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Research Article

Medical physiological perspective to biochemical assays and GC-MS results of corn tassel

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Abstract: Corn tassel (Zea may L.) is rich in phenolic compounds including flavonoids and anthocyanins. The aim of this study is to consider the results of the contents of phenolics (TPC), flavonoids (TFC), flavonol (TF), anthocyanins (TAC), alfa-amylase inhibitory activity, and antioxidant activity including FRAP and metal chelating capabilities (MCC) as potential Antiviral and anti-Rheumatoid arthritis. Significantly high levels of antioxidant capacity, total flavonol and alfa-amylase inhibition were found in ethanolic extracts of corn tassels. It was found that their concentrations are TPC= 40 mg GA/g, TFC= 13 mg QE/g, TF= 45 mg R/g, and TAC= 8 mg cyanidin-3-glucoside/g based on dry extract. Additionally, the extracts showed relatively higher antioxidant activities due to metal chelating capabilities (MCC) were found to be 217 mg Fe^{2+}/g dry extract. From the GC-MS analysis, corn tassel was found to be good source of arctigenin that has antiviral and anti- rheumatic properties. Further, the extracts of corn tassels showed significantly higher α-amylase inhibitory activity up to 90 %. Thus, it was concluded that extracts of corn tassels may be considered as pharmacological potential in rheumatoid and antiviral treatment.

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1. INTRODUCTION

Plants as producer of bioactive components are commonly ingested in nutrition and have been utilized as traditional treatments for generations, where they are still used in the form of classical extracts such as infusion, decoction, or maceration in aqueous media (Abraham *et al*., 2021). Among bioactive components, phenolic compounds in medicinal plants and foods are known to dramatically decrease the adverse effects of reactive species on physiological functions of humans. This is very important because oxidative stress and reactive oxygen species (ROS) are considered to be harmful for human as they damage the cells and results in various metabolic disorders.

Corn (Zea may L.) tassel is rich in phenolic compounds including flavonoids and anthocyanins. Some studies reported that corn tassel extract has antioxidant capacity (Mohsen & Ammar, 2009; Wang *et al*., 2014) and high ability to reduce the proliferation of gastric cancer cells (Duangpapeng *et al*., 2018).

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Corn tassels can be included as therapeutic agents in the treatment of diseases Thus, there is need to studies on the composition of this plant seeds.

In this study, biochemical assays including total phenolic content (TPC), total flavonoid content (TFC), total flavonol content (TF), total anthocyanin content (TAC), antioxidant assays such as ferric reducing antioxidant power (FRAP) and metal chelating capacity (MCC) were determined in corn tassels because these parameters project the extent of bioactive components of the samples.

Further, α -amylase inhibition assay (AAI) and GC-MS analysis were also examined. Finally, the results obtained were evaluated taking into account their health correlations by medical physiological approach.

2. MATERIAL and METHODS

2.1. Chemicals

In the current study, all chemicals and solvents were of analytical grade. The chemicals including Folin-ciocalteu's phenol reagent, sodium hydroxide, trichloroacetic acid, ferric chloride trihydrate, potassium hydroxide, formic acid, aluminum chloride, sodium acetate trihydrate, potassium ferricyanide, iodine, phenanthroline monohydrate, ferrous sulfate heptahydrate, dipotassium hydrogen phosphate, and sodium carbonate were obtained from Merck (Germany). Methanol, ethanol, hexane, and sodium dihydrogen phosphate were obtained from Carlo Erba (Spain). Quercetin and ethyl acetate were purchased from Sigma-Aldrich (Germany) and gallic acid anhydrous was taken from ISOLAB GmbH. Rutin trihydrate was obtained from DR Ehrenstorfer™.

2.2. Preparation of Plant Material

Corn tassels were collected from Gaziantep city in Türkiye and washed by tap and distilled water, respectively. After drying at 70 ^{o}C for two days, the samples were ground into a fine powder using grinding mill. Powdered seed samples were extracted firstly by using hexane to defatted for 4 hours at room temperature. After evaporation, the hexane was removed using vacuum-rotary evaporator, the residue was extracted using the mixture of ethanol/water:70/30 (70 mL for 10 g dried sample) at room temperature under reflax for 24 hrs. After filtration (through Whatman filter paper-white), new extract at the same volume was added, and the process was repeated two times more. The filtrates of three days were combined and concentrated under reduced pressure at 40°C by using rotary evaporator with vacuum. The residue was dried at room temperature following oven with vacuum. From the dried sample, 0.03 g was dissolved in 10 mL of methanol and used for both biochemical assays and individual compounds.

2.3. Biochemical Assays

2.3.1. *Total phenolic content* (TPC)

The Folin–Ciocalteu technique was used to determine the total phenolic content of the extract with a minor modification (Abraham *et al*., 2021). Briefly, 1.5 mL of distilled water was added to 0.1 mL of crude extract (0.03 g/10 mL of methanol). After adding 0.1 mL of Folin–Ciocalteu reagent and waiting for 5 min, 1.5 mL of 10 % (w/v) sodium carbonate was added. The mixture was left in the dark for 60 minutes. Absorbance of the samples were measured using UV-VIS spectrophotometer (Thermo Scientific GENESYS 10S UV-VIS spectrophotometer, USA) at 765 nm. The total phenolic content of the extract was converted to gallic acid equivalents (milligrams of gallic acid per gram of dried extract=mg GA/g)) using a regression equation derived from the gallic acid standard calibration curve.

2.3.2. *Total flavonoid content* (TFC)

To determine the total flavonoid content of crude extract, the aluminum chloride colorimetric method was used with minor modification (Do *et al*., 2014). In brief, 0.2 mL of crude extract (0.03 g/10 mL of methanol) was added to 1 mL of 5 % $AlCl_3$ solution, and then 0.1 mL of 1.0 M CH_3COOK solution was added. After adding 2.7 mL of methanol, the mixture was allowed to stand for 60 minutes. The absorbance was measured at 420 nm using UV-VIS spectrophotometer. The quercetin was used as standard reagent. The total flavonoid content was determined using the quercetin calibration curve and represented in milligrams of quercetin equivalents per gram of dry weight (mg Q/g extract).

2.3.3. *Total flavonol content* (TF)

The total flavonol content was determined using a colorimetric technique with aluminum chloride (Iqbal *et al*., 2015). Briefly, 0.5 mL of aluminum chloride (2 %) was added to 0.5 mL extracts (0.03 g/10 mL of methanol) in a test tube. After adding 6.0 mL of sodium acetate (5%), the mixture was vortexed and then was incubated at room temperature in the dark for 2.5 hrs. Absorbance of the solutions was measured at 440 nm. Rutin was used to obtain standard calibration curve. The results were represented as mg rutin (R) equivalent/g of crude extract.

2.3.4. *Total Anthocyanin content* (TAC)

Anthocyanin concentrations were measured using the pH differential method, which was carried out with the use of a UV-vis. spectrophotometer (Mihailović *et al*., 2016). Separately, the tassels extracts were diluted in 0.025 M potassium chloride and 0.40 M sodium acetate solutions and then their acidities were adjusted to pH 1.0 and 4.5 with HCl, respectively. After that, absorbance of the solutions was measured at 520 and 700 nm, respectively. The following formula was used to compute the absorbance (A):

$$A = (A_{520} - A_{700})_{pH=1.0} - (A_{520} - A_{700})_{pH=4.5}$$

The concentration of monomeric anthocyanin in the original sample was calculated as follows Eq. 1:

$$[\text{monomeric anthocyanins}]\ (mg/L) = (A \times MW \times DF \times 1000)/(\varepsilon \times l) \quad (1)$$

The monomeric and total anthocyanin contents were calculated using cyanidin-3-glucoside equivalents (mg cyanidin-3-glucoside/kg dry extract).

The total anthocyanin concentration was calculated using Eq. (2):

$$[\text{total anthocyanins}]\ (mg/L) = (A' \times MW \times DF \times 1000)/(\varepsilon \times l) \quad (2)$$

Where: $A' = (A_{520} - A_{700})_{pH=1.0}$; MW = molecular weight (449.2 g/mol cyanidin-3-glucoside); DF = dilution factor; ε = molar extinction coefficient (26900 L $mol^{-1}cm^{-1}$ cyanidin-3-glucoside), l = path length (1.0 cm).

2.4. Antioxidant Assays

2.4.1. *Ferric reducing antioxidant power* (FRAP)

Based on its antioxidant principles, the reducing power (FRAP) of extracts of corn tassels was measured to create a colorful complex with potassium ferricyanide (Işil Berker *et al*., 2010). Briefly, 0.1 mL sample (0.03 g/10 mL) was added to test tubes containing 2.5 mL of 1% $K_3Fe(CN)_6$ and 2.5 mL of 0.2 M phosphate buffer (pH: 6.6). After incubation for 30 minutes at 50 °C, 2.5 mL of 10 % TCA was added to the tube. The samples were then centrifuged at 3200 rpm for 10 minutes. The 2.5 mL of supernatant was pipetted into a second tube containing 2.5 mL water and 0.5 mL of freshly prepared $FeCl_3$ of 0.1% was added. Absorbance was

measured at 700 nm. The results are expressed as milligrams of Quercetin equivalents per gram of dry mass (mg Q/g dry extract).

2.4.2 *Metal chelating capacity* (MCC)

Because the antioxidants are oxidized when exposed to $FeCl_3$, the amount of $FeCl_3$ utilized should be excessive to ensure that all antioxidants are oxidized. In this approach, the complexing reagent is 1-10-phenanthroline, which produces a complex compound with Fe (II) was used in the MCC determination. The reduction of Fe (III) by antioxidants results in Fe(II). As a result, the amount of Fe-phenanthroline generated will be equal to the antioxidant content of the sample being evaluated (Yefrida *et al*., 2018). So, a 1,10-phenanthroline technique was used to determine metal chelating capacity. A 1.5 mL of distilled water was added to 0.1 mL of the sample solution (0.03 g/10 mL) in the test tube. 1.0 mL of 0.2 % $FeCl_3$, 1.0 mL of 0.2% phenanthroline and 1.4 mL water were added to the mixture. After vortexing, the tubes were incubated in the dark for 20 minutes. Absorbance was measured at a wavelength of 510 nm. The results were reported in mg Fe^{2+}/g dry extract as iron II sulfate equivalents.

2.4.3 α *-amylase inhibition assay* (AAI)

A modified starch iodine protocol was used for this investigation (Ademiluyi & Oboh, 2013). To make an iodine solution, 0.1 g I_2 and 1.0 g KI were dissolved in 50 mL of distilled water. The starch solution was made by dissolving 1.0 g of starch in 50 mL of distilled water, slowly heating, cooling, and completing to 100 mL with distilled water. The amylase solution was made by mixing 15 mg of α-amylase suspension with 30 mL of phosphate buffer (pH 6.9). Briefly, 0.25 mL α-amylase was incubated with 0.25 mL (3 mg/mL) of the extracts for 15 minutes at 37 °C. After that, 0.25 mL of starch solution was added and the mixture was re-incubated for 30 minutes. The process was stopped by adding 0.1 mL of HCl (1.0 M). After vortexing extensively, 1.0 mL of iodine reagent was added, followed by 3.0 mL of distilled water. A spectrophotometer was used to measure the absorbance at 580 nm. To adjust the background absorbance, individual blanks were also studied. The tassels extracts were replaced with 0.25 distilled water in the controls, which were carried out in the same way. As a positive control, acarbose, a well-known anti-diabetic drug was used. The inhibition % was determined using the following formula:

$$\% \text{ Inhibition} = [(A_c - A_S)/A_c] \times 100$$

A_c-absorbance for control; A_s-absorbance for standard

2.5. Gas-Chromatographic Determinations of Methanolic Extracts

From the dried sample detailed in the section 2.2, 0.03 g of extract was dissolved in 10 mL of ethanol and used for GC-MS (Shimadzu OP2010 ultra GCMS) determinations.

3. RESULTS

The quantitative phytochemical analysis shows that corn tassels extracts include considerable amounts of phenolic, flavonoids, and flavonol content, indicating its powerful antioxidant capacity. Polyphenolic compounds and their functional derivatives have an aromatic benzene ring with substituted hydroxyl groups and so, they can be effective as reducing agents, hydrogen donors, and metal chelators (Rice-evans *et al*., 1995). They are capable of absorbing free radicals (radical scavengers) and chelating metal ions that may stimulate the development of reactive oxygen species (ROS), which promotes lipid peroxidation (Iqbal *et al*., 2015); (Kessler, Ubeaud, and Jung, 2003).

Among polyphenols, flavonoids are particularly beneficial since they are powerful antioxidants and aid the human body in fighting disease. They are found in plants as glycosides,

commonly (Rajanandh & Kavitha, 2010). The most prevalent flavonol with antioxidant activity is quercetin, which possesses all of the necessary structural characteristics for free radical scavenging activity (Kalita *et al*., 2013). The TPC values for corn tassels reported in the literature are in a wide range of 15-45 mg/g dw (Aziz *et al*., 2021; Taha *et al*., 2015). This high range may be attributed to the grown conditions of the plant as well as the extraction conditions such as solvent species, extraction type, extraction time, temperature, ratio of sample/solvent and measurement conditions. From the Table 1 and Figure 1, it is seen that the obtained TPC values (40 mgGA/g) in this study are in the high region of the reported in the literature. So, the added solvent can highly extract the phenolic compounds due to the defatting from the matrix. The TFC values (13 mg Q/g) obtained (Table 1) are in the ranges of the literature (3.3-21 mg Q/g) for corn tassels (Aziz *et al*., 2021; Taha *et al*., 2015).

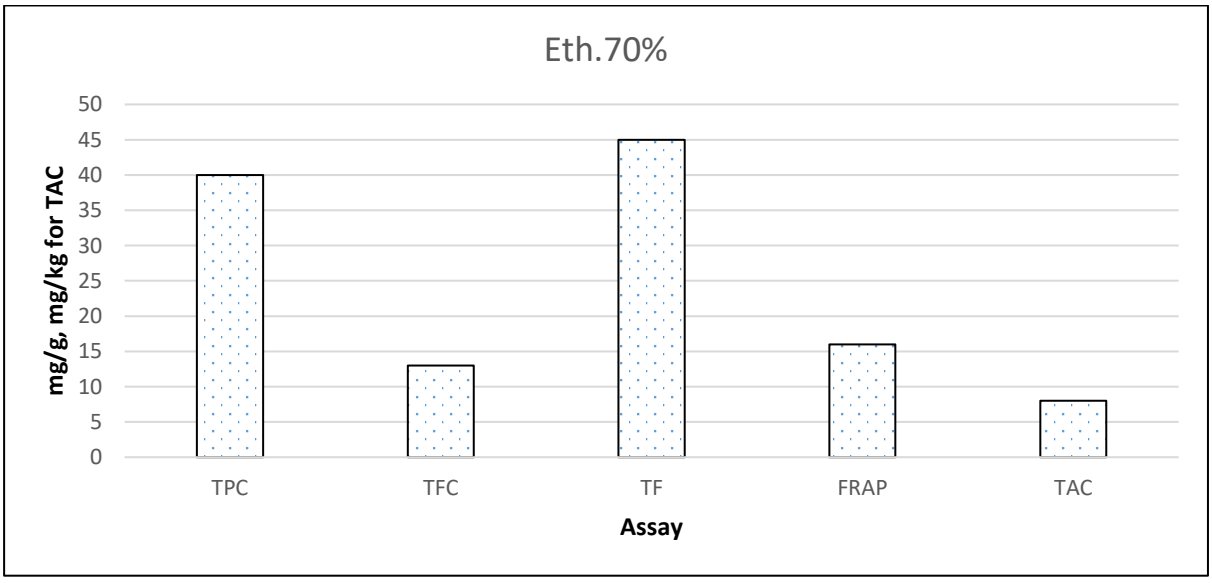
Interestingly, the obtained TF values (45 mg R/g) were found to be higher than the TFC values (13 mg Q/g) for the same samples (Table 1).

Table 1. Biochemical assays and antioxidant activities of the corn tassels extracts.

Assay	70%ethanol as extract
TPC (mg GA/g)	40±4
TFC (mg QE/g)	13±±2
TF (mg R/g)	45±5
Anthocyanin Monomeric (mg cy-3-glu/kg)	0.5±0.1
Anthocyanin Total (mg cy-3-glu/kg)	8±1
Antioxidant activity	
FRAP **(**mg $FeSO_4$/g extract)	16±2
MCC **(**mg Fe^{2+}/g dry extract)	217±19
Amylase inhib. %	90±10

GA= gallic acid equivalent, QE= Quercetin equivalent, R= Rutin equivalent
Data are expressed as mean ± standard deviation (n=3)

Figure 1. TPC, TFC, TF, FRAP and TAC values for the corn tassels extracts



3.1. Total Anthocyanin Contents

Anthocyanins may act as antioxidants and may provide additional health benefits (Hosseinian *et al*., 2008). Antioxidant power is widely recognized for anthocyanins (phenolic chemicals) that are responsible for the red, blue, or purple coloring of many plants. Because it is a quick and simple operation, the pH differential approach is the most commonly used method for quantifying anthocyanins (Lee *et al*., 2005). The monomeric and total Anthocyanins of the extract have been expressed in mg cy-3-glu/kg (Table 1). It was found that the monomeric and total anthocyanin contents are 0.3 and 1.1, respectively (Table 1).

3.2 Antioxidant capacities

3.2.1. *Ferric reducing antioxidant power* (FRAP)

The ability of extracts of corn tassels to reduce ferric ions was assessed using the FRAP test. It was found that the extracts of corn tassels have a significant antioxidant capacity (Table 1) that the obtained values (16 mg/g) are in ranges of the literature values (Aziz *et al*., 2021). The reducing power assay is frequently used to assess a natural antioxidant's ability to donate an electron or hydrogen, which is a key mechanism of phenolic antioxidant action (Dorman *et al*., 2003).

3.2.2. *Metal chelating capacity* (MCC)

By-products of mitochondrial electron transport and other metabolic activities constitute the majority of reactive oxygen species (ROS). As a result of metal-catalyzed oxidation processes, ROS are generated as essential intermediates. Using electron gain or loss, the transition metal ion Fe^{2+} can keep generating free radicals in the solution. So, chelating metal ions with chelating agents reduces the generation of reactive oxygen species. Therefore, the chelation ability of crude extracts was assessed using a chelation power test (Sudan *et al*., 2014). The results of this study (217 mg/g) showed extracts of corn tassels to be highly capable of chelating metals (Table 1) and may therefore protect against oxidative damage caused by metal-catalyzed degradation processes. The obtained high MCC values (217 mg/g) reveal that corn tassels have high antioxidant capacity.

3.2.3. *α -amylase inhibition assay*

Some studies have shown that plants used as conventional medicine are also useful in the treatment of diabetes, whereas synthetic anti-diabetic drugs can produce serious side effects such as hypoglycemic coma and liver and kidney disorders (Shabab *et al*., 2021).

α-Amylase is one of the most important enzymes in the human body, and it is responsible for the breakdown of starch into more simple sugars. Inhibitors of this enzyme can cause a delay in carbohydrate digestion and a reduction in the rate of glucose absorption. As a result, Amylase inhibitors have the potential to lower attenuated postprandial plasma glucose levels and enhance glucose tolerance in diabetic individuals (Nickavar & Yousefian, 2011). Inhibitors of alpha Amylase, also known as starch blockers, work by preventing dietary starch absorbed by the body and as a result, provide lower postprandial blood glucose levels. In persons with diabetes, slowing the digestion and breakdown of starch may have favorable benefits on insulin resistance and glycemic index control (Uddin *et al*., 2014). From the obtained results in Table 1 and Figure 2, it can be concluded that corn tassels is more effective as antidiabetic because amylase inhibition up to 90% was observed.

3.3. Individual Components of Corn Tassels by GC-MS

The obtained GC-MS chromatogram for the extract of corn tassels was given in Figure 3. From the library of GC-MS device, the evaluated components depending on the peaks in this chromatogram were given in Table 2. It was seen that the highest ratio of the compound (area%-

R. time) is the Dihydrofuran-2-one, 4-(3,4-dimethoxybenzyl)-3-(4-hydroxy-3-methoxybenzyl)- known as Arctigenin (69.60%-51.102 min).

The values given in Table 2 were analyzed against the GC-MS library. The percentage of the compound Dihydrofuran-2-one, 4-(3,4-dimethoxybenzyl)-3-(4-hydroxy-3-methoxybenzyl)dihydrofuran-2(3H)-one known as Arctigenin that considered in this study was found to be % 89.

Figure 2. MCC and Alfa amylase values for the corn tassels extracts.

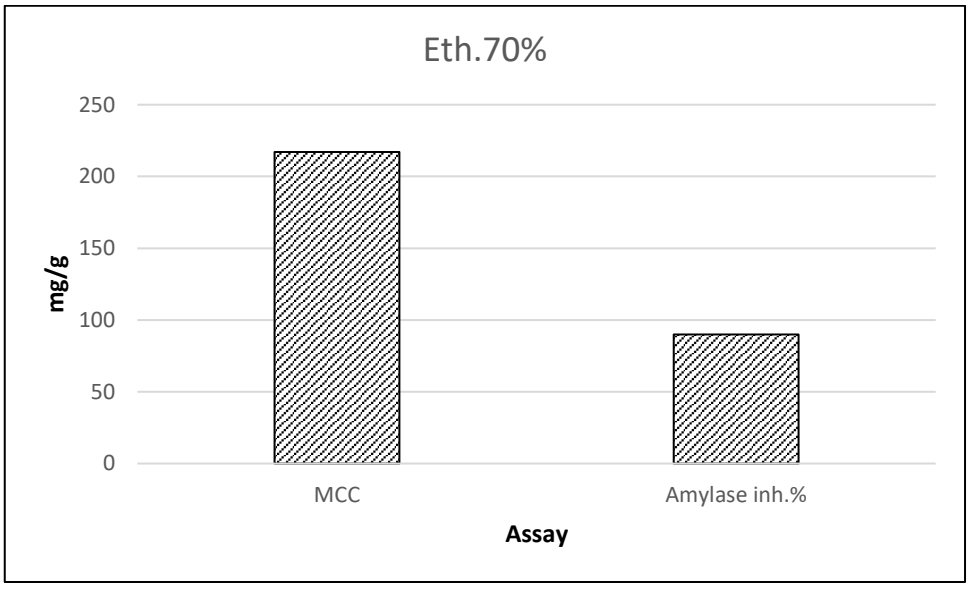


Figure 3. GC-MS chromatogram of the corn tassels extracts.

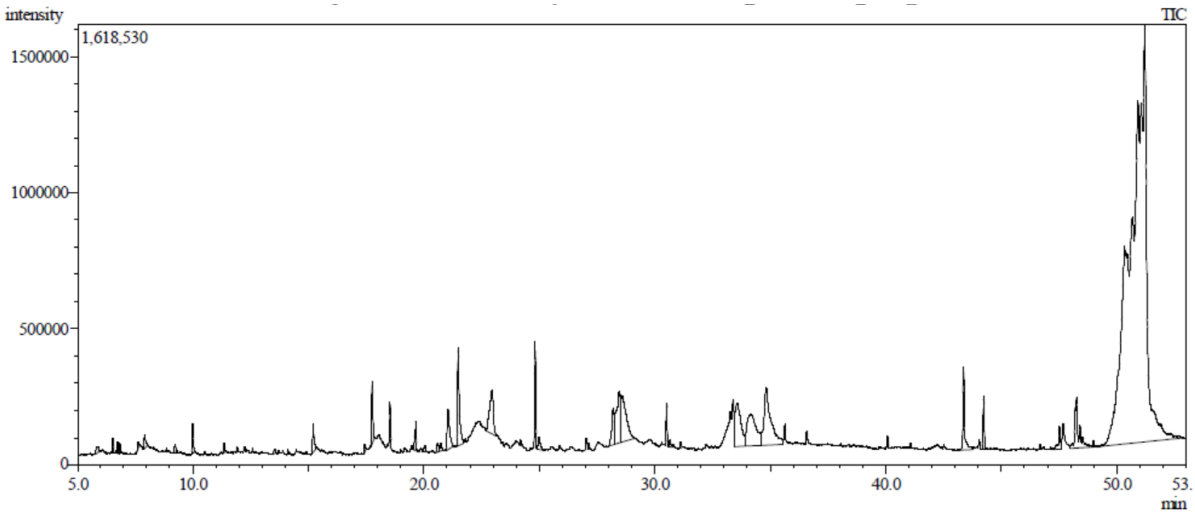


Table 2. GC-MS analysis of the corn tassels extracts.

Peak	R. Time	Area	Area%	Name
1	3.548	271560	0.26	1,2,3-Propanetriol (CAS)
2	3.973	223376	0.22	2-Propenoic acid, methyl ester (CAS)
3	4.015	247654	0.24	(R)-alpha-Methyl-beta-alanine
4	4.137	613917	0.60	N-methyl-N-(methyl-d3)aminoheptane
5	5.886	163529	0.16	dl-Glyceraldehyde
6	6.541	117138	0.11	Silane,(2-methoxyethyl)trimethyl-
7	6.740	100520	0.10	1,3-Dioxolane-4-methanol,2-ethyl-
8	6.845	88743	0.09	2-Furanmethanol (CAS)
9	7.617	102419	0.10	Butanoic acid, 2-ethyl-methyl ester (CAS)
10	7.911	213794	0.21	dl-Glyceraldehyde dimer
11	9.222	127222	0.12	2-Hydroxy-2-cyclopenten-1-one
12	9.977	307960	0.30	2,5 Furandione,3-methyl-
13	11.362	105084	0.10	2,4-Dihydroxy-2,5-dimethyl-3(2H)-furan-3-one
14	13.521	77747	0.08	4-Methylenecyclohexanone
15	15.212	453877	0.44	1.3.5-Triazine-2,4,6-triamine
16	17.446	83402	0.08	2-Propanamine, N-methyl-N-nitroso-(CAS)
17	17.765	793893	0.77	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-
18	19.650	485945	0.47	4-Methyl itaconate
19	20.058	94741	0.09	1,3-Benzenediol (CAS)
20	20.582	183087	0.18	Tetrahydrofuran-5-oı-2-methanol,alpha-[alpha-methoxy-(tetrahydrofuran-5-on-2-ylmethoxy)]-
21	20.730	144493	0.14	2,3-Dihydro-Benzofuran
22	21.048	1083282	1.05	5-hydroxymethylfurfural
23	21.489	1834159	1.78	1,2,3-Propanetriol,1-acetate (CAS)
24	22.938	1767818	1.72	2,3-Dihydro-3,5-dihydroxy-6-methyl-4H-pyran-4-one
25	24.172	92124	0.09	Guaiacol<4-vinyl->
26	24.986	284003	0.28	Butanedioic acid, 2-hydroxy-2-methyl-,(S)-
27	27.150	78510	0.08	Tetradecane
28	28.201	929739	0.90	Alpha-d-Lyxofuranoside,methyl
29	28.457	2222580	2.16	Benzaldehide,2-hydroxy-4-methyl-
30	28.550	2762467	2.68	1,3-Propanediol,2-(hydroxymethyl)-2-nitro-
31	30.667	120044	0.12	1-Dodecanamine,N,N-dimethyl- (CAS)
32	31.121	76991	0.07	2,5-Pyrrolidinedione,3-(1-aminoethylidene)-4-methyl-(CAS)
33	33.581	2647741	2.57	Quinic acid
34	34.189	3410195	3.31	3-Deoxy-d-mannoic acid
35	34.836	4311118	4.19	Beta-D-Glucopyranose, 4-O-beta,-D-galactopyranosyl-
36	43.378	1414390	1.37	Palmitic acid
37	44.265	637855	0.62	Hexadecanoic acid, ethyl ester (CAS)
38	47.543	472057	0.46	9,12-Octadecadienoic acid (Z,Z)-
39	48.266	2035793	1.98	Ethyl linoleate
40	49.015	115219	0.11	Stearate <ethyl->
41	51.102	71638186	69.60	Dihydrofuran-2-one, 4-(3,4-dimethoxybenzyl)-3-(4-hydroxy-3-methoxybenzyl)-
		102934372	100.00	

4. DISCUSSION

In the literature, there is not any information about the arctigenin in the corn tassel. It was reported that the seeds of *Arctium lappa* (Chinese medicinal plant) had high concentration of arctigenin (Gao *et al*., 2018).This study is the first on the high arctigenin levels in the corn tassel. Related with the biochemical assays, the obtained TF values were found to be higher (45 mgR/g) that is higher than the TFC values of 13 mgQ/g for the same samples. Due to the obtained high concentration of flavonol in the studied samples, it can be concluded that some flavonols do not signal at the TFC determination step.

The MCC results (217 mg/g) showed that the extracts of corn tassels have high capable of chelating metals and therefore protect against oxidative damage caused by metal-catalyzed degradation processes.

In the literature, it was reported that arctigenin stimulates glucose reuptake in cultured L6 skeletal muscle cells and AMPK (AMP-activated protein kinase) phosphorylation. The AMPK is striking target to treat type 2 diabetes (Srivastava & K, 2017). Briefly, arctigenin activates AMPK by inhibiting respiratory complex I and play antidiabetic role.

The obtained results in the current study showed that corn tussels is highly effective as antidiabetic because amylase inhibition was found to be 90%. The high actinic concentrations in the extract of corn tussels are in accordance with amylase inhibition.

Further, the arctigenin compound has anti-inflammatory, antidepressant and anticancer effects (Gao *et al*., 2018; Shabgah *et al*., 2021; Xu *et al*., 2020; Zhong *et al*., 2019). Due to the anti-inflammatory effects, it is also suggested in combination of drugs used for rheumatoid arthritis (Chakraborty *et al*., 2021).

In a behavior study, the antidepressant effect of arctigenin was shown and mechanism of this effect was described as suppressor effect on both HMGB1/TLR4/NF-κB and TNF-α/TNFR1/NF-κB signaling pathways (Xu *et al*., 2020). ATG may be useful in diabetic kidney disease by enhancing PP2A activity, reducing p65 NF-κB-mediated inflammatory response and also high glucose-induced migration in podocytes via interaction with Drebrin-1 (Zhong *et al*., 2019). ARG inhibits inducible nitric oxide synthase (INOS). Hence, ARG has potent anti-inflammatory effects in acute and chronic auto inflammatory diseases (Gao *et al*., 2018). Arctigenin can trigger apoptosis and necrosis and prevent drug resistance in tumor cells by stimulating apoptotic signaling pathways, caspases and cell cycle arrest. Anti-inflammatory properties of Arctigenin provide the inhibition of inflammation in the tumor microenvironment. Arctigenin also prevents tumor metastasis and angiogenesis downregulating some factors such as N-cadherin, TGF-β, and VEGF (Shabgah *et al*., 2021).

5. CONCLUSION

In this study, the antioxidant capacity as well as biochemical assays and GC-MS analysis were performed in the extract of corn tassels. The phytochemical examination of the sample is critical for determining the sample's antioxidant capacities. The amount of total phenolic was approximately three-times higher than the amount of total flavonoid. Thus, a significant amount of phenolic compounds is responsible for their high antioxidant and free radical scavenging ability and they could be used as a natural source of antioxidants to treat oxidative stress-related disorders. Again, the obtained total flavonol content is higher more than three times than TFC. This is considered that some flavonol compounds in the corn tassels could not be determined by the known TFC method. The effect of natural extracts as antioxidants was evaluated using FRAP-MCC, which demonstrated that these plants have a high capacity for scavenging free radicals. The extract evaluated for α-amylase inhibitory capacity had the highest level of inhibition, which may be a result of the synergistic action of the phytochemical ingredients present. GC-MS analysis revealed the presence of valuable compounds such as Arctigenin

because this compound has antidepressant, antiviral, anti-inflammatory, and anticancer effects as well as anti-rheumatic effects.

The findings of this research will assist future research in identifying, isolating, and characterizing the specific molecule responsible for increased antioxidant activity.

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Declaration of Conflicting Interests and Ethics

The author declares no conflict of interest. This research study complies with research and publishing ethics. The scientific and legal responsibility for manuscripts published in IJSM belongs to the author.

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REFERENCES

Abraham, A.M., Quintero, C., Carrillo-Hormaza, L., Osorio, E., & Keck, C.M. (2021). Production and Characterization of Sumac PlantCrystals: Influence of High-Pressure Homogenization on Antioxidant Activity of Sumac (Rhus coriaria L.). *Plants (Basel, Switzerland)*, *10*(6). https://doi.org/10.3390/PLANTS10061051

Ademiluyi, A.O., & Oboh, G. (2013). Aqueous Extracts of Roselle (Hibiscus sabdariffa Linn.) Varieties Inhibit α-Amylase and α-Glucosidase Activities In Vitro. *Journal of Medicinal Food*, *16*(1), 88–93. https://doi.org/10.1089/JMF.2012.0004

Aziz, M., Saeed, F., Ahmad, N., Ahmad, A., Afzaal, M., Hussain, S., Mohamed, A.A., Alamri, M.S., & Anjum, F.M. (2021). Biochemical profile of milk thistle (Silybum Marianum L.) with special reference to silymarin content. *Food Science & Nutrition*, *9*(1), 244–250. https://doi.org/10.1002/FSN3.1990

Chakraborty, D., Gupta, K., & Biswas, S. (2021). A mechanistic insight of phytoestrogens used for Rheumatoid arthritis: An evidence-based review. *Biomedicine and Pharmacotherapy*, *133*. https://doi.org/10.1016/J.BIOPHA.2020.111039

Do, Q.D., Angkawijaya, A.E., Tran-Nguyen, P.L., Huynh, L.H., Soetaredjo, F.E., Ismadji, S., & Ju, Y.H. (2014). Effect of extraction solvent on total phenol content, total flavonoid content, and antioxidant activity of Limnophila aromatica. *Journal of Food and Drug Analysis*, *22*(3), 296–302. https://doi.org/10.1016/J.JFDA.2013.11.001

Dorman, H.J.D., Peltoketo, A., Hiltunen, R., & Tikkanen, M.J. (2003). Characterisation of the antioxidant properties of de-odourised aqueous extracts from selected Lamiaceae herbs. *Food Chemistry*, *83*(2), 255–262. https://doi.org/10.1016/S0308-8146(03)00088-8

Duangpapeng, P., Ketthaisong, D., Lomthaisong, K., Lertrat, K., Scott, M.P., & Suriharn, B. (2018). Corn Tassel: A new source of phytochemicals and antioxidant potential for value-added product development in the agro-industry. *Agronomy*, *8*(11), 242. https://doi.org/10.3390/agronomy8110242

Gao, Q., Yang, M., & Zuo, Z. (2018). Overview of the anti-inflammatory effects, pharmacokinetic properties and clinical efficacies of arctigenin and arctiin from Arctium lappa L. *Acta Pharmacologica Sinica*, *39*(5), 787–801. https://doi.org/10.1038/APS.2018.32

Hosseinian, F.S., Li, W., & Beta, T. (2008). Measurement of anthocyanins and other phytochemicals in purple wheat. *Food Chemistry*, *109*(4), 916-924. https://doi.org/10.1016/J.FOODCHEM.2007.12.083

Iqbal, E., Salim, K.A., & Lim, L.B.L. (2015). Phytochemical screening, total phenolics and antioxidant activities of bark and leaf extracts of Goniothalamus velutinus (Airy Shaw) from

Brunei Darussalam. *Journal of King Saud University - Science*, *27*(3), 224–232. https://doi.org/10.1016/J.JKSUS.2015.02.003

Işil Berker, K., Güçlü, K., Tor, I., Demirata, B., & Apak, R. (2010). Total antioxidant capacity assay using optimized ferricyanide/Prussian blue method. *Food Analytical Methods*, *3*(3), 154–168. https://doi.org/10.1007/S12161-009-9117-9/TABLES/7

Kalita, P., Tapan, B.K., Pal, T.K., & Kalita, R. (2013). Estımatıon of total flavonoıds content (TFC) and antı oxıdant actıvıtıes of methanolıc whole plant extract of bıophytum sensıtıvum lınn. *Journal of Drug Delivery and Therapeutics*, *3*(4), 33-37. https://doi.org/10.22270/jddt.v3i4.546

Kessler, M., Ubeaud, G., & Jung, L. (2003). Anti-and pro-oxidant activity of rutin and quercetin derivatives. *Journal of Pharmacy and Pharmacology*, *55*(1), 131–142.

Lee, J., Durst, R.W., Wrolstad, R.E., Barnes, K.W., Eisele, ; T, Giusti, ; MM, Haché, ; J, Hofsommer, ; H, Koswig, ; S, Krueger, D. A., Kupina, ; S, Martin, ; S.K., Martinsen, ; B.K., Miller, T. C., Paquette, ; F, Ryabkova, ; A, Skrede, ; G, Trenn, ; U, & Wightman, J.D. (2005). Determination of Total Monomeric Anthocyanin Pigment Content of Fruit Juices, Beverages, Natural Colorants, and Wines by the pH Differential Method: Collaborative Study. *Journal of AOAC International*, *88*(5), 1269-1278. https://doi.org/10.1093/JAOAC/88.5.1269

Mihailović, V., Kreft, S., Benković, E.T., Ivanović, N., & Stanković, M.S. (2016). Chemical profile, antioxidant activity and stability in stimulated gastrointestinal tract model system of three Verbascum species. *Industrial Crops and Products*, *89*, 141–151. https://doi.org/10.1016/J.INDCROP.2016.04.075

Mohsen, S.M., & Ammar, A.S.M. (2009). Total phenolic contents and antioxidant activity of corn tassel extracts. *Food Chemistry*, *112*(3), 595-598. https://doi.org/10.1016/J.FOODCHEM.2008.06.014

Nickavar, B., & Yousefian, N. (2011). Evaluation of α-amylase inhibitory activities of selected antidiabetic medicinal plants. *Journal Fur Verbraucherschutz Und Lebensmittelsicherheit*, *6*(2), 191–195. https://doi.org/10.1007/S00003-010-0627-6

Rajanandh, M.G., & Kavitha, J. (2010). Quantitative estimation of β-sitosterol, total phenolic and flavonoid compounds in the leaves of Moringa oleifera. *International Journal of PharmTech Research*, *2*(2), 1409–1414.

Rice-evans, C.A., Miller, N.J., Bolwell, P.G., Bramley, P.M., & Pridham, J.B. (1995). The relative antioxidant activities of plant-derived polyphenolic flavonoids. *Free Radical Research*, *22*(4), 375–383. https://doi.org/10.3109/10715769509145649

Shabab, S., Gholamnezhad, Z., & Mahmoudabady, M. (2021). Protective effects of medicinal plant against diabetes induced cardiac disorder: A review. *Journal of Ethnopharmacology*, *265*, 113328. https://doi.org/10.1016/j.jep.2020.113328

Shabgah, A.G., Suksatan, W., Achmad, M.H., Bokov, D.O., Abdelbasset, W.K., Ezzatifar, F., Hemmati, S., Mohammadi, H., Soleimani, D., Jadidi-Niaragh, F., Ahmadi, M., & Navashenaq, J.G. (2021). Arctigenin, an anti-tumor agent; a cutting-edge topic and up-to-the-minute approach in cancer treatment. *European Journal of Pharmacology*, *909*. https://doi.org/10.1016/J.EJPHAR.2021.174419

Srivastava, D., & K, S. (2017). Arctigenin, A Plant Lignan With Tremendous Potential: A Review. *International Journal of Current Research*, *9*(05), 50232–50237.

Sudan, R., Bhagat, M., Gupta, S., Singh, J., & Koul, A. (2014). Iron (FeII) chelation, ferric reducing antioxidant power, and immune modulating potential of Arisaema jacquemontii (Himalayan Cobra Lily). *BioMed Research International*, *2014*. https://doi.org/10.1155/2014/179865

Taha, M.N., Krawinkel, M.B., & Morlock, G.E. (2015). High-performance thin-layer chromatography linked with (bio)assays and mass spectrometry - A suited method for

discovery and quantification of bioactive components? Exemplarily shown for turmeric and milk thistle extracts. *Journal of Chromatography A, 1394*, 137-147. https://doi.org/10.1016/J.CHROMA.2015.03.029

Uddin, N., Hasan, M.R., Hossain, M.M., Sarker, A., Nazmul Hasan, A.H.M., Mahmudul Islam, A.F.M., Chowdhury, M.M.H., & Rana, M.S. (2014). In vitro α-amylase inhibitory activity and in vivo hypoglycemic effect of methanol extract of Citrus macroptera Montr. fruit. *Asian Pacific Journal of Tropical Biomedicine*, *4*(6), 473. https://doi.org/10.12980/APJTB.4.2014C1173

Wang, L.C., Yu, Y.Q., Fang, M., Zhan, C.G., Pan, H.Y., Wu, Y.N., & Gong, Z.Y. (2014). Antioxidant and antigenotoxic activity of bioactive extracts from corn tassel. *Journal of Huazhong University of Science and Technology - Medical Science*, *34*(1), 131–136. https://doi.org/10.1007/s11596-014-1244-x

Xu, X., Piao, H.N., Aosai, F., Zeng, X.Y., Cheng, J.H., Cui, Y.X., Li, J., Ma, J., Piao, H.R., Jin, X., & Piao, L.X. (2020). Arctigenin protects against depression by inhibiting microglial activation and neuroinflammation via HMGB1/TLR4/NF-κB and TNF-α/TNFR1/NF-κB pathways. *British Journal of Pharmacology*, *177*(22), 5224-5245. https://doi.org/10.1111/BPH.15261

Yefrida, Suyani, H., Alif, A., Efdi, M., & Aziz, H. (2018). Modification of phenanthroline method to determine antioxidant content in tropical fruits methanolic extract. *Research Journal of Chemistry and Environment*, *22*(4), 28–35.

Zhong, Y., Lee, K., Deng, Y., Ma, Y., Chen, Y., Li, X., Wei, C., Yang, S., Wang, T., Wong, N.J., Muwonge, A.N., Azeloglu, E.U., Zhang, W., Das, B., He, J.C., & Liu, R. (2019). Arctigenin attenuates diabetic kidney disease through the activation of PP2A in podocytes. *Nature Communications*, *10*(1). https://doi.org/10.1038/S41467-019-12433-W