ORİJİNAL MAKALE / ORIGINAL ARTICLE

Sağlık Bilimlerinde Değer / Sağlık Bil Değer
Value in Health Sciences / Value Health Sci
ISSN: 2792-0542 sabd@duzce.edu.tr 2022; 12(3): 534-539
doi: https://dx.doi.org/10.33631/sabd.1145694

Antimicrobial and Anticancer Activity of *Corydalis solida*

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ABSTRACT

Aim: The present study, it was aimed to evaluate the bioactive properties of *Corydalis solida.*

Material and Methods: In the study, the anticancer activity of ethanolic extracts prepared from *C. solida* was determined on HCT116 colon cancer, AGS gastric cancer and HepG2 hepatocellular carcinoma cell lines and HUVEC cells, healthy control cell line. Well diffusion method was used to determine the antimicrobial properties of solida. For this purpose, ethanolic extracts were used for antimicrobial activity against four bacterial isolates (*Escherichia coli, Bacillus cereus, Staphylococcus aureus* and *Klebsiella oxytoca)* and three yeast strains *(Candida albicans, C. tropicalis* and *C .glabrata*).

Results: *Corydalis solida* plant extract produced significant antiproliferative effect in HCT116 (colon cancer), AGS (gastric cancer) and HepG2 (liver cancer) cell lines. This effect was more remarkable in the HepG2 cell line. In addition, negligible cell death in HUVEC cells indicated that the plant was not toxic to healthy cells. Plant extract application also caused significant Caspase-3, 8 and 9 activation in HepG2 and HCT116 cells, consistent with the antiproliferative effect. Antimicrobial studies have shown that the extract made inhibition zone on bacteria.

Conclusion: In the study, it was determined that the ethanol extract of *Corydalis solida* had anticancer effect. In addition, the extract had inhibitory properties on bacteria. The data obtained from the study are qualified to support further pharmacological studies.

Keywords: Antimicrobial activity; anticancer activity; *Corydalis solida*

Corydalis solida'nın Antimikrobiyal ve Antikanser Aktivitesi

ÖZ

Amaç: Mevcut çalışmada *Corydalis solida*' nın biyoaktif özelliklerinin değerlendirilmesi amaçlandı.

Gereç ve Yöntemler: Çalışmada HCT116 kolon kanseri hücre hattı, AGS mide kanseri hücre hattı ve HepG2 hepatoselüler karsinom hücre hattı ile sağlıklı kontrol hücre hattı olarak kullanılan HUVEC hücreleri üzerinde *Corydalis solida*'dan hazırlanan etanolik ekstrelerin antikanser aktivite düzeyleri belirlendi. *Corydalis solida* etanolik ekstrelerinin antimikrobiyal özelliklerini belirlemek için kuyu difüzyon yöntemi kullanıldı. Bu amaçla, dört bakteri (*Escherichia coli, Bacillus cereus, Staphylococcus aureus ve Klebsiella oxytoca*) ve üç maya suşuna (*Candida albicans, C. tropicalis ve C. glabrata*) karşı antimikrobiyal aktivite düzeyini araştırmak için etanolik ekstreler kullanıldı.

Bulgular: *Corydalis solida* bitki ekstraktı, HCT116 (kolon kanseri), AGS (mide kanseri) ve HepG2 (karaciğer kanseri) hücre hatlarında önemli düzeyde antiproliferatif etki gösterdi. Bu etki HepG2 hücre dizisinde daha dikkat çekici seviyede gözlendi. Ek olarak, HUVEC hücrelerinde ihmal edilebilir düzeyde gözlenen hücre ölümü, bitkinin sağlıklı hücreler için toksisitesinin olmadığını gösterdi. Bitki ekstraktı uygulaması ayrıca HepG2 ve HCT116 hücrelerinde görülen antiproliferatif etki ile tutarlı olarak önemli düzeyde Kaspaz-3, 8 ve 9 aktivasyonuna neden oldu. Antimikrobiyal çalışmalar, ekstraktın bakterilerde inhibisyon zonu oluşturduğunu gösterdi.

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Geliş Tarihi / Received: 19.07.2022, Kabul Tarihi / Accepted: 10.09.2022

Sonuç: Çalışmada *Corydalis solida*' nın etanol ekstraktının önemli düzeyde antikanser etkisinin olduğu aynı zamanda da bakteriler üzerinde inhibe edici etkisinin bulunduğu belirlendi. Çalışmadan elde edilen veriler daha ileri farmakolojik çalışmaları destekleyecek niteliktedir.
Anahtar Kelimeler: Antimikrobiyal aktivite; antikanser aktivite; *Corydalis solida*

INTRODUCTION

Corydalis, belonging to the Papaveraceae family, is the largest genus of the Fumarioideae subfamily. *Corydalis solida* is distributed throughout nearly all of Europe, with the exception of the extreme North and West regions. *C. solida* has been used in folk medicine as a sedative, pain reliever, and blood pressure reducer. Because it has starch-rich tubers, it was cooked and eaten (1). The Papaveraceae family of plants is of great interest in the field of medical use due to their content with significant bioactivity. The biological properties of these compounds include antitumor, antimicrobial, and anti-inflammatory activity (1).

The incidence of cancer and the number of cancer-related deaths are increasing all over the world. As in the world, cancers are the second most common cause of death from all causes in Turkey, after ischemic heart diseases. After lung, prostate, and breast cancer, cancers originating mostly from the gastrointestinal tract, including the esophagus, stomach, colorectal, liver, and pancreas, are responsible for cancer-related deaths. (2-4).

In addition to common cancer treatments such as surgery, radiation therapy, chemotherapy, combination therapy and laser therapy, selective treatments based on a better understanding of biology and molecular genetics appear promising to prevent tumor progression. However, most patients with advanced gastrointestinal cancer are resistant to most treatment modalities and therefore have low survival rates. It is possible to say that the resistance to chemotherapy, which is still a promising option in cancer treatment, is based on more than one molecular basis, despite the advances in treatment methods today (5,6).

As an alternative to such situations, there is substantial evidence to suggest that more than 50% of approved anticancer agents are either natural compounds or derivatives of natural products from herbal medicines. In addition, the possible important effects of many natural products such as phenolics, flavonoids, alkaloids, carotenoids, gingerols and organosulfur compounds on early and late stages of cancer have been demonstrated in various in vivo and in vitro model studies in recent years. Therefore, there is a continuing scientific interest in obtaining effective anticancer agents from natural product sources (7).

Apoptosis is programmed cell death that occurs both intrinsically and extrinsically. In the extrinsic pathway, FAS, TNF-R, binding proteins, ligands such as caspase-3, -6, -7 and -8, and cell death receptors are involved. In the intrinsic pathway carried out in mitochondria, Bcl2 and AKT act as anti-apoptotic proteins, while Bax, Bak and caspase-9 act as pro-apoptotic proteins. Upregulation of Bcl2 and AKT-like anti-apoptotic genes and downregulation of Bax and Bclxl pro-apoptotic genes are common in tumor cells (8). Therefore, it is of great importance to test agents that will activate apoptosis in tumor cells.

The aim of the present study was to determine the antiproliferative and apoptotic effect of ethanolic extracts prepared from *Corydalis solida* on HCT116 colon cancer, AGS gastric cancer, HepG2 hepatocellular carcinoma cell lines and HUVEC cells, as control. In addition, the antimicrobial and antifungal effects of the plant were also studied.

MATERIAL AND METHODS

Plants Extraction Preparation

Aerial parts of the plant were collected from Duzce, Turkey, during the flowering stage in May, 2022. The extraction was performed as described previously by Dulger et al. with some modifications (9).

Test Microorganisms

The in vitro antimicrobial studies were carried out with four bacteria strains (*Escherichia coli*, *Bacillus cereus*, *Staphylococcus aureus* and *Klebsiella oxytoca*) and three yeast strains (*Candida albicans*, *C. tropicalis* and *C. glabrata*) obtained from the Microbiology Research Laboratory of the Duzce University Department of Biology.

Well Diffusion Method

Well diffusion method was used to determine antibacterial and antifungal activity of *Corydalis solida*. Nutrient Broth was used for bacteria and Malt Extract Broth was used for fungi to prepare 24-hour young cultures of microorganisms. After preparation according to 0.5 McFarland standardization, bacteria were incubated at 35-37 °C and fungi at 25-27 °C for 24-48 hours. The prepared media were cooled to 40-45 °C and activated microorganisms were inoculated into the medium. Wells with a diameter of 6 mm were drilled into the cooled medium with a sterile punch. Sterile agar was placed in the wells opened in the media and filled with 100 µL of solution. Petri dishes containing bacteria were incubated at 35-37 °C, and Petri dishes containing fungi were incubated at 25-27 °C for 24-48 hours, and the diameters of the formed zones were measured with the help of a caliper. In order to compare the antimicrobial activity levels of *Corydalis solida*, Ampicillin and Amikacin (BIOANALYSE) antibiotics were used for bacteria, while Nystatin (BIOANALYSE) antibiotic was used for fungi. Antimicrobial activity experiments were performed in triplicate independently of each other. The results were evaluated by finding the mean and standard deviations.

Cell Culture

HCT116 colon cancer, AGS gastric cancer, HepG2 hepatocellular carcinoma cell lines and HUVEC cells were used in this study. Cells were grown in RPMI-1640 and DMEM media supplemented with 10% inactivated fetal bovine serum (Fetal Bovine Serum, FBS), 200 mM L-glutamine, 100 U/ml penicillin, 100 pg/ml streptomycin at 95% humidity and 5%. They were reproduced by culturing in an incubator (Nuve, Turkey) at 37 C in CO2 environment.

Cell Proliferation Assay (WST-1 method)

The media were removed when the HCT116, AGS, HepG2 and HUVEC cell lines covered approximately 70% of the T-75 cell flasks. Cells were separated from the base and each other using a trypsin-EDTA mixture, and after centrifugation at 1200 rpm for 10 minutes, RPMI-1640/DMEM medium containing 1% FBS was added to the pellet. Then, cells were homogeneously suspended in RPMI-1640/DMEM medium containing 1% FBS, and then seeded into 96-well cell culture dishes by drawing approximately 5000 cells/100µL into each well. After the cells were incubated overnight in an incubator at 37°C and 5% CO2, the media were removed. The extract at the specified doses (25-600µg/ml) was added to the cells and incubated in a medium containing 1% FBS for 24 and 48 hours at 37°C with 5% CO2. At the end of the specified times, the medium in each well was removed and replaced with 100 µL of phenol-red-free RPMI-1640/DMEM medium and 10 µL of WST-1 kit. The color change caused by the formazan product was determined at the wavelength range of 450 nm with a microplate reader (Epoch Microplate Spectrophotometer, Agilent Technologies, Inc., USA) after 4 hours. Each experiment was performed in triplicate. Cell viability calculations were made on the Excel program.

Protein isolation and ELISA assay

Protein isolation was performed 24 h after the plant extract was applied to cells at doses of 100 µg/mL and 400 µg/mL with RIPA buffer (A.B.T, Turkey) following the appropriate protocol steps. BCA protein assay kit (ABP Biosciences, LLC) was used to determine the amount and concentration after protein isolation. Colorimetric human Caspase-3, 8 and 9 ELISA kits (BT LAB, Shanghai, China) were used to determine protein expression levels of Caspase-3, 8 and 9 in cell supernatant samples treated with plant extract according to manufacturer's instructions. After the procedures, the results were obtained by reading the ELISA reader (Epoch Microplate Spectrophotometer, Agilent Technologies, Inc., USA) at Optical Density (OD) of 450 nm.

Statistical Analysis

Descriptive statistics of the quantitative variables in the study are given as mean, median, standard deviation, minimum and maximum. The conformity of the variables to the normal distribution was examined using the Shapiro Wilk test. The homogeneity of variance assumption was examined with the Levene test. The independent t test (student t) was used for the two-group mean comparisons of normally distributed variables. The Mann-Whitney U test was used for the two-group mean comparison of non-normally distributed variables. All of the given p values were obtained by comparing the control group values with the sample applied group values as two independent groups. The statistical significance level was taken as 0.05 and the SPSS (version 28) package program was used in the calculations.

RESULTS

Antimicrobial ActivityThe antimicrobial activities of *Corydalis solida* extracts against the pathogens examined in this study were assessed by the presence of inhibition zones (Table 1).

Table 1. Antimicrobial activity of *Corydalis solida* and standard antibiotics.

AM10: Ampicillin 10 µg; AK30: Amikacin 30 µg; NY100: Nystatin 100 µg.
*Mean zone diameters of testes performed in triplicate for each strain were taken.

	Inhibition Zones				
Test Microorganisms	**50µL extract**	**100µL extract**	**AMP 10**	**AK 30**	**NY 100**
	Mean±SD	Mean±SD			
Escherichia coli	19.66±1.52	22.33±0.57	15.0	19.0	-
Bacillus cereus	24±3	26.66±1.52	22.0	20.0	-
Staphylococcus aureus	15.33±1.15	19±1.73	27.0	20.0	-
Klebsiella oxytoca	11±0	15±2.08	-	18.0	-
Candida albicans	11±0.57	13.33±2.51	-	-	17.0
Candida glabrata	11.33±2.3	9.66±1.15	-	-	19.0
Candida tropicalis	10±1	12±0	-	-	18.0

The ethanol extracts obtained from *C. solida* had antimicrobial activities against the pathogens, with inhibition zones of 11.0-26.66 mm. Especially, *B. cereus* and *E. coli* had more large zone diameter to the extract of *C. solida* than the antibiotics such as ampicillin and amikacin. The zone diameter of the plant extracts on *S. aureus* and all yeasts had narrow than the antibiotics.

Antiproliferative effects of *Corydalis solida* plant extract on HCT116, AGS and HepG2 cells.

Corydalis solida plant extract was applied to all three cancer cell lines and HUVEC cells as control at doses of 25-600 µg/ml for 24 and 48 hours (Table 2 and Table 3). While no reduction in viability was observed in HUVEC cells at the 24-hour dosing, very little loss of viability was observed at the 48-hour doses compared to the control. The fact that no inhibition of proliferation was observed in HUVEC cells is an important result as it shows that the toxicity of the plant extract is very low (Figure 1A)

Table 2 . Statistical analysis of viability values observed as a result of the application of the plant extract to HUVEC cells for 24 hours.

*Non Normal Distribution

	Control group	**Plant extract group**				
Dose	**Mean± SD**	**Mean± SD**	**Median**	**Minimum**	**Maximum**	**p value**
25µg/ml	100±0.000	102.33±2.516	102	100	105	0.184
50µg/ml	100±0.000	102.66±3.214	10	99	105	0.224
75µg/ml	100±0.000	97.66±1.527	98	96	99	0.057
100µg/ml	100±0.000	99.66±1.527	100	98	101	0.725
150µg/ml	100±0.000	93.66±1.527	94	92	95	0.119
300µg/ml *	100±0.000	97.66±1.154	97	97	99	0.100
400µg/ml *	100±0.000	100.66±1.154	100	100	102	0.700
600µg/ml *	100±0.000	98.00±1.154	100	94	100	0.700

Table 3. Statistical analysis of viability values observed as a result of the application of the plant extract to HUVEC cells for 48 hours.

	Control group	**Plant extract group**	

Dose	Mean± SD	Mean± SD	p value
25µg/ml	100±0.000	89.33±2.516	0.018
50µg/ml	100±0.000	91.33±1.527	0.010
75µg/ml	100±0.000	86.66±1.527	0.004
100µg/ml	100±0.000	90.00±2.000	<0.001
150µg/ml	100±0.000	85.00±2.000	<0.001
300µg/ml	100±0.000	84.00±2.000	<0.001
400µg/ml	100±0.000	82.33±2.516	0.003
600µg/ml	100±0.000	83.33±4.509	0.024

The most notable results in proliferation inhibition as a result of the application of the plant extract were observed in HepG2 cells (Table 4 and Table 5). After 600µg/ml dose administration for 24 hours, compared to control group the proliferation inhibition value was significant (p=0.001). The decrease in viability was more pronounced at 48-hour application doses. Cell proliferation inhibition decreased from 100µg/ml dose and above. While inhibition increased at this dose (p<0.001), it increased significantly (p<0.001) in 600µg/ml application compared to control. (Fig. 1B).

Table 4. Statistical analysis of the viability values observed as a result of the application of the plant extract to HepG2 cells for 24 hours.

	Control group	Plant extract group	
Dose	Mean± SD	Mean± SD	p value
25µg/ml	100±0.000	84.66±1.527	0.003
50µg/ml	100±0.000	80.00±2.000	<0.001
75µg/ml	100±0.000	79.66±4.041	<0.001
100µg/ml	100±0.000	80.00±9.643	0.023
150µg/ml	100±0.000	75.00±7.549	0.029
300µg/ml	100±0.000	76.33±11.930	0.029
400µg/ml	100±0.000	71.00±5.567	0.012
600µg/ml	100±0.000	58.66±2.516	0.001

Table 5. Statistical analysis of the means of viability values observed as a result of the application of the plant extract to HepG2 cells for 48 hours.

In AGS cells, the cell viability value was 61% at the highest application dose of 600 µg/ml and this value was significant compared to control group (p<0.001). Time-dependent proliferation inhibition was observed at 48-hour administration (Figure 1C). (Table 6 and Table 7).

	Control group	Plant extract group	
Dose	Mean± SD	Mean± SD	p value
25µg/ml	100±0.000	67.00±2.000	<0.001
50µg/ml	100±0.000	70.33±0.577	<0.001
75µg/ml	100±0.000	58.00±3.000	<0.001
100µg/ml	100±0.000	50.33±2.516	<0.001
150µg/ml	100±0.000	40.33±3.511	<0.001
300µg/ml	100±0.000	38.33±2.516	<0.001
400µg/ml	100±0.000	29.00±2.000	<0.001
600µg/ml	100±0.000	22.33±1.527	<0.001

Table 6. Statistical analysis of viability values observed as a result of the application of the plant extract to AGS cells for 24 hours.

	Control group	Plant extract group	
Dose	Mean± SD	Mean± SD	p value
25µg/ml	100±0.000	95.00±3.000	0.022
50µg/ml	100±0.000	90.00±4.000	0.006
75µg/ml	100±0.000	92.00±3.000	0.005
100µg/ml	100±0.000	87.00±3.000	<0.001
150µg/ml	100±0.000	75.33±2.516	<0.001
300µg/ml	100±0.000	78.66±2.516	<0.001
400µg/ml	100±0.000	68.00±3.000	<0.001
600µg/ml	100±0.000	61.00±1.000	<0.001

Table 7. Statistical analysis of viability values observed as a result of the application of the plant extract to AGS cells for 48 hours.

	Control group	Plant extract group	
Dose	Mean± SD	Mean± SD	p value
25µg/ml	100±0.000	87.00±4.000	0.002
50µg/ml	100±0.000	80.00±2.000	<0.001
75µg/ml	100±0.000	78.00±3.000	<0.001
100µg/ml	100±0.000	70.00±1.000	<0.001
150µg/ml	100±0.000	60.33±2.516	<0.001
300µg/ml	100±0.000	47.67±2.516	<0.001
400µg/ml	100±0.000	38.66±1.527	<0.001
600µg/ml	100±0.000	31.66±1.527	<0.001

Although inhibition was observed in HCT116 cells at 24-hour dose administration, this inhibition was lower than compared to other cells (Figure 1D). Cell proliferation inhibition was observed for 600µg/ml dose compared to control as significantly (p<0.001). In 48-hour dose applications, a significant decrease in viability was observed after 150µg/ml dose. In the 150µg/ml dose application, inhibition of proliferation was significant compared to the control. (p<0.001). In the 600µg/ml dose application, cell viability decreased considerably and was significant compared to the control. (p<0.001) (Table 8 and Table 9).

Table 8. Statistical analysis of viability values observed as a result of the application of the plant extract to HCT116 cells for 24 hours.

	Control group	Plant extract group	
Dose	Mean± SD	Mean±SD	p value
25µg/ml	100±0.000	94.66±1.527	0.026
50µg/ml	100±0.000	90.00±1.000	<0.001
75µg/ml	100±0.000	91.66±4.509	0.033
100µg/ml	100±0.000	90.67±0.577	<0.001
150µg/ml	100±0.000	85.00±2.000	<0.001
300µg/ml	100±0.000	87.66±1.523	<0.001
400µg/ml	100±0.000	77.66±3.511	<0.001
600µg/ml	100±0.000	69.00±3.000	<0.001

Table 9. Statistical analysis of viability values observed as a result of the application of the plant extract to HCT116 cells for 48 hours.

	Control group	Plant extract group				
Dose	Mean± SD	Mean± SD	Median	Minimum	Maximum	p value
25µg/ml	100±0.000	85.00±2.000	85.00	83.00	87.00	<0.001
50µg/ml	100±0.000	80.00±0.000	80.00	80.00	80.00	<0.001
75µg/ml	100±0.000	68.33±2.516	68.00	66.00	71.00	<0.001
100µg/ml	100±0.000	60.33±0.577	60.00	60.00	61.00	0.034
150µg/ml	100±0.000	55.33±1.527	55.00	54.00	57.00	<0.001
300µg/ml	100±0.000	47.66±2.516	48.00	45.00	50.00	<0.001
400µg/ml	100±0.000	38.66±0.577	39.00	38.00	39.00	0.034
600µg/ml	100±0.000	32.00±1.000	32.00	31.00	33.00	<0.001

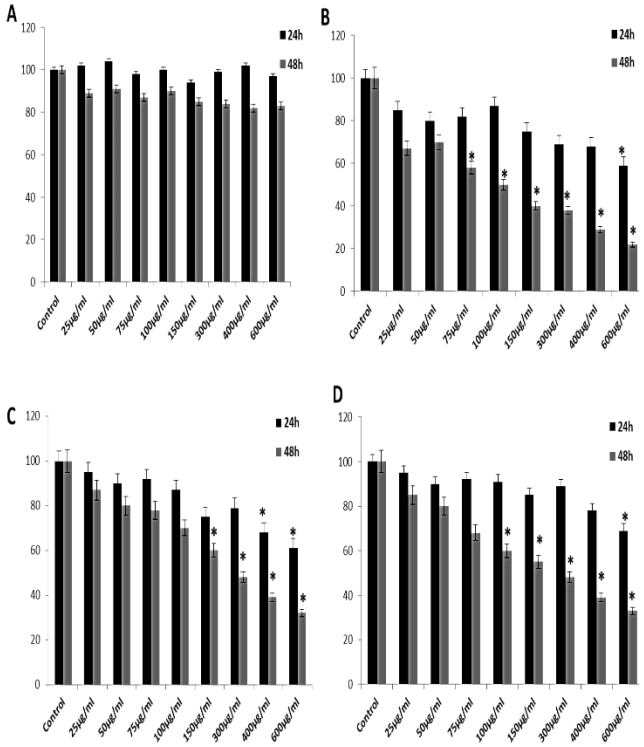

Figure 1: The effect of *Corydalis solida* plant extract on proliferation of HUVEC (A), HepG2 (B), AGS (C) and HCT116 (D) cells at 24 and 48 hours

Effect of *Corydalis solida* plant extract on Caspase-3, 8 and 9 expression levels in HCT116, AGS and HepG2 cell lines.

Caspase-3, 8 and 9 expression was investigated in protein lysates obtained after 100 and 400µg/ml plant extract was applied to HepG2, AGS and HCT116 cells for 24 hours.

Caspase-3, 8 and 9 activation was observed at a significant level in HepG2 cells. (Figure 2A). Caspase-3 expression increased approximately 2-fold as a result of 100µg/ml dose application compared to control (p=0.06), while this increase was approximately 3.2-fold in 400µg/ml application (p=0.001). As a result of 400µg/ml dose application, Caspase-8 expression increased approximately 3.6-fold (p=0.004), while Caspase-9 expression increased approximately 2-fold (p=0.013) compared to control group (Table 10).

Table 10. Statistical analysis of the caspase expression values observed as a result of the application of the plant extract to HepG2 cells.

	Dose	Mean± SD	p value
Caspase-3	Control	0.438±0.070	
	100µg/ml	0.8810±0.117	0.006
	400µg/ml	1.4300±0.182	0.001
Caspase-8	Control	0.216±0,072	
	100µg/ml	0.4550±0.086	0.029
	400µg/ml	0.7730±0.130	0.004
Caspase-9	Control	0.588±0.121	
	100µg/ml	0.7090±0.072	0.275
	400µg/ml	1.2100±0.203	0.013

Although an increase in the expression of Caspase-8 and 9 proteins as a result of 100µg/ml dose application was observed in AGS cells,this increase was not at a significant level (p=0.166 and p=0.137 respectively). (Table 11). While there was no significant increase in Caspase-3 expression in 100µg/ml dose application (p=0.470). an approximately 2-fold increase was observed in 400µg/ml dose application compared to control (p=0.009). (Figure 2B).

Table 11. Statistical analysis of the caspase expression values observed as a result of the application of the plant extract to AGS cells.

	Dose	Mean±SD	p value
Caspase-3	Control	0.354±0.080	
	100µg/ml	0.4250±0.118	0.470
	400µg/ml	0.6560±0.048	0.009
Caspase-8	Control	0.287±0.025	
	100µg/ml	0.3540±0.061	0.166
	400µg/ml	0.3880±0.028	0.014
Caspase-9	Control	0.404±0.035	
	100µg/ml	0.5540±0.072	0.137
	400µg/ml	0.5070±0.010	0.016

Also there were significant increases observed in the expression of all three caspase proteins in HCT116 cells as a result of the application of the plant extract at the indicated doses (Table 12). In the 400µg/ml dose application an approximately 3.4-fold increase in Caspase-3 expression was observed (p<0.001). while an approximately 3.2-fold increase in Caspase-9 expression was observed compared to control (p<0.001). (Figure 2C).

Table 12. Statistical analysis of the caspase expression values observed as a result of the application of the plant extract to HCT116 cells.

	Dose	Mean± SD	p value
Caspase-3	Control	0.341±0.058	
	100µg/ml	0.9450±0.131	0.002
	400µg/ml	1.1520±0.123	<0.001
Caspase-8	Control	0.401±0.085	
	100µg/ml	0.8040±0.105	0.009
	400µg/ml	0.8810±0.122	0.007
Caspase-9	Control	0.281±0.027	
	100µg/ml	0.5670±0.033	<0.001
	400µg/ml	0,9110±0,030	<0.001

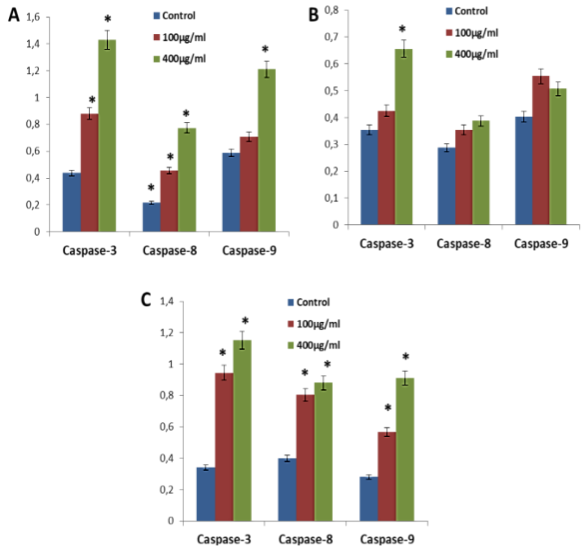

Figure 2: Effect of *Corydalis solida* plant extract on Caspase-3. 8 and 9 expression levels on HepG2 (A), AGS (B) and HCT116 (C) cells.

DISCUSSION

In accordance with our study, researchers examined the antimicrobial activity of *Corydalis solida* against *C. albicans*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* in micro dilution method and they found the extracts of *C. solida* exhibited inhibitory activity (from MIC of 0.39 to 1.56 mg L−1) against the test microorganisms (1)

Increasing the intracellular concentrations of anticancer agents and resulting drug resistance is an important factor that reduces the efficiency of treatment. Therefore, it is very important to develop alternative therapy methods as complementary in the clinic. However, there is a great need for in vitro studies at the first stage in the process leading to clinical trials. For this purpose, biological effects of *Corydalis solida* plant extract were studied on gastrointestinal cancer cell lines. When the results are considered in general, although it varies depending on the cancer cell type, proliferation inhibition was clearly observed in all three cell lines depending on the dose and time. There has been no study in the literature investigating the antiproliferative effect of *Corydalis solida* plant extract on cancer cells. Therefore, this study is important as it is the first study to examine the effects of this plant on gastrointestinal cancer cell lines. In addition, the high antiproliferative effect obtained in HepG2 cells shows that this plant can be used to understand the molecular biology of liver cancer. Further and more detailed in vivo studies raise the possibility of testing this plant as an alternative or complementary to the traditional therapies used in liver cancer. Caspase activation is one of the cornerstones of apoptosis. When the obtained antiproliferative results and increased caspase expressions were examined together, it was thought that further in vivo studies should be done with this plant. Although naturally the results may vary due to the different nature of different cancer cells, promising results were observed especially in HepG2 and HCT116 cells in this study.

CONCLUSION

C. solida ethanolic extract significantly reduced cell viability in gastrointestinal tract cancer cell lines and also induced apoptosis activation mediated by caspase activation. Antimicrobial activities of *C. solida* extracts against pathogenic microorganisms were also observed at a satisfactory level. If these promising results are confirmed by further and detailed in-vivo models, they will have important contributions to the understanding of the molecular biology of gastrointestinal cancers.

Authors's Contributions: Idea/Concept: G.D.; Design: G.D.; Data Collection and/or Processing: G.D.; Analysis and/or Interpretation: G.D.; Literature Review: G.D.; Writing the Article: G.D.; Critical Review: G.D.

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