTT dye reduction assay.

Results: The Lycium barbarum’s pectin-free fraction showed concentration-dependent growth inhibition on the three cell lines, moreover, on cancer cells (MCF-7 and MDA-MB-231) it was significantly more pronounced. The polysaccharide fraction showed negligible activity on the three cell lines, only the highest concentration (1000 μg/mL), suppressed the proliferation of MCF-7 cells. The combination of pectin-free and polysaccharide fraction on MCF-7 did not show the expected synergistic effect.

Conclusion: We found a relative correlation between the polyphenolic content of the extracts and the observed effects. The pectin-free extract had the highest content of polyphenols with the best antioxidant and antineoplastic activity against breast cancer cells. Addition of polysaccharide to the pectin-free fraction contributes to its pharmacological activity.

INTRODUCTION

Breast cancer is the most common cancer in women population worldwide.1,2 For advanced breast cancer, chemotherapy is the only chance for survival, but often it fails due to development of resistance or intolerable side effects. Phytotherapy has become an important complementary factor in the treatment of breast cancer. Lycium barbarum polysaccharides (LBPs) have been demonstrated to inhibit the growth of MCF-7 breast cancer cell line in dose- and time-dependent manner. The involved mechanisms include modulation of estrogen metabolism3 and activation of extracellular signal-regulated kinase 1/2 (Erk1/2), followed by increased expression of p534.

The population of China, and some other Asian countries, has used Lycium barbarum L. (Ningxia gou qi in Chinese, Goji berry, Wolfberry in literature in English) for more than 2,000 years as a traditional medical plant and as a food.5 Recently, the fruit has gained considerable popularity in the West due to its anti-aging and antioxidant properties.2 The compounds isolated from Lycium barbarum-scopoletin and 2-O-β-D-glucopyranosyl-L-ascorbic acid (AA-2βG) as well as the whole polysaccharide fraction undoubtedly determine the biological activity of the Goji fruit. However, little is known about the other components of the fruit such as the content of total phenols, flavonoids, phenolic acids and anthocyanins, which also contribute to those effects.7

The aim of this study was to investigate the antioxidant and antineoplastic activity of isolated fractions from Lycium barbarum fruits on three different breast cancer cell lines and to compare their sensitivity.
MATERIALS AND METHODS

*L. barbarum* fruits (Lot №: L05042017) were provided by Paula Fruits Ltd – an official importer of Goji berries for Bulgaria with guaranteed Chinese origin. All chemicals were of analytical grade and were purchased from the local representatives of Merck (Darmstadt, Germany) and Sigma (St. Louis, USA), unless otherwise indicated.

**Preparation of Plant extracts**

The scheme that we followed for the preparation of different *L. barbarum* extracts is shown on Fig. 1.

**Preparation of polysaccharide-free extract and isolation of *L. barbarum* pectic polysaccharide.**

**Preparation of alcohol insoluble solids (AIS) and pectin-free extract**

Extraction was carried out in a glass flask (4 L) placed in an incubator as follows: 500.0 g of sliced and dried goji berry fruits were transferred to 3.0 L of pre-heated at 70°C ethanol/water 70:30 (v/v) solution (solid–liquid ratio: 1:6, w/v). The obtained mixture was kept for 1 h and 30 min at 70ºC under vigorous shaking (every 10 min) and then the heating was discontinued. The resulting material was allowed to cool and incubated overnight at room temperature. Then the mixture was filtered through a nylon cloth to remove solid particles. The same procedure was repeated as incubation was carried out for 1 h. After filtration, the insoluble residue was washed with ethanol/water 70:30 (v/v) (70°C) solution (solid–liquid ratio: 1:5, w/v). Finally, the solid part was incubated with acetone (solid–liquid ratio: 1:4, w/v) at 30°C for 1 h. The solid material was vacuum-filtrated and additionally squeezed from excess of solvent though a cloth. The obtained alcohol insoluble residue was vacuum-dried (40°C, -0.1 mbar) to a constant weight. Alcohol-water solution obtained after the treatment of AIS was vacuum concentrated for the full removal of ethanol. The volume of the extract was adjusted to two liters with distilled water and extract was denoted as pectin-free extract.

**Isolation of pectic polysaccharides**

AIS was extracted with dH$_2$O (1:25, w/v) at 82°C for 1 h with continuous stirring and then filtered. The solid residue was re-extracted in the same way with dH$_2$O and then filtered. The combined filtrates were vacuum-concentrated and centrifuged (4000 g, 30 min, 15°C). After additional filtration of obtained supernatant through B"uchner funnel it was precipitated by adding two volumes of cold 96% (v/v) ethanol to one volume extract. After storage at 4°C for 24 hour, the coagulated polysaccharide was separated by filtration, washed with excess

![Figure 1. Workflow for preparation of *L. barbarum* extracts.](image-url)
of 70% (v/v) ethanol, and finally with 96% (v/v) ethanol. Then, the precipitate was re-dissolved in water, freeze-dried (Christ® Alfa 1-4 LD plus) to a constant weight, and stored in a desiccator until use.

**Preparation of total L. barbarum extract**

200 g of dried Goji berries were soaked in cold distilled water for 30 minutes and then homogenized in a laboratory blender. The obtained mixture was extracted for 1 hour at 60°C and shaking on thermostatic water bath (NUVE, Turkey). After that, extract was centrifuged (6000g) and supernatant was denoted as Goji berry total extract.

**Analysis of total polyphenolic content (TPC)**

Total polyphenols were determined by the method of Singleton and Rossi using Folin-Ciocalteu’s reagent. As calibration standard we used gallic acid and the results are presented as gallic acid equivalents per liter extract (GAE/L) after calculation of mean values (minimum three measurements).

**Analysis of polysaccharide fraction**

The anhydrouronic acid content (AUAC) was determined colorimetrically by the m-hydroxydiphenyl method (Blumenkrantz & Asboe-Hansen, 1973), using D-GaLA as a standard. Degree of methyl-esterification (DM) was determined by quantification of methanol after saponification (0.5 M NaOH, 1 h) of pectin sample. The released methanol was determined by combined enzymatic and colorimetric method with alcohol oxidase and Purpald® reagent (Anthon & Barrett, 2008). Degree of acetylation (DA) was assayed by the hydroxamic acid method, using β-D-glucose pentaacetate as a standard (McComb & McCready, 1957). Bradford method (1976) was used to analyze protein content.

**Antioxidant assays**

The oxygen radical absorbance capacity (ORAC) assay was measured according to Ou et al. (2001) with some modifications described by Denev et al. (2010). The method is based on antioxidant activity against peroxy radicals. AAPH (2,2'-azobis[2-methyl-propionamidine] dihydrochloride) generates peroxy radicals which degrades fluorescein. The last one is used as the fluorescent probe. Antioxidant activity is measured as constructing an area under the curve (AUC) under the fluorescence decay in the presence of an antioxidant and relative to blank (without antioxidant added). Expression of antioxidant activity is in milimole trolox equivalents per liter extract (mM TE/L).

The hydroxyl radical antioxidant capacity (HORAC) assay was conducted as described by Ou et al. (2002) with some modifications as well. The method is based on antioxidant activity against hydroxyl radicals generated via a classic hydrogen atom transfer (HAT) mechanism. In a similar manner as the ORAC assay, fluorescence of fluorescein decrease in the presence of solution of hydrogen peroxide and Co²⁺ over time. Antioxidant activity is measured as constructing an area under the curve (AUC) under the fluorescence decay in the presence of an antioxidant and relative to blank (without antioxidant added). Expression of antioxidant activity is in milimole galic acid equivalents per liter extract (mM GAE/L). The both methods were carried out by FLUOstar OPTIMA plate reader (BMG Labtech, Germany). The used wavelength were 485 nm for the excitation and 520 nm for the emission.

**MTT cell proliferation assay**

The cell lines we used were cultivated in a 96-well plates. 24 hours after that they were treated with isolated goji bery’s pectin-free fraction in concentration range (2-250 μg/mL, double increasing manner) or goji bery’s polysaccharide fraction in concentration range (2-1000 μg/mL, double increasing manner) or a combination of both. 72 hours after treatment we added tetrazolium salt MTT (3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) (Sigma Chemical Co.) and antiproliferative affects was measured colorimetrically based on the fact that living cells convert MTT into purple crystals. The assay was performed as described by Mosmann with some modifications. ELISA plate reader (TECAN, Sunrise TM, Grodig/Salzburg, Austria) was set to read the optical density at a wavelength of 540 nm and a reference wavelength of 620 nm. The calculation of the results was carried out as a percentage of the untreated control.

**Statistical analysis**

Statistical analysis of the antioxidant assays was performed using Excel 2016 software package. Data were reported as mean ± SD of experiments conducted in triplicate. A probability level of 0.05 or lower was considered as statistically significant. The antiproliferative activity data were fitted to sigmoidal dose-response curves and the corresponding IC₅₀ values were calculated using nonlinear regression analysis (SigmaPlot 12.5 Software). The statistical processing of MTT data included the Student’s t-test with significance level of p ≤ 0.05. The equation used to calculate predicted theoretical values of...
combination was \( C = \frac{a \cdot b}{100} \), where \( a \) and \( b \) are the values obtained with single agents, presented as a percent of untreated control. For each combination, a theoretical value was calculated that was compared to the real value of the combination. When \( C_{\text{measured}} = C_{\text{calculated}} \), \( C_{\text{measured}} < C_{\text{calculated}} \) and \( C_{\text{measured}} > C_{\text{calculated}} \) the combination effect was presented as additive, synergistic or antagonistic, respectively.

RESULTS

DETERMINATION OF PHENOLIC COMPOUNDS CONTENT AND ANTIOXIDANT ACTIVITY

In the first set of our study we obtained total water extract from Lycium barbarum fruits containing polyphenols and polysaccharides, pectin-free extract – rich only in polyphenol compounds and polysaccharide fraction. The latter was characterized by content of total uronic acid (UC), degree of esterification (CE), acetylation grade (CA), and protein (Table 1).

Then we analyzed their antioxidant properties. For determination of antioxidant activity, we used two methods, in order to be able to explore a wider aspect of the antioxidant properties of the obtained extracts. The both methods we used represent the most significant physiologically radicals – peroxyl by ORAC method and hydroxyl by HORAC method. In the first one we determined the ability to capture radicals through hydrogen atom transfer, and in the second one - the metal-chelating ability under Fenton’s reaction conditions. The results are presented in Table 2.

As can be seen from the table, the pectin-free extract contains a greater amount of total polyphenols - 2.6±0.01 g/L, compared to the total water extract in which polyphenolic content is 1.9±0.08 g/L. In both methods, the ethanol extract showed higher antioxidant activity with mean values of 90.8±2.6 mmolTE/L (evaluated by ORAC method) and 15.7±0.5 mmol GAE/L (evaluated by HORAC method).

ANTINEOPLASTIC EFFECTS

In the second set of our work, we investigated the effects of pectin-free, polysaccharide and total water extract from Lycium barbarum fruits on tumorigenic MDA-MB-231 and MCF-7 and non-tumorigenic MCF-10A breast cells. Breast cancer cell lines - MDA-MB-231 and MCF-7 are with different aggressive phenotype. MCF-7 cells express sex-steroid receptors - estrogen and progesterone receptors (ER+, PR+) and is negative in regard to human epidermal growth factor receptors (HER-). It is an ideal model to study modulation of hormone response. The MDA-MB-231 cell line is highly invasive and metastatic human breast cancer cells. MDA-MB-231 cells are triple negative (ER-, PR-, HER2-) with low response to chemotherapy. To investigate the antinecancer effects in breast cells, MTT assay was performed, which estimates cell viability based on the conversion of dye from yellow to violet crystals. Cells were exposed for 72 hours with media containing extracts in concentration from 2 to 125 μg/mL (Fig. 2).

Reduction in cell viability by 50% was calculated and designated as the IC\(50\). All values of IC\(50\) are presented in Table 3.

All three cell types show concentration-dependent inhibition of growth and comparable sensitivity to the polyphenolic compounds isolated from Lycium barbarum fruits. Even more sensitive to the action of polyphenols are the two tumor cell lines - MCF-7 and MDA-MB-231, with IC\(50\) values of less than 100 μg/mL, 60.51 and 79.93 μg/mL, respectively.

Table 1. Basic characteristic of pectin type polysaccharides with an intermediate degree of esterification

| Content                  | %     |
|--------------------------|-------|
| Total uronic acid (UC)   | 34.1% |
| Degree of esterification (CE) | 54%   |
| Acetylation grade (CA)   | 5.5%  |
| Protein                  | 7.3%  |

Table 2. Content of total polyphenols (TPC), ORAC and HORAC antioxidant activity of Goji berry extracts. Each value is the mean ± SD of three independent measurements. TE: Trolox equivalents. GAE: Gallic acid equivalents

|                      | TPC, g/L | ORAC, mmol TE/L | HORAC, mmol GAE/L |
|----------------------|----------|-----------------|-------------------|
|                      | Mean     | SD              | Mean             | SD              | Mean             | SD              |
| Pectin-free extract  | 2.6      | 0.01            | 90.8             | 2.6             | 15.7             | 0.5             |
| Total water extract  | 1.9      | 0.08            | 46.7             | 1.3             | 9.2              | 0.4             |
Non-tumorigenic epithelial breast cell line MCF-10A is less sensitive and has IC_{50} value of 108.3 μg/mL. The data in this study suggested that the total polyphenolic content from Lycium barbarum fruits show relative selective activity to breast cancer cells with estrogen and progesterone receptors (MCF-7) as well as the triple negative breast cells (MDA-MB-231), without causing harm to non-tumorigenic cells (MCF-10A). There is also a relative correlation between the observed antioxidant activity and the antineoplastic effect.

Polysaccharide content of Lycium barbarum fruits shows negligible effect on proliferation of MDA-MB-231 and MCF-10A cell lines. On the hormone receptor positive cell line - MCF-7, only the highest concentration used - 1000 μg/mL, showed 50% inhibition of proliferation (Fig. 3).

To investigate whether the combination of pectin-free extract and polysaccharides will have a synergistic effect on the hormone-positive breast cancer tumor line MCF-7, we treated it with the polysaccharide content at a constant concentration of 1000 μg/mL, at which we observed significant inhibition of proliferation on MCF-7 cells, and the pectin-free extract in increasing concentrations of 2-125 μg/mL.

The combination of pectin-free extract plus polysaccharide did not result in synergic effect, as we expected, on the contrary, the effects we have observed are rather antagonistic (Fig. 4). However,

![Antiproliferative effects of Lycium barbarum's pectin-free fraction](image)

**Figure 2.** Growth inhibition of pectin-free extract from Lycium barbarum fruits on normal (MCF-10) and tumor (MCF-7 and MDA-MB-231) breast cell lines. Measurement was done by MTT-assay after 72 h of incubation with extract.

**Table 3.** IC\textsubscript{50} values obtained after 72 h exposure with total polyphenolic content from Lycium barbarum fruits on normal (MCF-10) and tumor (MCF-7 and MDA-MB-231) breast cell lines

| Cell type   | Mean IC\textsubscript{50} values ± SD (μg/mL) |
|-------------|---------------------------------------------|
| MCF-10A     | 108.3±2.24                                  |
| MCF-7       | 60.51±2.42                                  |
| MDA-MB-231  | 79.93±4.12                                  |

The addition of polysaccharides to pectin-free extract increases the activity on MCF-7 cells and the inhibitory concentration value 50 drops to 47.02±2.64 (μg/mL ± SD).

**DISCUSSION**

Numerous experimental studies have proven the broad pharmacological application of L. barbarum berries.\textsuperscript{20} Most of them are of the opinion that activity is due to high polysaccharide content (Licium barbarum polysaccharide, LBPs, comprising almost...
Various activities have been observed relating to the use of different fractions of polysaccharides, but the focus is on the content of galacturonic compound that is of utmost importance for biological activity. In our obtaining polysaccharide extract, the content of total uronic acid was almost 35% (Table 1), indicating significant amount of the required active ingredients. The other extracts - the pectin-free and the total water extract, were both rich in polyphenols, which contributes to the biological activity of the fruits of the Lycium barbarum (Table 2). The subsequent antioxidant

Figure 3. Antiproliferative effects of polysaccharide content isolated from Lycium barbarum fruits on normal (MCF-10) and tumor (MCF-7 and MDA-MB-231) breast cell lines. Measurement was done by MTT-assay after 72 h of incubation with polysaccharides.

Figure 4. Growth inhibition of combination of pectin-free extract with polysaccharide content isolated from Lycium barbarum on MCF-7 cells. Measurement was done by MTT-assay after 72 h of incubation.
activity demonstrated a significant correlation depending on the polyphenol content of the extracts. Quite logically, the pectin-free extract rich in polyphenol compounds showed the highest antioxidant activity expressed by two of the most commonly used antioxidant methods (Table 2).

Li G et al. (2009) reported that Lycium barbarum aqueous extracts inhibit the proliferation of Michigan Cancer Foundation-7 (MCF-7) cells by modulating the metabolic pathways of estradiol. They demonstrated enhancement of the formation of antimitogenic 16α-OHE1 and/or acceleration of the conversion of promitogenic 16α-OHE1 to its inert proximal metabolite E3. Telang N et al. (2014) also make similar reports on MCF-7 cell line, in which the water extracts of bark and berry of Lycium barbarum were comparable, and the greater potency of bark than fruit extract was showed. These two studies use total aqueous extracts. We have isolated and tested fractions for guidelines which of the substances contained in the total extract is responsible for the observed effects on breast cancer tumor cells. For this purpose, we used three breast cell lines - MCF-10A (non-tumorigenic epithelial breast cell line), MCF-7 (breast cancer cell line, estrogen, progesterone receptors +/-, HER2-), and MDA-MB-231 (breast cancer cell line, triple negative). The pectin-free fraction of Lycium barbarum fruits has exhibited a dose-dependent growth inhibition of the three cell lines, more pronounced on tumorigenic - MCF-7 and MDA-MB-231, with selectivity index of 1.79 and 1.35, respectively. The results have showed that the possible mechanisms involved in antiproliferative effects are not fully dependent on estrogen modulation, but may be a part of other signaling paths, such as extracellular signal-regulated kinase 1/2 (Erk1/2), demonstrated by Shen L and Du G (2012). The polysaccharide fraction did not show the expected result on the three cell lines, neglected inhibition of proliferation on MCF-7 cells was noticed only with the highest concentration we used - 1000 μg/mL. The other cells - MCF-10A and MDA-MB-231, did not differ from the control. In the last attempt we tried to find whether there were synergistic effects on MCF-7 cells between the pectin-free fraction and the polysaccharide. The polysaccharides were applied in a constant concentration of 1000 μg/mL and the pectin-free fraction in varying concentrations of 2-250 μg/mL. As demonstrated in the results, the calculated values of the combination significantly outweighed those of their self-administration. The results show lack of a classical synergistic effect, but it should be noted that some potentiation is observed. Then we could assume that the polysaccharide fraction supports the action of the polyphenol-rich fraction, demonstrated with reduction of IC50 value by about 20%.

CONCLUSIONS
In this study we have investigated the antioxidant and antitumor activity of the total water, the pectin-free and the polysaccharide fraction of Lycium barbarum fruit on three breast cell lines. We found a positive correlation between the polyphenolic content of the extracts and the observed effects. The pectin-free extract had the highest content of polyphenols and the best antioxidant and antineoplastic activity against breast cancer cells. Addition of the polysaccharide to the pectin-free fraction contributes to its pharmacological activity. Future research would focus on the observation of possible synergistic effects of pectin-free extract from Lycium barbarum fruits with the approved chemotherapeutics in the treatment of breast cancer.

REFERENCES
1. Ferlay J, Soerjomataram I, Ervik M, et al. GLOBOCAN 2012 v1.0, Cancer Incidence and Mortality Worldwide: IARC CancerBase No. 11 [Internet]. Lyon, France: International Agency for Research on Cancer; 2013.
2. DeSantis C, Ma J, Bryan L, et al. Breast cancer statistics, 2013. CA Cancer J Clin 2014; 64(1): 52-62.
3. Li G, Sepkovic DW, Bradlow HL, et al. Lycium barbarum inhibits growth of estrogen receptor positive human breast cancer cells by favorably altering estradiol metabolism. Nutr Cancer 2009; 61(3): 408-14.
4. Shen L, Du G. Lycium barbarum polysaccharide stimulates proliferation of MCF-7 cells by the ERK pathway. Life Sci 2012; 91(9-10): 353-7.
5. Potterat O. Goji (Lycium barbarum and L. chinense): phytochemistry, pharmacology and safety in the perspective of traditional uses and recent popularity. Planta Med 2010; 76(1): 7-19.
6. Ulbricht C, Bryan JK, Costa D, et al. An evidence-based systematic review of Goji (Lycium spp.) by the Natural Standard Research Collaboration. J Diet Suppl 2015; 12(2): 184-240.
7. Georgiev K, Jelev I, Georgieva S. Investigation of active ingredients of Goji berry (Lycium barbarum). Varna Medical Forum Suppl 2013; 12: 29-33.
8. Singleton V, Rossi J. Colorimetry of total phenolic with phosphomolibdic-phosphotungstic acid reagents. Am J Enol Vitic 1965; 16: 144-58.
9. Blumenkrantz N, Asboe-Hansen G. New method for quantitative determination of uronic acids. Analytical Biochemistry 1973; 54: 484-9.

10. Anthon GE, Barrett DM. Combined enzymatic and colorimetric method for determining the uronic acid and methylester content of pectin: Application to tomato products. Food Chemistry 2008; 110: 239-47.

11. McComb EA, McCready RM. Determination of acetyl in pectin and in acetylated carbohydrate polymers. Analytical Chemistry 1957; 29: 819-21.

12. Bradford MM. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Analytical Biochemistry 1976; 72: 248-54.

13. Ou B, Hampsh-Woodill M, Prior RL. Development and validation of an improved oxygen radical absorbance capacity assay using fluorescein as the fluorescent probe. J Agric Food Chem 2001; 49(10): 4619-26.

14. Denev P, Ciz M, Ambrozova G, et al. Solid-phase extraction of berries’ anthocyanins and evaluation of their antioxidative properties. Food Chemistry 2010; 123(4): 1055-61.

15. Ou BX, Huang DJ, Hampsch-Woodill M, et al. Analysis of antioxidant activities of common vegetables employing oxygen radical absorbance capacity (ORAC) and ferric reducing antioxidant power (FRAP) assays: a comparative study. J Agric Food Chem 2002; 50(11): 3122-8.

16. Mosmann T. Rapid colorimetric assay for cellular growth and survival: application to proliferation and cytotoxicity assays. J Immunol Methods 1983; 65: 55-63.

17. Alam MN, Bristi NJ, Rafiquzzaman M. Review on in vivo and in vitro methods evaluation of antioxidant activity. Saudi Pharm J 2013; 21(2): 143-52.

18. Levenson AS, Jordan VC. MCF-7: the first hormone-responsive breast cancer cell line. Cancer Res 1997; 57(15): 3071-8.

19. Holliday DL, Speirs V. Choosing the right cell line for breast cancer research. Breast Cancer Res 2011; 13(4): 215.

20. Jin M, Huang Q, Zhao K, et al. Biological activities and potential health benefit effects of polysaccharides isolated from Lycium barbarum L. Int J Biol Macromol 2013; 54:16-23.

21. Cheng J, Zhou ZW, Sheng HP, et al. An evidence-based update on the pharmacological activities and possible molecular targets of Lycium barbarum polysaccharides. Drug Des Devel Ther 2014; 9: 33-78.

22. Telang N, Li G, Sepkovic D, et al. Comparative efficacy of extracts from Lycium barbarum bark and fruit on estrogen receptor positive human mammary carcinoma MCF-7 cells. Nutr Cancer 2014; 66(2): 278-84.
Антиоксидантная активность и антипролиферативное действие фракций Lycium barbarum (ягоды годжи) на клеточные линии рака молочной железы

Калоян Д. Георгиев 1, Илия Ж. Славов 1, Иван А. Илиев 2

1 Кафедра фармацевтических технологий, Факультет фармации, Медицинский университет "Проф. Панасек Стоянов", Варна, Болгария
2 Институт экспериментальной морфологии, патологии и антропологии с музеем, БАН, София, Болгария

Введение: Лиций (Lycium barbarum) приобрёл широкую популярность за последнее десятилетие благодаря своим антиоксидантным свойствам. Существует много сообщений о пользе для здоровья человека при приёме сока, включая профилактику опухолевых заболеваний и лечение опухолей.

Материалы и методы: В этом исследовании мы выделили три фракции ягод Lycium barbarum - общую воду, без пектинов и полисахаридов, а также определили антиоксидантную активность с помощью анализов ORAC и HORAC.

Мы исследовали антипролиферативные эффекты фракции, не содержащей пектинов, и фракции полисахаридов китайского лиция на трёх различных линиях клеток молочной железы - MCF-10A (неонкогенная эпителиальная линия клеток рака молочной железы), MCF-7 (линия клеток рака молочной железы, эстроген, прогестерон рецепторы +, HER2-) и MDA-MB-231 (клеточная линия рака молочной железы, тройная отрицательная) с помощью метода редуцирования МТТ.

Результаты: Фракция лиция без пектина показала зависимое от концентрации ингибирование роста в трёх клеточных линиях, более того, оно было значительно более выраженным в раковых клетках (MCF-7 и MDA-MB-231). Фракция полисахаридов показала незначительную активность на трёх клеточных линиях, причём только самая высокая концентрация (1000 μg/mL) подавляла пролиферацию клеток MCF-7. Комбинация из не содержащей пектинов фракции и полисахаридной фракции MCF-7 не показала ожидаемого синергетического эффекта.

Заключение: Мы установили значительную корреляцию между полифенольным составом экстрактов и наблюдаемыми эффектами. Экстракт без пектинов имел самое высокое содержание полифенолов с лучшей антиоксидантной и противопухолевой активностью в отношении клеток рака молочной железы. Добавление полисахарида к фракции, не содержащей пектинов, способствует его фармакологической активности.