



Phytochemical screening and antimicrobial potential of *Chenopodium quinoa* extract against pathogenic bacterial strains

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Abstract

Pathogenic diseases and complications associated with them are one of the most prevailing problems around the world. Excessive use of synthetic antibiotic drugs for the treatment of microbial diseases leads to multi-drug resistance in many pathogenic bacteria. Such problem leads to herbal treatment involving medicinal plants. The present study was designed to evaluate the phytochemistry and antimicrobial potential of *Chenopodium quinoa*. Two varieties depending upon the phenotype of plant material were selected and methanolic extract of leaves and seeds was prepared by using two different extraction techniques. Total phenolic and total flavonoid content assays were done following folin-ciocalteu (FC) and colorimetric protocol, respectively. Antimicrobial activity was evaluated using the disc diffusion method against *Escherichia coli* (*E. coli*) and *Staphylococcus aureus* (*S. aureus*). The results of phytochemical analysis showed that leaves and seeds extract of quinoa plant has high TPC with a maximum value of 181.4 ± 1.54 (mgGAE/1g extract) and TFC with a maximum range of 42.15 ± 1.21 (mg QE/1 g extract). The antimicrobial activity showed a maximum inhibition zone against *S. aureus* in the range of 12–20 nm and that against *E. coli* as 10–18 nm. Ampicillin, a standard antibiotic drug was used as a positive control. In conclusion, *Chenopodium quinoa* can be used as a potential source of an antimicrobial drug rich in phytochemicals.

Keywords Antimicrobial potential · *Chenopodium quinoa* · *E. coli* · Flavonoid contents · Phenolic contents

Introduction

Pathogenic microorganisms such as viruses, bacteria and fungi are the main reason behind serious infectious diseases which cause life-threatening problems to human health. Over time, the expansion and occurrence of these microorganisms with diversity and antibiotic resistance has the potential of causing new and complicated diseases which is a matter of great concern to the health community worldwide (Hussain et al. 2022). In poor and developing countries, food poisoning due to microorganisms is one of the main factors of sickness and death. Bacterial contamination mostly among the members of the family of Gram-negative bacteria like *Salmonella typhi*, *Escherichia coli* and *Pseudomonas aeruginosa* is mainly linked with most of the food spoilage. Also, many members of Gram-positive bacterial strains, for example *Staphylococcus aureus* and *Bacillus cereus* have been reported as the causing agent of many food-borne diseases or food poisoning. Preventive measures against these microorganisms to prevent food spoilage can be achieved

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by using chemical or natural preservatives (Mostafa et al. 2018).

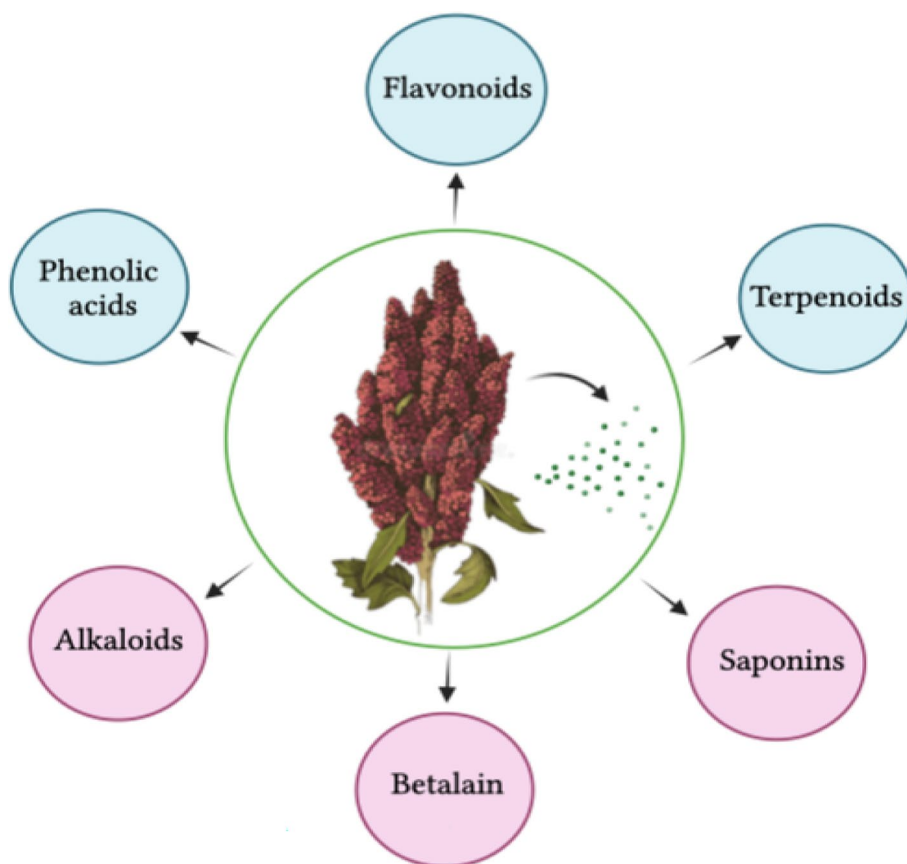
Allopathic treatment of bacterial, fungal or viral diseases by using synthetic antibiotics drugs causes serious side effects and allergic reactions to the human body. Moreover, extensive use of such antibiotics lead to the development of constant resistance in the pathogenic organism. Antibiotic resistance is one of the most prevailing problems in modern veterinary medicine (Hrytsyk et al. 2021). Pathogenic bacteria including *Salmonella typhimurium*, *Listeria monocytogenes*, *Escherichia coli*, *Klebsiella pneumoniae*, *Corynebacterium xerosis*, *Proteus vulgaris* and *Candida albicans*, have significant potential for resisting synthetic antibiotic drugs. Microbial resistance as a result complicates the treatment procedure of infectious diseases caused by these microorganisms. Moreover, antibiotic resistance ultimately decreases the therapeutic potential of modern anti-bacterial and anti-parasitic medicines (Zazharskyi et al. 2019).

These negative aspects of curing microbial diseases can be avoided using herbal remedies. Plants are rich source of health care remedies. In ancient times, man had been using herbal medicines as his first aid treatment. World health organization (WHO) estimates that more than 80% of the world's population depends on medicinal plants for their basic health care requirements (Patel and Mohan 2017;

Kumar and Ahamed 2017). Medicinal plants used in the herbal treatment are rich in organic compounds that are responsible for biological activities. These organic compounds are called phytochemicals including phenolics, flavonoids, tannins, alkaloids, steroids, glycosides, etc. (Fig. 1) (Altemimi et al. 2017; Natarajan and Dhas 2015).

The availability and use of appropriate drug is an important requirement for the success of basic health care. Plant-based products are used as traditional medicines as well as in the development of active drugs as a common source. Current research on medicinal plants for the discovery of new therapeutic agents involves a versatile approach that merges all botanical, phytochemical, biological, as well as molecular techniques. Drug discovery from medicinal plants leads pharmacists to achieve important pharmacological targets (Rivas-Morales et al. 2018). *Chenopodium quinoa* is a traditionally used medicinal plant for instance, the gluten-free nutritional composition of quinoa makes it very useful for consumption by celiac patients (Zevallos et al. 2014). Various clinical trials suggest that quinoa has many cholesterol-lowering and antioxidant compounds, such as tocopherols, carotenoids, phytosterols, and phytocdysteroids, among others (Farinazzi-Machado et al. 2012). It is an ancient plant with modern perspectives, known as “quinoa”. Quinoa is a pseudocereal crop and

Fig. 1 Phytochemistry of medicinal plants



known to have more nutritional value than whole cereals like wheat, barley, millet, rice, etc. Quinoa is one of the plants with many phenolic contents present in its seeds and leaves (Gordillo-Bestidas et al. 2016). Quinoa has been used as a complete food as well as a therapeutic agent for the last thousands of years. It has been reported as one of the healthiest food worldwide, because of its high nutritional composition and potential to treat various diseases in health industry (Singh et al. 2016). High phytochemical contents in quinoa seeds and leaves make it useful in pharmaceutical industry. Vital biological components help it to inhibit the proliferation of various chronic diseases such as cancer, diabetes mellitus, microbial infections, obesity, etc. (Fig. 2) (Zikankuba and James 2017; Corall and Cusimamani 2014). Various phytochemicals, including phenolic acids such as vanillic acid and ferulic acid, as well as flavonoids consisting of quercetin, kaempferol, and their derivatives, are responsible for biological potential of the quinoa plant (Vilcacundo and Hernandez-Ledesma 2017). Other phytochemicals found in various parts of quinoa, such as saponins (mainly triterpenoids), and betalains, for instance, betacyanin and betaxanthins, also contribute to

its biological response (Rizvi et al. 2017; Tang and Tsao 2017).

The present study was designed to analyze the phytochemical profile of leaves and seeds extract of *Chenopodium quinoa* plant through total flavonoid content (TPC) and total phenolic content (TFC) assay. The extract was evaluated for its antimicrobial activity against two bacterial strains *E. coli* and *Staphylococcus aureus*.

Materials and methods

Plant collection

Two different varieties, Quinoa 1 and Quinoa 2 depending on the phenotype of selected medicinal plant (*Chenopodium quinoa*) were collected from Layyah region of Punjab, Pakistan. Different parts of *Chenopodium quinoa* were separated and washed thoroughly with distilled water to remove dust particles or any other contamination. The plant material was then dried under shade for one week. The leaves and seeds of both varieties were then separated manually and grounded

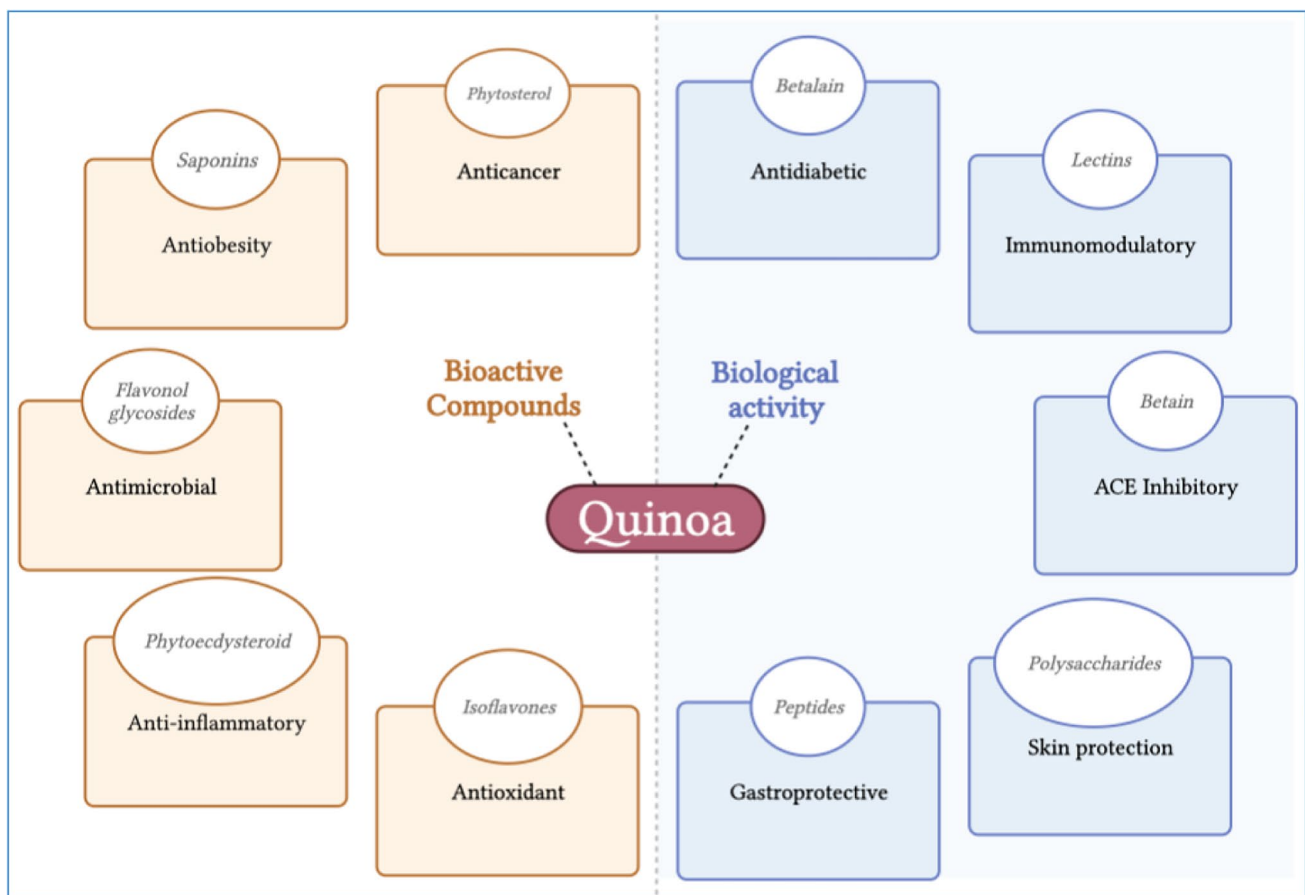


Fig. 2 Graphical representation of biological potential of *Chenopodium quinoa*

into fine powder through mechanical grinder and named as L_1 , S_1 , L_2 and S_2 for leaves and seeds of Quinoa 1 and Quinoa 2, respectively.

Ultra-sound wave-assisted extraction

The extract was prepared by taking dried powder of leaves and seeds of *Chenopodium quinoa* (20 g) and mixing it with 200 mL of methanol in a conical flask. The mixture was then put into an ultrasonic bath (Transsonic T 460/H Elma, Germany). The ultrasonic bath was operated at 35 kHz with maximum input power of 240 W for 1 h at 60 °C. The mixture was then cooled and filtered using filter paper. The obtained extract was stored at 4 °C for further analysis (Gadjalova and Mihaylova 2019).

Magnetic stirrer extraction

The beaker contained 20 g of each dried sample and 200 mL of solvent covered by aluminum foil placed on the magnetic plate (Yellow line, IKA, USA) and a stir bar was introduced into the sample beaker employing a spatula. After it, the device was switched on at the speed of 800 RPM for 1 h. After that the extract mixture was cooled, filtered and evaporated on a hot plate at moderate temperature. The extract obtained was then weighed to calculate yield and stored in a refrigerator at about 4 °C for further analysis (Cárdenas and Lucena 2017).

Biochemical analysis

Solution preparation

Sample solutions with ppm concentrations were prepared using methanol as the solvent. 100 mL solution with a concentration of 1000 ppm was prepared by adding 0.1 g of each semisolid sample to 100 mL of solvent.

Total phenolic contents (TPC) assay

TPC was calculated by following the folin-ciocalteu (FC) principle using an FC reagent. 1 mL of each sample was taken in test tubes and 1 mL of FC reagent was added in it. The mixture was then kept for 5 min at room temperature. 7% sodium carbonate solution was prepared by taking 7 g of sodium carbonate in a beaker and adding distilled water to dissolve it. Once the salt was fully soluble in water, enough water was added to bring the volume up to 100 mL. After Na_2CO_3 solution preparation, 10 ml of this solution was added to reaction mixture and mixed well. Then, 13 mL of deionized distilled water was added to the solution mixture. The reaction solution was then kept in dark at room

temperature for 2 h. After taking out, the solution was analyzed through UV/Vis spectroscopy and absorbance was measured at 760 nm. Gallic acid, which is a phenolic acid, was taken as the standard for the determination of TPC. Total phenolic contents were determined by using a standard curve which was prepared as a standard solution of gallic acid as shown in Fig. 3. TPC of plant extract was measured as milligram of gallic acid equivalent to per gram of extract (mgGAE/1g extract) (Kupina et al. 2019).

Total flavonoid contents (TFC) assay

Aluminum chloride colorimetric method was used for the determination of total flavonoid contents in plant extract. In different test tubes, 1 mL of each sample solution was added, followed by the addition of 4 mL of distilled water. 50 mL solution of 5% sodium nitrite was prepared by taking 2.5 g of sodium nitrite in a beaker and adding distilled water to dissolve the crystalline sodium nitrite. Volume of the solution was then adjusted to 50 mL by adding more water. Then, 0.3 mL of 5% NaNO_2 solution was added to the solution mixture and incubated for 5 min in dark, followed by addition of 0.3 mL of 10% AlCl_3 solution and kept again for 5 min. 1 M NaOH solution was prepared by dissolving 2 g of sodium hydroxide in 50 mL of distilled water. Then, 2 mL of 1 M NaOH solution was added to the reaction mixture, followed by the addition of distilled water to bring the volume of the mixture up to 10 mL. The mixture was allowed to stand for 20 min at room temperature and finally absorbance was measured at 510 nm using UV/Vis spectrophotometer. Quercetin, which is a flavonoid, was taken as standard and a standard curve was plotted to measure total flavonoid contents in plant extract with different concentrations as shown in Fig. 4. TFC was expressed in terms of milligram quercetin equivalent to per gram of extract (mg QE/1 g extract) (Baba and Malik 2015).

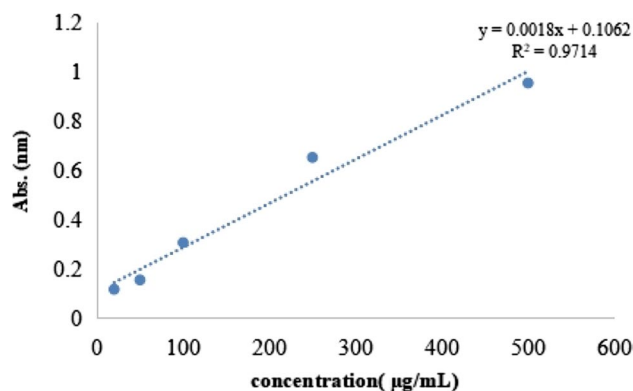


Fig. 3 Standard curve of gallic acids for determination of total phenolic contents

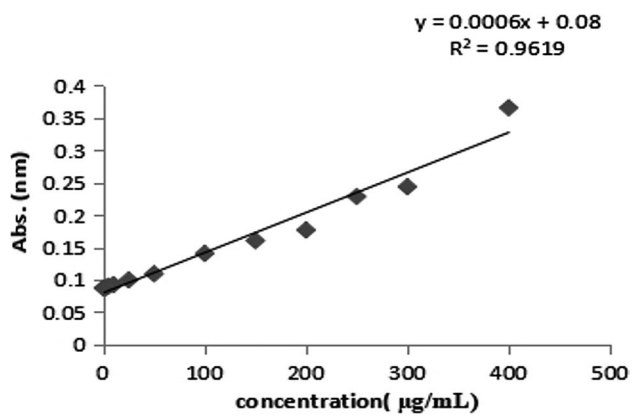


Fig. 4 Standard curve of Quercetin for total flavonoid contents determination

Antimicrobial activity

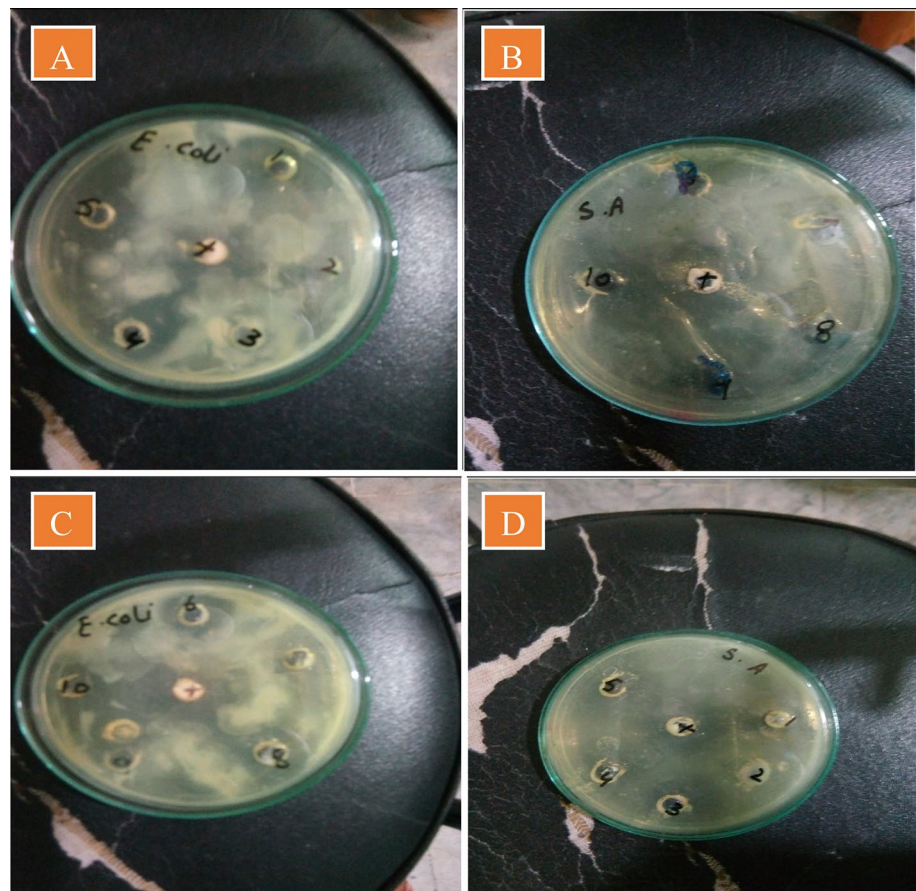
The antimicrobial activity of extract was determined by using disc diffusion method according to CLSI, 2007 (The Clinical and Laboratory Standards Institute, (2007)). Nutrient agar (Oxoid, UK) 28 g/L was suspended in distilled water. It was mixed well to obtain its distribution

homogeneously. The medium was sterilized by autoclaving at 121 °C for 15 min and 100 µL/100 mL of the inoculum was added to the medium. The medium was transferred to sterilized petri plates to solidify. After this, a sterile borer of 6 mm diameter was used to prepare sample wells in solidified nutrient agar gel. 50–70 µl of the sample was poured into the sample wells and ampicillin was poured as positive control. Plates were prepared under aseptic condition in laminar airflow (Fig. 5). Petri plates were incubated at 37 °C for 24 h for the growth of bacteria. Diameter of inhibition zones were measured in millimeters with the help of a zone reader. The results were compared with the standard antimicrobial agent ampicillin (Nwachukwu and Uzoeto 2010).

Statistical analysis

Three samples of each plant material were assayed. Each sample was analyzed individually in triplicate for its total flavonoids, total phenolic contents, and in vitro antimicrobial activities. Data were reported as mean ± standard deviation and analyzed by analysis of variance (ANOVA) using Minitab 2000 version 13.2 statistical software (Minitab Inc. Pennsylvania, USA). A difference of ($p \leq 0.05$) was considered significant (Shahat et al. 2011).

Fig. 5 Antimicrobial activity of *E. coli* and *S. aureus* Inhibition zones



Results and discussion

Total phenolic contents (TPC) assay

Total phenolic contents in plant extract were measured by following folin-ciocalteu protocol which is generally known as FC principle. The procedure includes reaction of polyphenolic compounds present in plant extract with FC solution resulting in appearance of blue color of the solution mixture. The solution showed an absorbance peak at 760 nm. Total phenolic compounds concentration was measured as equivalent to gallic acid which is a phenolic acid. The procedure is known as the spectrophotometric method (Grace et al. 2016).

Leaves and seeds extract prepared by two different techniques of two phenotypes of *Chenopodium quinoa* were analyzed for their total phenolic contents analysis. The results showed that the plant has a high phenolic contents profile which ranges between 85.7 ± 1.6 and 181.4 ± 1.54 (mgGAE/1g extract) (Table 1). The seed extract of Quinoa 1 prepared by ultrasound wave-assisted extraction showed the highest value of TPC which was 181.4 ± 1.54 followed by 160.2 ± 1.34 (mgGAE/1g extract). The leaf extract prepared by ultrasound wave-assisted extraction was also observed with a high value of TPC as compared to other extraction techniques. TPC results were comparable with the study conducted by Chen et al. (2022) and Vega-Gálvez et al. (2018). Chen et al. (2022) calculated TPC range between 16.03 ± 2.49 and 345.43 ± 6.80 (mgGAE/1g) in *Chenopodium quinoa* extract fraction prepared in different solvents including petroleum ether, chloroform, ethyl acetate and n-butanol along with water residual and crude extract. The experiment performed by Al-Qabba et al. (2020) showed that total phenolic contents can be varied depending upon their germination period. Authors of that study performed TPC assay at different time intervals during the germination

of quinoa seeds. They concluded that TPC contents increase as germination time increases. TPC shown by seeds before germination was 105.16 ± 9.66 and that on the 9th day of germination was 251.23 ± 13.77 (mgGAE/1g). Graphical representation of the above-mentioned results is presented in Fig. 6 which demonstrates an ongoing trend from leaves to seeds and extract prepared from ultrasound wave assisted extraction has high amount of TPC.

The seed extract of Quinoa 1 prepared by magnetic stirrer extraction technique showed TPC value of 148.3 ± 1.45 followed by the seed extract of Quinoa 2 which is 129.5 ± 2.68 . These values are comparable with Vega-Gálvez et al. (2018) that observed total phenolic contents ranged between 112 and 194 mg GAE 100 g. They also calculated free and bound phenolics contents in different varieties of quinoa and concluded that free phenolics are much higher than their bound form in the quinoa plant. All of these in some parameters are similar to our findings related to total phenolic contents values. However, leaves extract of both phenotypes prepared by stirrer extraction showed a lower value that was 94.5 ± 2.21 and 85.7 ± 1.65 (mgGAE/1g), respectively. Total phenolic contents contribute to antimicrobial activity by reacting with the sulfhydryl groups of proteins in microorganisms, particularly DNA in bacteria. Additionally, they inhibit the availability of substrates necessary for microorganism growth (Shan et al. 2007).

However, some studies also showed variations to the present study's experimental values of TPC. Mounira et al. (2021) experimented to measure the total phenolic contents in hydroalcoholic seed extract of *Chenopodium quinoa*. The study showed maximum value of 11.647 ± 1.91 μ g GAE mg extract of TPC in plant extract which is much lower as compared in the present study. An experiment was performed by Buitrago et al. (2019) on different parts of the quinoa plant including leaves, stems, roots, flowers and seeds. Variation in TPC value from the current study as compared to previous study might be due to changes in phenotype, genotype, environmental conditions, experimental procedures and many other factors. They performed an experiment by using two different methods of plant drying such as air-drying and freeze-drying. The freeze-dried extract showed maximum value of TPC which was 6.02–43.47 mg of gallic acid equivalents per gram of plant material. Moreover, Li et al. (2021) observed lower value of TPC in *Chenopodium quinoa* which was 2.18 ± 0.45 mgGAE /g extract.

Total flavonoid contents (TFC) assay

Flavonoids are important phenolic derivatives with significant biological activity and encompass wide range of chemical compounds across various categories, such as flavanones, flavones, isoflavones, and flavanols. Several in vitro and clinical studies have suggested that dietary flavonoids

Table 1 Phytochemical analysis of total phenolic and flavonoid contents of Quinoa 1 and Quinoa 2

Extraction techniques	Samples	TPC (mg GAE/1g extract)	TFC (mg QE/1 g extract)
Ultrasound Assisted Extraction	L ₁	145.5 ± 2.5	15.45 ± 0.50
	L ₂	130.4 ± 1.35	24.51 ± 1.24
	S ₁	181.4 ± 1.54	35.24 ± 0.48
	S ₂	160.2 ± 1.34	42.15 ± 1.21
Magnetic stirring	L ₁	94.5 ± 2.21	10.45 ± 0.52
	L ₂	85.7 ± 1.65	21 ± 1.21
	S ₁	148.3 ± 1.45	22.14 ± 0.67
	S ₂	129.5 ± 2.68	30.54 ± 0.58

L/ Leaf, S/ Seed

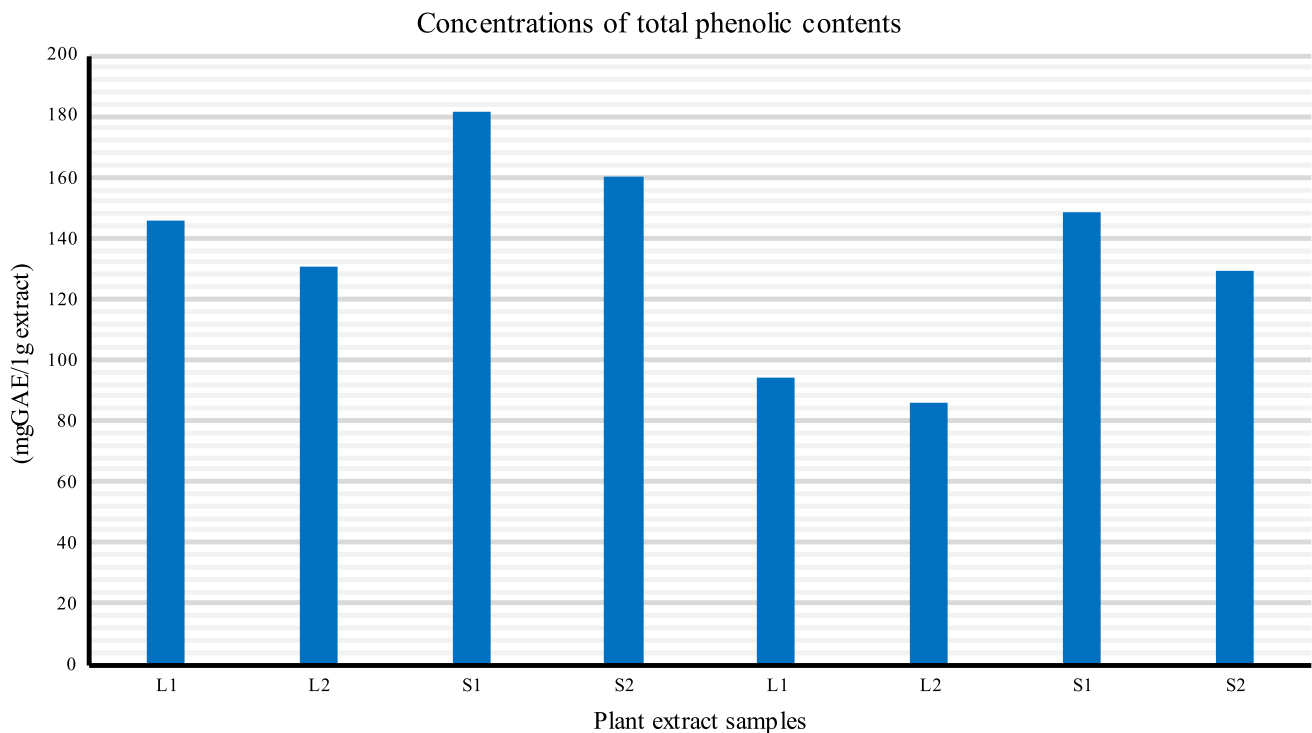


Fig. 6 Graphical representation of total phenolic contents in leaves and seeds extract

have therapeutic effects in treating various diseases. This is because they have the potential to affect and regulate different signaling pathways in hepatocytes, pancreatic beta cells, skeletal myofibrils, and adipocytes (Lavle et al. 2016). Flavonoids play a crucial role in the defense mechanisms of plants, which has motivated researchers to explore the antibacterial, antiviral, and antifungal activities of flavonoids in humans. This is particularly important due to the increasing prevalence of synthetic antibiotic resistance in bacteria worldwide (Harborne and Williams 2000).

In the present study selected plant material was analyzed for its total flavonoid contents assay using the colorimetric method. TFC was calculated by using a standard curve (mg QE/1 g extract) of Quercetin, which is a flavonoid and is mostly used as a standard in the TFC calculation of plant material (Khettaf et al. 2016).

Total flavonoid contents of plant extract of two varieties of *Chenopodium quinoa* were calculated (Table 1) and seed extract of both varieties was shown to have higher TFC as compared to their leaves extract. TFC value in plant material ranged between 10.45 ± 0.52 and 42.15 ± 1.21 (mg QE/1 g extract). The extract prepared by ultrasound wave-assisted extraction to have the highest TFC value in seeds of both varieties were 35.24 ± 0.48 and 42.15 ± 1.21 (mg QE/1 g extract) in Quinoa 1 and 2, respectively. TFC value in seeds was comparable to an experiment conducted by Carciochi et al. (2014) that

studied total flavonoid contents in seeds of *Chenopodium quinoa* extract prepared by ultrasound-assisted extraction. Maximum amount of total flavonoid contents studied were 25.13 mg QE/100 g extract. The seed extract prepared by magnetic stirrer extraction also showed significant amount of total flavonoid contents which were 22.14 ± 0.67 and 30.54 ± 0.58 (mg QE/1 g extract) in both Quinoa, respectively. A study conducted by Abdelaleem and Elbassiony (2021) showed higher contents of TFC in *Chenopodium quinoa* when exposed to radiation which resulted in 67.44 and 62.89 mg quercetin equivalents (QE)/100g in irradiated and 53.15 mg QE/100g in non-irradiated plant material. The study presented that safe level of radiation like ultrasound was better to activate effective organic compounds in medicinal plants.

However, leaves extract showed lower amount of TFC as compared to seed extract. The leaves extract prepared by ultrasound-assisted extraction was 15.45 ± 0.50 and 24.51 ± 1.24 followed by magnetic stir extraction of 10.45 ± 0.52 and 16.21 ± 1.21 (mg QE/1 g extract) in phenotype 1 and 2, respectively as studied by Enciso-Roca et al. (2021) determined TFC in four different colored varieties of *Chenopodium quinoa* which varied from 7.44 ± 0.50 to 14.31 ± 0.5 mg EQ/g. Graphical representation as shown in Fig. 7 illustrated a trend that goes on increasing from leaves extract to seed extract in both extraction techniques

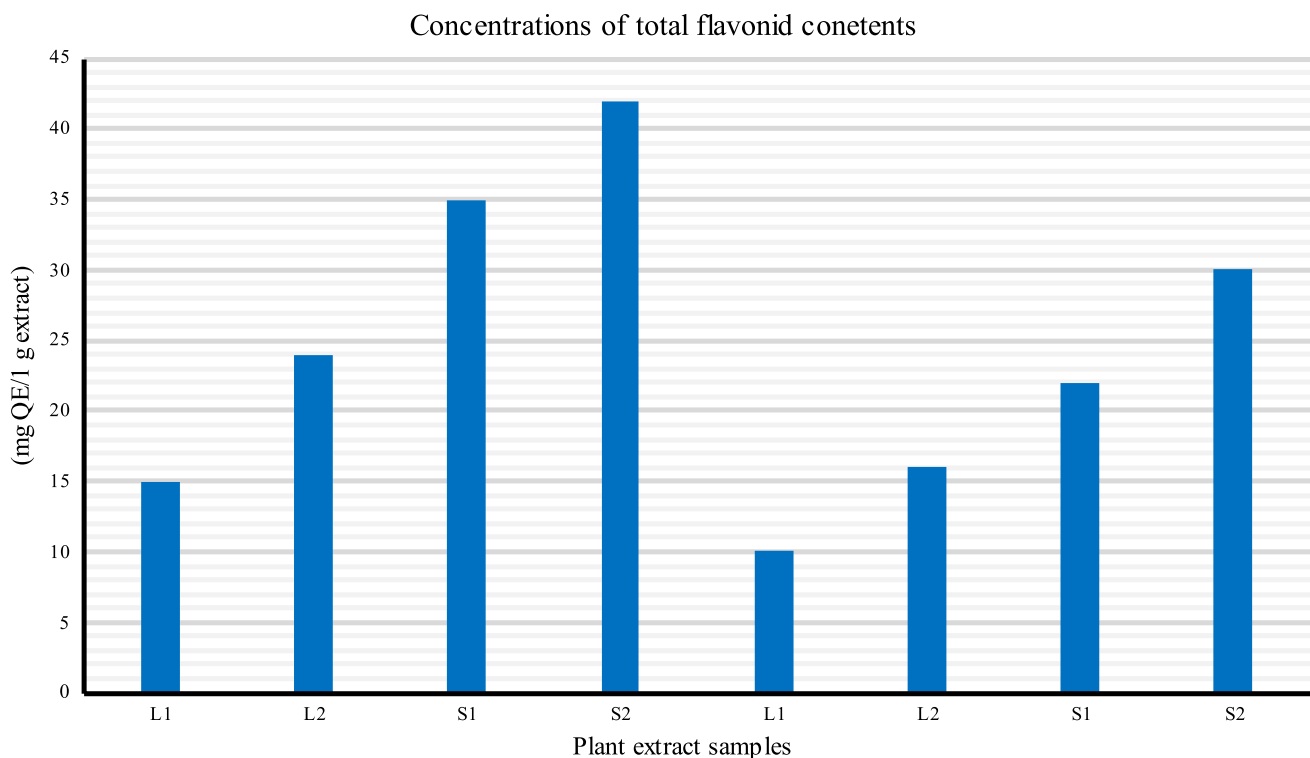


Fig. 7 Graphical representation of total flavonoid contents in leaves and seeds extract

but magnetic stir extraction has lower amount of TFC as compared to other techniques.

Some studies observed variation in TFC contents in *Chenopodium quinoa* as compared to recent study results, as described by Kaur et al. (2016) who calculated TFC in raw, domestically, and industrially processed seeds with TFC ranging between 5.8 and 18.02 mg EQ/g which is of much smaller range as compared to the current study. Lim et al. (2020) calculated TFC in root and sprout extract of quinoa which showed a maximum value (61.68 mg RE 100 g⁻¹) which is much higher value of TFC in quinoa. The variations in TFC contents either small or high might be due to changes in environmental condition in which the plant has been grown, phenotype or genotype, methodology of the experiment, conditions of laboratories, instrumental differences and many other such factors which are responsible for causing change in physical, chemical, and medicinal properties of plant material.

Antimicrobial activity

Chronic infections and mortality rates increase mainly due to bacterial infection. This trend is increasing because most pathogens acquire drug resistance toward synthetic antibiotic drugs because of excessive misuse of these drugs. Therefore, an alternative treatment is needed on an urgent basis which is leading scientists towards the discovery of effective

antimicrobial agents from natural resources, especially from medicinal plants to overcome this prevailing problem (Antika et al. 2020).

There are many organic compounds present in plant material as their secondary metabolites responsible for their bioactivities. Most common classes of these bioactive components in plant body are phenolic, flavonoid, alkaloids, tannins, saponins, steroids, etc. Medicinal plants vary with variations in concentration of these bioactive compounds which imparts unique biochemical properties to a specific plant. Evaluation of medicinal plants against their antimicrobial activity is a major concern of today's global health community because of an intense increase in antimicrobial resistance globally (Farjana et al. 2014).

The current experiment was designed to evaluate antimicrobial potential of crude methanolic extract of the medicinal plant *Chenopodium quinoa*. The antimicrobial potential was analyzed by disc diffusion method using ampicillin as a standard antibiotic drug (Khomarlou et al. 2017). The plant material presented a significant inhibition zone against two pathogenic bacterial strains that were *E. coli* and *S. aureus* (Table 2 and Fig. 5). Maximum inhibition zone was 20 nm against *S. aureus* bacterial strain expressed by seed extract prepared by ultrasound-assisted extraction of Quinoa 1. The sample extract also showed significant antimicrobial potential for *E. coli* ranging between 14 and 18 nm. Different inhibition zone values for

Table 2 Antimicrobial activity of leaves and seeds against *E. coli* and *S. aureus* (inhibition zones in mm)

Extraction techniques	Samples	<i>S. aureus</i> (zone in mm)	<i>E. coli</i> (zone in mm)
Ultrasound Assisted Extraction	L ₁	–	18
	L ₂	16	–
	S ₁	18	14
	S ₂	12	18
Magnetic stirrer Assisted Extraction	L ₁	–	10
	L ₂	16	16
	S ₁	14	16
	S ₂	20	14
Control	Ampicillin	26	22

L₁ and S₁ Quinoa 1, L₂ and S₂ Quinoa 2

both *E. coli* and *S. aureus* bacterial strains were 18, 16, 14, 12 and 10 nm. Ampicillin, which is a standard antibiotic drug was used as standard and it showed inhibition zone at 26 and 22 nm against *S. aureus* and *E. coli*, respectively (Miranda et al. 2014). They measured antimicrobial effect in the range of 8.3–14.8 mm against *E. coli* and 8.5–15 mm for *S. aureus*. The results were comparable to the current experiment outcomes. Organic compounds isolated from *Chenopodium quinoa* have a strong potency to inhibit pathogenic bacteria. Furthermore, Dong et al. and Khan and Javaid (2020) isolated various bioactive compounds

from different fractions of quinoa extract and analyzed their effects against microbial strains. The results demonstrated that the compounds derived from quinoa exhibit significant inhibitory strength. The isolated compounds from quinoa fractions included hexacosanoic acid methyl ester (Hagr et al. 2019), monomethyl ester of nonanedioic acid (Chaudhery et al. 2014), and hexadecanoic acid (Kumar et al. 2011), which are primarily responsible for the antibacterial activity.

Although *Chenopodium quinoa* has a high amount of TPC and TFC which possesses significant antimicrobial potential, some sample extracts did not show any inhibition zone against one or both bacterial strains. The leaves extract of Quinoa 1 prepared by both extraction techniques did not show any inhibition value. In a study, Park et al. (2017) evaluated the antimicrobial potential of quinoa extract against four food-borne bacterial strains including *E. coli* and *S. aureus*, but the extract did not show strong antimicrobial activity. The graphical representation described an overall strong activity of plant extract when compared with standard antibiotic drug ampicillin which possesses a stronger antimicrobial potential as shown in Fig. 8. The blue bar lines shown in the figure represent antimicrobial potential against *S. aureus* and the orange line showed the antimicrobial activity against *E. coli* bacterial strains.

The variation of current study analysis and literature-site data might involve many factors starting from environmental

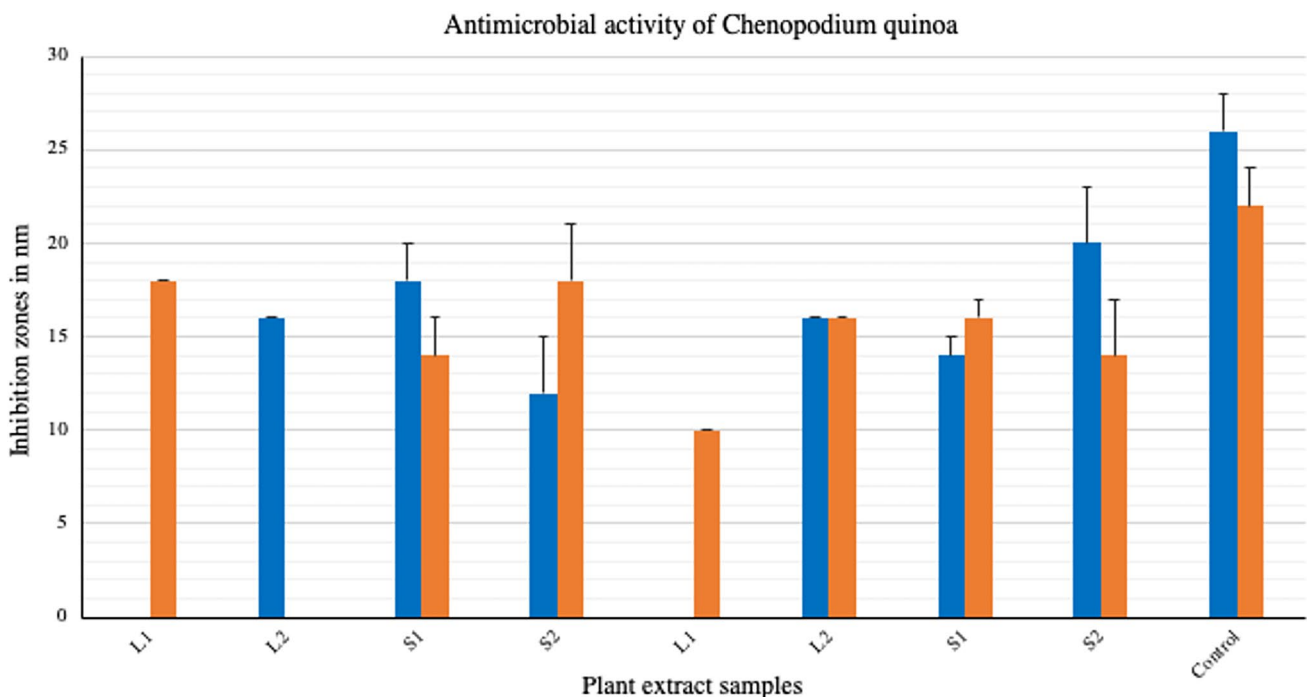


Fig. 8 Antimicrobial activity of *E. coli* and *S. aureus* inhibition zones in mm

conditions leading toward laboratory and instrumental differences.

Conclusion

Chenopodium quinoa is a traditional pseudo-cereal crop having high nutritional as well as medicinal properties. The current study was designed for phytochemical and antimicrobial analysis of leaves and seeds extract of two varieties of quinoa plants. Total phenolic and total flavonoid contents were measured using an appropriate assay and it was evaluated that quinoa plant has profile of phytochemicals and is rich in organic compounds useful for its bioactive potency. The bioactivity of quinoa extract was analyzed through an antimicrobial assay by using *E. coli* and *S. aureus* bacterial strains. It was concluded that *Chenopodium quinoa* is effective against these two strains. The present study expressed that *Chenopodium quinoa* is an effective medicinal plant with higher phytochemical contents and can be used to treat bacterial-borne diseases.

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Data availability The data of this work will be available after a reasonable request to the corresponding authors.

Declarations

Conflict of interest All authors declare that they have no conflict of interest.

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