DOI: http://dx.doi.org/10.32571/ijct.1087514 E-ISSN: 2602-277X

International Journal of Chemistry and Technology

http://dergipark.org.tr/ijct

Research Article

Antimicrobial, antioxidant and mutagenic effect potential of red pepper (*Capsicum annum*)

Yakup AKKOÇ[1,*], Mehmet ARSLAN[2], Nurcan ERBİL[3], Zehra Tuğba MURATHAN[4]

[1]*Posof Vocational School, Medical Techniques Department, Ardahan University, Ardahan, Türkiye*

[2]*Faculty of Health Sciences, Department of Health Administration, Ardahan University, Ardahan, Türkiye*

[3]*Faculty of Health Sciences, Department of Nursing, Ardahan University, Ardahan, Türkiye*

[4]*Department of Plant and Animal Production, Battalgazi Vocational School, Malatya Turgut Özal University, Malatya, Türkiye*

Received: 14 March 2022; Revised: 20 June 2022; Accepted: 26 June 2022

*Corresponding author e-mail: yakupakkoc@gmail.com

Citation: Akkoç, Y.; Arslan, M.; Erbil, N.; Murathan, Z. T., O. *Int. J. Chem. Technol.* **2022**, 6 (1), 48-55.

ABSTRACT

In this study, the biochemical, microbiological, mutagenic and antioxidant properties of red pepper (*Capsicum annum*) grown in 6 districts of Adıyaman province (Kahta, Gerger, Sincik, Samsat, Tut, Gölbaşı) were investigated. The bioactive compounds of Gerger samples, which also exhibited higher antioxidant activity. The results of antimicrobial activity showed that Kahta pepper extract exhibited antibacterial activity against *Staphylococcus aureus* ATCC 6538 with an MIC (minimum inhibition concentration) value of 0.715 mg/ml. The lowest MIC values in the pepper extracts were obtained in Kahta pepper extract (0.715-1.43 mg ml^{-1}), and the highest MIC values were recorded in Tut pepper extract (1.1525-4.61 mg ml^{-1}). The mutagenic activity results of peppers indicated no mutagenic effect at the doses tests and in the studies carried out on TA 100 strains and Salmonella typhimurium TA 98 and in the absence of S9. Dose dependent increase was recorded on *Salmonella typhimurium* TA 98 strain of Samsat pepper samples. But, the rising was not statistically importent.

Keywords: Phenolics compounds, bioactive compounds, medicinal plants, flavonoids.

Kırmızı biberin (*Capsicum annum*) antimikrobiyal, antioksidan ve mutajenik etki potansiyeli

ÖZ

Bu çalışmada Adıyaman ilinin 6 ilçesinde (Kahta, Gerger, Sincik, Samsat, Tut, Gölbaşı) yetiştirilen kırmızı biberin (*Capsicum annum*) biyokimyasal, mikrobiyolojik, mutajenik ve antioksidan özellikleri araştırılmıştır. Gerger örneğinin biyoaktif bileşikleri en yüksek antiaoksidan aktivite gösterdi. Antimikrobiyal aktivitenin sonuçları, Kahta biber ekstraktının, 0.715 mg/ml MİK (minimum inhibisyon konsantrasyonu) değeri ile *Staphylococcus aureus* ATCC 6538'e karşı antibakteriyel aktivite sergilediğini gösterdi. Biber ekstraktlarında en düşük MİK değerleri Kahta biber ekstraktında (0.715-1.43 mg ml-1), en yüksek MİK değerleri Tut biber ekstraktında (1.1525-4,61 mg ml^{-1}) elde edilmiştir. Biberlerin mutajenik aktivite sonuçları, doz testlerinde ve TA 100 suşları ve *Salmonella typhimurium* TA 98 üzerinde yapılan çalışmalarda ve S9 yokluğunda mutajenik etki göstermedi. Samsat biber örneklerinde *Salmonella typhimurium* TA 98 suşunda doza bağlı artış kaydedilmiştir. Ancak, yükseliş istatistiksel olarak önemli değildir.

Anahtar Kelimeler: Fenolik bileşikler, biyoaktif bileşikler, şifalı bitkiler, flavonoidler.

1. INTRODUCTION

Pepper is cultivated under cover or in the open field in various countries of the world, and is an important crop for the consumer, producer and processing industry.[1] The pepper is an annually cultivated crop in temperate climates. The species cultivated in the Southeastern Anatolia and the Eastern Mediterranean Regions of Türkiye is *Capsicum annuum* L.[2] The carotenoid and vitamin C content of red pepper has significant effects on anti-cardiovascular diseases, some types of cancer, atherosclerosis and anti-aging. A plethora of researchers have been addressed on the carotenoids due to the benefits on human health and attractive color in foods.[3] The pepper has been used in medicine since ancient times due to the diuretic effect and activation of the stomach

DOI: http://dx.doi.org/10.32571/ijct.1087514 E-ISSN: 2602-277X

and glands.[1] Positive effects of red pepper on lipid metabolism, diabetic neuropathy, gallstones and inflammatory diseases, and accelerating effect on digestion have been reported.[4] The pepper has been used as a medicine for stomachache, arthritis, rash, snake bites and dog bites and for healing wounds in China and America.[5]

Previous studies have been conducted to define biochemical, antimicrobial and antimutagenic properties of red pepper grown in different regions of Türkiye. "We herein examined the biochemical, antimicrobial and antimutagenic properties of red peppers grown in Adıyaman province. The goal of this study was to determine the biochemical, antimicrobial and mutagenic properties of red peppers grown in Adıyaman province of Türkiye.

2. MATERIALS AND METHODS

2.1. Plant Materials

The red pepper samples were collected from 6 different districts of Adıyaman province (Kahta, Gerger, Sincik, Samsat, Tut, Gölbaşı) and stored at -20 ºC in the laboratory until analysis.

2.2. Extraction

Leaves, stems and seeds were removed from pepper samples and 20 ml of methanol was added to 2 gram of red pepper sample, and homogenized. The mixture was held ed at 4 ºC for 24 hours in a shaking oven, and centrifuged at 5000 rpm for 10 min. The supernatant was utilized for total flavonoid, phenolic substance and antioxidant capacity analysis. Oxalic acid was used as the solvent for total vitamin C analysis, and the same extraction method was used. Biochemical analyzes were carried out immediately after the extraction.

40 g of red pepper samples were weighed for the extracts used in mutagenic and antimicrobial tests, and the pepper samples were homogenized by adding 200 ml of distilled water. The mix was extracted at 190 rpm and room temperature for 72 h. Later on, the mix was centrifuged at 5000 rpm for 10 min. The supernatants were concentrated using a rotary evaporator. The concentrated extracts were sterilized with a 0.22 µm microfilter and kept at -20 ºC until further analysis.

2.3. Catalase activity analysis

Catalase activity was measured using the modified method described by Lartillot and co-workers[6] and Bergmeyer.[7] A substrate solution was prepared adding 10 mmol L^{-1} H_2O_2 in 50 mmol L^{-1} phosphate buffer. Then, 2.5 mL of substrate solution was added onto 20 mL of enzyme-containing solution (prepared by diluting with 1/2000 buffer) and incubated at 37 °C for 2 minutes. In order to stop the reaction, 0.5 mL of 1N HCl was added to the solution, and the absorbance was measured at 240 nm. For blank (Ar), 2.5 mL buffer (50 mmol L^{-1} phosphate buffer with pH 6.8) and 0.5 mL 1 N HCl were used. The absorbance (As) of the reaction mix was measured with a mixture of 2.5 mL of substrate and 0.5 mL of 1 N HCl. The absorbance (At) caused by the protein was measured in the mixture of 20 mL of the test solution, 2.5 mL of buffer and 0.5 mL of 1 N HCl. The change in absorbance due to enzymatic activity was calculated using the following equivalence (Eq. 1).

$$A = (As + At) - Ar \quad \text{(Eq. 1)}$$

In the equation; Ar is absorbance in the presence of enzyme and substrate; As is the initial absorbance (absorbance of the reaction mixture at the time zero); At is the absorbance of the mixture (in the presence of enzyme and the lack of substrate). The activity of catalyze was calculated using the following equation (Eq. 2).

$$Activity\ (IU\ mL^{-1}) = A.V_{total} / \hat{I}.t.\ V_{sample} \quad \text{(Eq. 2)}$$

In the equation; Î is the specific absorbance coefficient of hydrogen peroxide is about 0.0396 $cm^2/\neq mol$, the value is 0.068 $cm^2/\neq mol$ for tertiary hydrogen peroxide. t is the reaction time.

2.4. Total phenolic content

Total phenolic content was defined using the Folin-Ciocalteu method proposed by Spanos and Wrolstad.[8] The 1000 µl of Folin-Ciocalteu and 800 µl (7.5%) sodium carbonate were added to the 200 µl extract. After the incubation for 2 h. at room temperature, the absorbance at 765 nm was measured using a spectrophotometer. Total phenolic content of red pepper samples was calculated as mg gallic acid equivalent (GAE) 100 g^{-1} extract using gallic acid standard. The analysis was reiterated three times.

2.5. Total flavonoid content

Total flavonoid substance of red pepper samples was defined using the method suggested by Quettier and co-workers.[9] 1 ml of 2% aluminum chloride was added to 1 ml of extract and held in the dark for 1 hour at room temperature. The total flavonoid content of the red peppers was measured in a spectrophotometer at 415 nm. The equivalent of mg quercetin was calculated as mg quercetin 100 g^{-1} extract using the calibration curve prepared by the routine standard. The analysis was reiterated three times.

2.6. Total ascorbic acid content

Total ascorbic acid was defined spectrophotometrically according to the AOAC[10] method. 400 µL of 0.4%

DOI: http://dx.doi.org/10.32571/ijct.1087514 E-ISSN: 2602-277X

$C_2H_2O_4$ and 4.5 ml of 2.6-$C1_2H_7NCl_2O_2$ solutions were added into 100 µl of supernatant, and the absorbance was measured at 520 nm. The amount of vitamin C in red pepper samples was calculated as mg 100 g^{-1} using the calibration curve obtained with pure ascorbic acid.

2.7. Antioxidant activity assays

2.7.1. DPPH radical scavenging activity

The 1,1-diphenyl-2-picrylhydrazyl (DPPH) scavenging activity of red pepper extracts was determined using the method proposed by Bakhshi and Arakawa.[11] 4 ml of DPPH solution (0.1 M) was combined with 1 ml of extract and kept in a shaker at room temperature for 30 min. in a dark environment. The absorbance of the solution at 515 nm was determined in a spectrophotometer. The antioxidant capacity of red pepper was calculated using the following equivalence (Eq. 3)

%DPPH=(AcontrolAsample)/Acontrolx100 (Eq. 3)

2.7.2. ABTS radical scavenging activity

The 2,2′-azino-bis (3-ethylbenzthiazoline-6-sulphonic acid) (ABTS) radical scavenging activity was defined using the method proposed by Re and co-workers.[12] A 1:1 stock solution was prepared with 2.45 mM potassium per sulfate and 7 mM ABTS and incubated at room temperature for 16 hours in the dark. For the measurements, the stock solution was diluted with C_2H_4O until the absorbance of 0.7±0.05 at 734 nm. 150 µl of sample was mixed with 2.85 ml ABTS solution and incubated for 6 min. at room temperature. The absorbance was measured at 734 nm, and CH_3OH solution was used as the blank. The percent ABTS was computed using the following equivalence (Eq. 4). The analysis was reiterated three times.

%ABTS inhibition = (AcontrolAsample)/Acontrolx100.

2.7.3. FRAP Assay activity

FRAP (ferric reducing ability of plasma) analysis was implemented using the method introduced by Benzie and Strain.[13] The solution of the method was prepared by stiring 25 ml of $C_2H_3NaO_2$ buffer (300 mM, pH 3.6), 2.5 ml of TPZT solution (10 mM in 40 mM HCl) and 2.5 ml $FeCl_3.6H_2O$ (20 mM). The mixture was heated at 37 °C in a water bath and 900 µl of the solution was taken into a cuvette and the first absorbance was determined. 100 µl of the diluted (1:4 v/v water) sample was taken into the cuvette and 3 ml of FRAP solution was added. After 4 minutes, absorbance was measured at 593 nm. A standard curve (100-1000 µl) was prepared using $FeSO_4$ solution, and the results were calculated in µmol Fe (II)g^{-1}. The analysis was reiterated three times.

2.8. Antimicrobial activity

The antimicrobial activity of the aqueous extracts obtained from the Gerger, Sincik, Gölbaşı, Kahta, Samsat and Tut pepper samples was tested by the Broth Microdilution Method.[14,15] The test bacteria used in the study were *Enterobacter aerogenes* ATCC 13048, *Klebsiella pneumoniae* ATCC 33495, *Bacillus licheniformis* ATCC 14580 and *Staphylococcus aureus* ATCC 6538. Bacterial cultures incubated for 16 hours were set to McFarland 0.5 turbidity standard, and Mueller Hinton Agar was used as the medium.

The amount of dilution for Sincik pepper extract was between 6.89-0.0269 mg/ml, 4.61-0.0180 mg/ml for Tut pepper extract, 4.14-0.1567 mg/ml for Gölbaşı pepper extract, 5.72-0.0223 mg/ml for Kahta pepper extract, 10.65-0.0416 mg/ml for Samsat pepper extract and 6.12-0.0239 mg/ml for Gerger pepper extract. Plates were incubated at 37 ºC for 18 hours. After the incubation, 0.5% TTC solution was added to the wells and incubated for another 30 min. The wells with no color change at the last of the incubation were determined as MICs (minimum inhibition concentration).

2.9. Genotoxicity tests

2.9.1. *Salmonella typhimurium* reverse mutation assay

The mutagenic activity of aqueous extracts obtained from red pepper samples were determined using the plaque incorporation method developed by Maron and Ames.[16] The mutagen activity analyzes were performed on Salmonella typhimurium TA 100 and Salmonella typhimurium TA 98 strains. 4-Nitro-Ophenylenediamine (4-NPD; Product Number: 108898-5G, Sigma Aldrich, St. Louis, MO, USA) was used as a positive control for TA 98 (10µg/plate). Sodium azide (SA; Cat. No. S 2002, Sigma Aldrich) was used as a positive control for TA 100 (100µg/plate). Plates were incubated at 37°C for 48-72 hours, then his+ revertant bacterial colonies were counted on the plates. The analyzes were used in the tests without the metabolic activation system S9 mix using the S. typhimurium TA 98 and TA 100 strains. The analysis was reiterated three times.

2.10. Statistical analyses

Statistical analysis of the datum was implemented using SPSS (version 20) statistical software. The number of colonies that returned with the effect of red pepper samples were determined. One-way analysis of variance (ANOVA) was used to define the statistical difference among the control and the dissimilar concentrations of red pepper samples. The mean values of different pepper cultivars were grouped using the Dunnett test.

DOI: http://dx.doi.org/10.32571/ijct.1087514 E-ISSN: 2602-277X

3. RESULTS AND DISCUSSION

3.1. Results

The catalase activities of red pepper samples are given in Table 1. The highest catalase activity was recorded in Gerger (1106.7 U/mg) and the lowest was in Kahta (763.3) pepper samples.

Table 1. Catalase activities of red pepper samples.

SAMPLES	ACTIVITY (U/mg Protein)
Kahta	763.3
Tut	899.4
Gölbaşı	8651
Gerger	1106.7
Sincik	764.5
Samsat	941.9

The total phenolic, total ascorbic acid, total flavonoid contens and antioxidant capacities of the red pepper samples are given in Table 2. The Gerger samples had the highest total ascorbic acid content (259.8 mg 100^{-1}). The total ascorbic acid content of Sincik, Samsat and Tut samples was not importantly different from each other. The lowest total ascorbic acid content was determined in Gölbaşı samples (209.8 mg/100g). The total phenolic content in methanolic extracts of pepper samples was determined spectrophotometrically using the Folin Ciocalteu method. The maximum total phenolic acid content was obtained in Gerger sample (235.9 mg/100g), and the lowest content was in Kahta samples (73.4 mg/100g). The maximum total flavonoid content was recorded in Samsat samples (139.6 mg/100g), and the minimum content was in Sincik and Kahta samples. The highest FRAP content was determined in Gerger and Tut samples, and the lowest value was in Sincik samples. The maximum ABTS radical scavenging activity was in Gerger (35.3%) and the minimum activity was in Kahta (8.5%) sample. The maximum DPPH radical scavenging activity was obtained in Gerger and Samsat (52, 50%) sample, while the lowest value was obtained in Kahta (22.5%) sample. The results showed that bioactive compounds and antioxidant activities were high in Gerger sample.

Table 2. Total ascorbic acid, phenolic substance, flavonoid substance and antioxidant capacity in red pepper samples.

SAMPLES	TAC (mg/100g)	Total phenolic substance (mg/100g)	Total flavonoid substance (mg/100g)	FRAP (µmol FeII/g)	ABTS (%)	DPPH (%)
Kahta	232.3±3.6^{bc}	73.4±2.4^{e}	66.1±3.5^{d}	144.4±3.9^{c}	8.5±0.3^{d}	22.5±2.7^{c}
Tut	246.5±2.5^{b}	191.2±3.5^{b}	102.3±7.4^{b}	253.8±16.1^{a}	28±0.2^{b}	36±3.8^{b}
Gölbaşı	209.8±34.1^{c}	126.7±2.9^{d}	72.8±12.6^{c}	149±7.4^{c}	21.3±0.7^{bc}	33±1.2^{b}
Gerger	259.8±3.8^{a}	235.9±12.5^{a}	109.3±16.2^{b}	251.7±6.3^{a}	35.3±2.2^{a}	52±3.3^{a}
Sincik	247.3±5.2^{b}	147.2±2.3^{c}	67.3±5.3^{d}	141.1±1.4^{c}	14.5±0.3^{c}	28±0.9^{bc}
Samsat	245.7±3.8^{b}	184.2±4.9^{b}	139.6±12.3^{a}	243.8±17.3^{b}	32.6±3.2^{a}	50±2.9^{a}

The antimicrobial activity of the samples is given in Table 3. The antimicrobial activity results revealed that pepper extracts exhibited a significant antibacterial activity, and *Staphylococcus aureus* ATCC 6538 is more sensitive to pepper extracts. Kahta pepper extract exhibits antibacterial activity against *Staphylococcus aureus* ATCC 6538 with a MIC value of 0.715 mg/ml. Kahta pepper extract had the lowest MIC values (0.715-1.43 mg/ml), while Tut pepper extract (1.1525-4.61 mg/ml) had the highest MIC values.

Table 3. MIC values of red pepper extracts.

Bacteria	Kahta (mg/ml)	Tut (mg/ml)	Gölbaşı (mg/ml)	Sincik (mg/ml)	Gerger (mg/ml)	Samsat (mg/ml)
Klebsiella pneumoniae ATCC 33495	1.43	4.61	2.007	1.7225	3.06	2.6625
Bacillus licheniformis ATCC 14580	1.43	4.61	2.007	1.7225	1.53	1.3312
Enterobacter aerogenes ATCC 13048	1.43	4.61	4.14	3.445	3.06	2.6625
Staphylococcus aureus ATCC 6538	0.715	1.1525	1.0035	1.7225	1.53	2.6625

The mutagenic activities of the samples are shown in Tables 4 and 5. The mutagenicity tests of pepper extracts used in this study were investigated on *Salmonella typhimurium* TA 98 and TA 100 strains. Four different doses of pepper samples (12.5, 25, 50 and 100 µl/plate) were used in the mutagenicity experiments. The mutagenic effect of pepper samples on *Salmonella typhimurium* TA 98 and TA 100 strains was not detected at the doses tested and in the absence of S9 (Tables 4, Table 5). The mutagenic effect on Salmonella typhimurium TA 98 strain of Samsat pepper samples was increased with the rise in the treatment dose. However, the increase in mutagenic effect was not statistically significant.

3.2. DISCUSSION

Many different studies have been implemented on red pepper; however, the antioxidant capacity, genotoxicity, antimicrobial and mutagenic activity of Adıyaman red

DOI: http://dx.doi.org/10.32571/ijct.1087514 E-ISSN: 2602-277X

peppers have not been investigated. The maximum total phenolic content was acquired in Gerger sample (235.9 mg/100g), and the lowest content was in Kahta sample (3.4 mg/100g). The highest total flavonoid content was defined in Samsat sample (139.6 mg/100g), and the minimum value was in Sincik and Kahta samples. Ergün[17] reported that the total phenolic content in the methanol extracts of Cemele pepper grown in Kırşehir province was 27.03 µg/ml and the total flavonoid content was 39.67 µg/ml. The highest FRAP contents were obtained in the Gerger and Tut pepper samples, and the minimum value was in the Sincik sample. The FRAP content ranged from 141.1 to 253.8 µmol Fe II/g. The minimum ABTS radical scavenging activity was obtained in Gerger (35.3%), and the minimum value was in Kahta (8.5%) samples. The maximum DPPH radical scavenging activity was recorded in Gerger and Samsat (52, 50%) samples, and the minimum value was in Kahta (22.5%) samples. The bioactive compounds and the antioxidant activity of

Table 4. Mutagenic effect of red pepper extracts on *Salmonella typhimurium* TA 98.

Samples	Concentration	Number of colonies returned
		Mean±Sd**
Kahta	Control	16.67±1.45
	Positive control (4-NPD)*	2086±109
	12.5 µl/plate	19.33±4.67
	25 µl/plate	10.33±1.2
	50 µl/plate	28.33±4.48
	100 µl/plate	20.00±1.00
Tut	Control	16.67±1.45
	Positive control (4-NPD)*	2989±109
	12.5 µl/plate	13.00±3.51
	25 µl/plate	13.33±1.76
	50 µl/plate	28.67±6.69
	100 µl/plate	19.33±0.882
Gölbaşı	Control	16.67±1.45
	Positive control (4-NPD)*	2889±109
	12.5 µl/plate	23.00±1.53
	25 µl/plate	16.00±0.577
	50 µl/plate	13.67±2.4
	100 µl/plate	39.3±15.2
Gerger	Control	23.00±6.43
	Positive control (4-NPD)*	1754±588
	12.5 µl/plate	16.00±2.89
	25 µl/plate	15.67±1.86
	50 µl/plate	18.67±1.20
	100 µl/plate	15,33 ± 2,40
Sincik	Control	23,00 ± 6,43
	Positive control (4-NPD)*	1754 ±588
	12.5 µl/plate	14,667±0,882
	25 µl/plate	17,00 ±4,51
	50 µl/plate	16,00±1,00
	100 µl/plate	18,00± 4,36
Samsat	Control	12,67 ± 2,60
	Positive control (4-NPD)*	1262,0±57,6
	12.5 µl/plate	12,333±0,882
	25 µl/plate	19,33 ±1,67
	50 µl/plate	31,33±6,84
	100 µl/plate	34,00±4,16

DOI: http://dx.doi.org/10.32571/ijct.1087514 E-ISSN: 2602-277X

Table 5. Mutagenic effect of red pepper extracts on *Salmonella typhimurium* TA 100.

Samples	Concentration	Number of colonies returned Mean±Sd**
Kahta	Control	232.00±2.31
	Positive control (4-SA)*	2326±183
	12.5 µl/plate	360.0±30.1
	25 µl/plate	252.0±18.3
	50 µl/plate	258.3±14.9
	100 µl/plate	290.0±23.4
Tut	Control	232.00±2.31
	Positive control (4-SA)*	2326±183
	12.5 µl/plate	591±151
	25 µl/plate	394.0±51.8
	50 µl/plate	340.0±54.5
	100 µl/plate	396.7±11.7
Gölbaşı	Control	232.00±2.31
	Positive control (4-NPD)*	2326±183
	12.5 µl/plate	407.3±66.8
	25 µl/plate	551±114
	50 µl/plate	520.7 ±35.8
	100 µl/plate	366.7±22.8
Gerger	Control	98.00±11.2
	Positive control (4-NPD)*	5677±1138
	12.5 µl/plate	65.33± 4.33
	25 µl/plate	97.33±6.36
	50 µl/plate	81.3±14.4
	100 µl/plate	96.3±12.8
Sincik	Control	98.0±11.2
	Positive control (4-NPD)*	5677±1138
	12.5 µl/plate	146.00±5.13
	25 µl/plate	129.3±19.2
	50 µl/plate	80.00 ±5.69
	100 µl/plate	71.67±1.67
Samsat	Control	128.0±23.4
	Positive control (4-NPD)*	2059 ±152
	12.5 µl/plate	128.0± 34.1
	25 µl/plate	141.3±39.8
	50 µl/plate	136.0±13.7
	100 µl/plate	115.67±3.84

Gerger pepper sample were high. Arın [18] reported that the DPPH radical scavenging activity of hot red pepper was 35%. Shan and co-workers[19] determined the total antioxidant capacity in hot pepper samples as 6.05 mmol/100 g. Keçeli[20] determined the antioxidant levels of bell pepper, green pepper and paste pepper as 1.264, 0.562 and 0.386 mmol/100 g fresh matter, respectively. Akça[21] reported the antioxidant values of Kundu F1, Bafra F1, Abide F1 and Istek F1 pepper varieties as 5.09, 8.88, 6.26 and 6.90 mmol/100 g dry matter, respectively. The differences between studies may be based on to the differences in climatic characteristics, soil structure and cultural practices, and the differences in varieties and cultivars may also affect the results.

The antimicrobial activity analysis indicated that all pepper samples had varying degrees of antimicrobial activity. The lowest MIC values were determined in Kahta red pepper extract. The most sensitive test bacteria

DOI: http://dx.doi.org/10.32571/ijct.1087514 E-ISSN: 2602-277X

was *Staphylococcus aureus* ATCC 6538. Previous studies on *Capsicum annum* show that extracts of *Capsicum annum* generally exhibit antimicrobial activity, which is in conformity with the results acquired in this study. Ali and co-workers[22] reported the inhibitory effect of ethyl acetate extract among the different extracts (hexane, acetone, dichloromethane, ethyl acetate and ethanol) obtained from *Capsicum annum* on *Bacillus subtilis* ATCC 6663, *Aspergillus flavus* ATCC 3261 and *Trichophyton longifusus* ATCC 22397 (73, 77 and 70%, respectively).

In another study, the effects of different varieties of *Capsicum annum* on foodborne pathogenic microorganisms were investigated. The results showed that all pepper extracts used inhibited the growth of *Staphylococcus aureus* and *Listeria monocytogenes*, and Effix and Fantasia varieties of peppers were considered the most effective varieties in terms of antimicrobial activity.[23]

Gebara and co-workers[24] reported that *Capsicum annum* fractions exhibited the highest inhibitory activity especially against *Candida* and *Mycobacterium tuberculosis* species. The results of this working consistent with those previously reported show that pepper has varying degrees of antimicrobial effect on the test microorganisms.

The mutagenicity studies carried out are generally related to capsaicin, which is obtained from the cayenne pepper. Previous studies have shown that capsaicin may have anticarcinogenic and antimutagenic activity.[25,26] In addition, the capsaicin selectively induces apoptosis in cancerous cells and may have a tumor stimulating effect.[26,27] Oğuzhan and co-workers[28] reported that capsaicin is one of the most important secondary metabolites in peppers, and capsaicin has antimutagenic and anticarcinogenic potential. In addition, the researchers indicated that the extract in methanol showed a better protective effect in terms of DNA protection at the highest concentrations, while the dichloromethane extract of capsaicin provided a higher protective effect at low concentrations.

The mutagenicity was not reported in two different studies using the *Salmoonella-microsome* assay to detect capsaicin and pepper extract mutagenicity.[29,30] Another study was revealed that capsaicin was mutagenic with metabolic activation in test strains of TA 98, TA 100, TA 1535, TA 1537 and TA 1538 with *Salmonella typhimurium* histidine deficiency.[31] The intraperitoneal application of capsaicin to male mice caused an increase in micro nucleated normochromic erythrocytes in peripheral blood and sister chromatid exchanges in bone marrow cells.[32] Similarly, the intraperitoneal application of alcoholic extracts of *Capsicum frutescens* pepper fruits to mice led to positive results in mouse bone marrow micronucleus test.[33]

The mutagenic activity results revealed that different pepper extracts of Adıyaman province do not have a mutagenic effect on *Salmonella typhimurium* TA 98 and TA 100 strains in the absence of S9 and at the doses tested in this working. These results are coherent with the findings of Rockwell and Raw,[29] Buchmann and co-workers.[30]

The antioxidant capacity, genotoxicity and antimicrobial catalase enzyme activities of red peppers collected from different regions of Adıyaman province were different. The difference can be associated with soil type, climate and growing conditions of pepper plants.

4. CONCLUSIONS

Red pepper is an important vegetable for many countries. In this study, the biochemical, antimicrobial mutagenicity and antioxidant properties of red peppers collected from different regions of Adıyaman province of Türkiye were investigated. Mutagenic activities on *Salmonella typhimurium* TA 98 and TA 100 strains were not detected in the absence of S9 and at the doses tested.

The results revealed that the catalase activity of pepper samples was high. Bioactive compounds and antioxidant activity were high in Gerger samples. The antimicrobial activity results showed that the lowest MIC values were in Kahta pepper extract, and the highest MIC values were in Tut pepper extract.

Conflict of interests

I declare that there is no a conflict of interest with any person, institute, company, etc.

REFERENCES

1. Duman, A. D.; Zorlugenç, B.; Evliya, B. KSU Journal of Science and Engineering. **2002,** 5, 111-117.

2. Topak, H.; Erbil, N.; Dığrak, M. Fırat University Journal of Science and Engineering Sciences. **2008**, 20, 257-264.

3. Kusçu, A. The Effect of Continuous Drying Process on Quality Characteristics of Red Pepper. Master Thesis. Süleyman Demirel University, Institute of Science and Technology, Isparta, Türkiye. 2002

4. Sim, K. H.; Sil, H. Y. International Journal of Food Science and Technology. **2008**,43, 1813-1823.

5. Zimmer, A. R.; Leonardi, B.; Miron, D.; Schapoval, E.; de Oliveira, J. R.; Gosmann, G. Journal of Ethnopharmacology. **2012**, 139, 228-233.

DOI: http://dx.doi.org/10.32571/ijct.1087514 E-ISSN: 2602-277X

6. Lartillot, S.; Kedziora, R.; Athias, A. Preparative Biochemistry. **1988**, 18(3), 241-6.

7. Bergmeyer, H.U. Methods of Enzymatic Analysis V2. Verlag Chemie, Weinheim. **1974**. eBook ISBN: 9780323161374

8. Spanos, G.A.; Wrolstad, R.E. J.Agric.Food Chem. **1992**, 40(9),1478-1487.

9. Quettier-Deleu, C.; Gressier, B.;Vasseur, J.; Dine, T.; Brunet, J; Luyck, M.; Cazin, M.; Cazin, J. C.; Bailleul, F.; Trotin, F. Journal of Ethnopharmacology. **2000**, 72, 35-40.

10. AOAC. Official Methods of Analysis of The Association of Official Analytical Chemists 15th ed., Arlington VA, USA, **1990,**1058-1059.

11. Bakhshi, D.; Arakawa, O. Journal of Food, Agriculture & Environment. **2006**, 4 (1), 75-79.

12. Re, R.; Pellegrini, N.; Proteggente, A.; Pannala, A.; Yang, M.; Rice-Evans, C. Free Radical Biology and Medicine. **1999**, 26(9/10), 1231-1237.

13. Benzie, I. F. F.; Strain, J. J. Analytical Biochemistry. **1996**, 239, 70-76.

14. Abbasoğlu, U.; Tosun, F.; Aydınoğlu, A. Journal of Pharmaceutical Sciences. **1995**, 20, 125-127.

15. Uysal, N. E. Taraxacum farinosum Hausskn. Determination of antibacterial activities of Et Bornm and Taraxacum mirabile Wagenitz extracts. Master Thesis. Selcuk University, Institute of Science and Technology, Konya, 2011.

16. Maron, D.M.; Ames, B.N. Revised methods for the Salmonella mutagenicity test. Mutation Res. **1983**, 113,173-215.

17. Ergün, F. Turkish Journal of Agriculture and Natural Sciences. **2021**, 8(3), 693-701.

18. Arın, B. Investigation of Antimicrobial and Antioxidant Activities of Some Spices used in Meat Products. Doctoral dissertation, İstanbul Technical University, Graduate School of Natural and Applied Sciences. Istanbul, 2009.

19. Shan, B.; Yizhong, Z.; Sun, M.; Corke, H. Journal of Agricultural and Food Chemistry. **2005**,53, 7749-7759

20. Keçeli, M.A. Characterization of peppers for antioxidant content and virus resistance. Master Thesis. İzmir Institute of Technology, İzmir, 2008.

21. Akça, A. Evaluation of pepper varieties in terms of antioxidant capacities and components. Master Thesis. IU. Graduate School of Natural and Applied Sciences, 2012.

22. Ali, F; Jan, A.K.; Khan, N.M.; Ali, R.; Mukhtiar, M.; Khan, S.;Khan, S.A.; Aziz, R. Chiang Mai Journal of Science. **2018**, 45(2), 881-887.

23. Loizzo, M.R.; Bonesi, M.; Serio, A.; Chaves-Lovez, C.; Falco, T.; Paparella, A.; Menichini, F.; Tundis, R. International Journal of Food Properties. **2017**, 20(4): 899-910.

24. Gebara R.D.; Taveira G.B.; dos Santos L.D.; Calixto S.D.; Simao T.L.B.V.; Lassounskaia E.; Muzitano M.F.; Teixeira-Ferreira, A.; Perales J.; Rodrigues, R.; Carvalho, A.D.; Gomes,V.M. Probiotics and Antimicrobial Proteins. **2020**, 12(3): 1253-1265.

25. Surh, Y.J; Lee, S.S. Food Chem Toxicol. **1996**, 34,313–316

26. Sing, S.; Asad, S.F.; Ahmad, A.; Khan, N.; Hadı, S.M. Cancer Letters. **2001**, 139-146.

27. Gannett, P.M.; Nagel, D.L.; Reilly, P.J.; Lawson. T.; Sharpe, J.; Toth, B. J. Org Chem. **1988**, 53, 1064- 1071.

28. Sibel, B. O.; Merve, C.; Halil, İ.; Halil, İ. U.; Mehmet, Ö. KSÜ Tarim ve Doğa Dergisi. **2018**,21(1), 26-31.

29. Rockwell, P.; Isaias, R. A mutagenic screening of various herbs, spices and food additives, Nutr. Cancer. **1979**,1.5-10.

30. Buchmann, R.L.; Goldstein, S.; Budroe, J.P.; J. Food Sci. **1982**, 47,330-333.

31. Nagabhushan, M.; Bhide, S.V. Environ. Mutagen. **1985**, 7, 881-888.

32. Diaz Barriga Arceo, S.; Madrigal-Bujaidar, E.; Calderon Montellano, E.; Ramirez Herrera, L.; Diaz Garcia, B.D. Mutat. Res. **1995,** 345, 105-109.

33. Villasenor, I.M.; De Ocampo, E.J.; Bremner, J.B. Natural Prod. Lett. **1995**, 6, 247-253.