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Research article

Total phenolic, total flavonoid contents and antioxidant potential of Common Bean (*Phaseolus vulgaris* L.) in Vietnam

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Abstract: In this study, the antioxidant properties of total phenolics and flavonoids extracts from different parts (leaves, pods, and seeds) of common bean were evaluated. Specifically, the highest total phenolic content was recorded with methanol extracts of pods (95.41 ± 1.18 mg GAE/g), whereas methanolic extract of seeds contained the lowest content of phenols (6.87 ± 1.45 mg GAE/g). The highest total flavonoid content was found in methanol extracts of leaves (44.59 ± 2.15 mg RE/g). Meanwhile, the methanol extract of seeds and pods contained less flavonoid content (9.29 ± 1.65 mg RE/g and 3.64 ± 0.87 mg RE/g, respectively). The GC-MS analysis showed the presence of 29, 18 and 29 different plant compounds in methanol extracts of leaves, seeds and pods, respectively. The methanol extracts of leaves showed the highest antioxidant capacity with an inhibitory percentage of 48.74 ± 0.32% at a concentration of 100 μg/mL and the EC_{50} value of 137.4 μg/mL. The methanol extracts of seed had the lowest antioxidant capacity with an inhibitory percentage of 13.99 ± 1.22% at a concentration of 100 μg/mL and the EC_{50} value of 486.2 μg/mL. The results showed that the extract from leaves of common bean had the highest antioxidant activities as well as total contents of flavonoid in comparison with an extract from seeds and pods and the positive relationship between total flavonoids content and antioxidant activities in this plant.

Keywords: common bean; phenolic contents; flavonoid contents; antioxidant activity

1. Introduction

Nowadays, the development of chronic (e.g., renal failure, myocardial infarction, and heart failure) and neurogenerative (e.g., Parkinson's, multiple sclerosis, and Alzheimer's) diseases have

been attributed to oxidative stress as result of an imbalance between prooxidants and antioxidants [1]. Prooxidant refers to any endobiotic or xenobiotic that induces oxidative stress either by the generation of ROS or by inhibiting antioxidant systems. It can include all reactive, free radical containing molecules in cells or tissues [2]. Free radicals such as hydroxyl, singlet oxygen, nitric oxide, hydrogen peroxide, and superoxide radicals are produced as part of normal cellular function [3]. However, above physiological levels, free radicals have been shown to induce negative health effects such as carcinogenesis, aging DNA damage, and enzyme inactivation by attacking biological macromolecules [4].

To prevent the oxidation of molecules and cells by free radicals, the body has endogenous antioxidative systems through which it is able to quench free radicals and protect against oxidative stress [5]. Antioxidants might be categorized in multiple different ways like based on their activity, which they can be classified into two categories as enzymatic and non-enzymatic antioxidants. Enzymatic antioxidants will be breaking down and be removing free radicals by converting dangerous oxidative products to hydrogen peroxide (H_2O_2) and then to water, the process had multi-step and had the presence of cofactors such as copper, zinc, manganese, and iron. On the other hand, non-enzymatic antioxidants will interrupt free radical chain reactions [6]. However, in the immune system, antioxidants can deplete due to environmental pollutants, radiation, chemicals, toxins, deep-fried foods, and spicy foods as well as physical stress, which induce changes in gene expression and formation of abnormal proteins [7]. Hence, the need is for sufficient dietary levels of antioxidants, to help protect the body against oxidative stress [8].

Phenolic compounds are natural compounds ubiquitous in plants and are the product of secondary plant metabolism [6]. They can be classified into various groups like phenolic acids, flavonoids, stilbenes, and lignans base on the presence of multiple phenolic groups that are associated with more or less complex structures [9]. Phenolic compounds are largely found in fruits, vegetables, cereals, olive, legumes, chocolate, and beverages, such as tea, coffee, and wine [9]. Although phenolics are primarily known for their antioxidative functions, they have also been shown to offer other beneficial health effects such as antidiabetic, anticancer, anti-inflammatory, cardioprotective, osteoprotective, neuroprotective, antiasthmatic, antihypertensive, antiageing, antiseptic, cerebrovascular protection, cholesterol-lowering, hepatoprotective, antifungal, antibacterial, and antiviral properties, specifically, their primary functions are as antioxidant [10]. According to previous studies, the presence of hydroxyl groups in the B-ring of flavonoids is responsible for their observed antioxidant properties through their donation of hydrogen atoms during free radical reactions [11]. Besides, phenolics is also a good source of antioxidants due to a number of different mechanisms such as free radical-scavenging, hydrogen donation, singlet oxygen quenching, metal ion chelating, and acting as a substrate for radicals such as superoxide and hydroxyl [12].

The common bean (*Phaseolus vulgaris* L.) is a member of the legume family [13]. It is considered as important food resources due to their rich source of proteins, carbohydrates, dietary fiber, minerals, vitamins, phenolic acids, and flavonoids [14]. Many studies show that diets including common beans help reduce LDL-cholesterol while increasing HDL-cholesterol, thus helping reduce risks of cardiovascular diseases, obesity, and diabetes [15]. Moreover, previous researchers reported that common bean containing phenolics and showed high antioxidant activity by *in vitro* methods of 2,2-Diphenyl-1-picrylhydrazyl (DPPH), ferric-reducing antioxidant power (FRAP), and oxygen radical absorbance capacity (ORAC) [16–19]. Therefore, the objectives of the present study were to

determine the total phenolic and flavonoid contents as well as the antioxidant potential of common bean (*Phaseolus vulgaris* L.) in Vietnam.

2. Materials and methods

2.1. Plant material and extract preparation

Leaves, pods, and seeds of common bean (GRIS2) (Figure 1) were collected at Genomic Research Institute and Seed (GRIS), Ton Duc Thang University, Ho Chi Minh City, Vietnam. Before extraction, they were cleaned to eliminate soil and damaged seeds, dried and ground into a fine powder. The sample extract was extracted using the method according to [20]. The leaves, pods, and seeds extract were individually prepared in methanol (plant: solvent ratio [1: 10], w/v), and extracted for shaken overnight at 28 ℃. The extract was then filtered through filter paper. The solvent was then removed by evaporation in a vacuum to obtain dry extracts. This process was repeated once. The extracts were stored at 4 ℃ in a refrigerator prior to use.

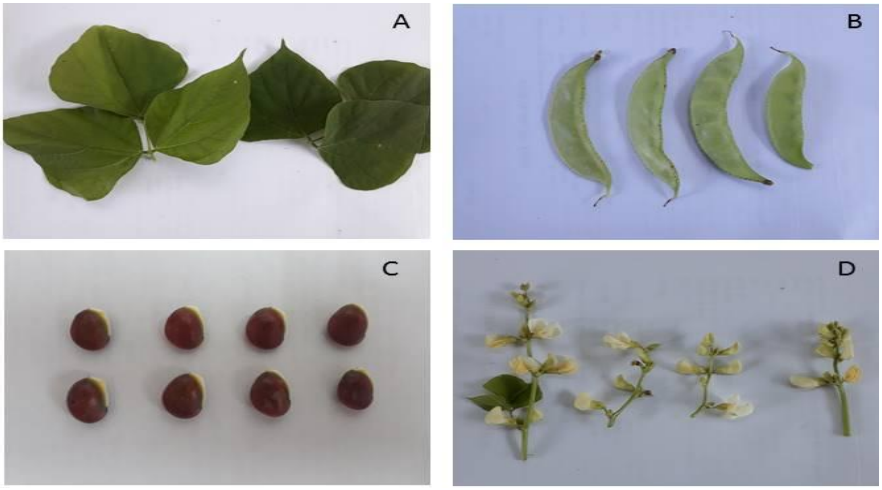

Figure 1. Common bean (*Phaseolus vulgaris* L.) (A) Leaves, (B) Pods, (C) Seeds, and (D) Flowers.

2.2. Total phenolic contents

The total phenolic content of each leaf, pods, and seeds extract was determined using the Folin-Ciocalteu reagent as described by the method of Singleton et al. [21] with slight modification. Approximately 0.5 mL of each extract was dissolved in methanol (100 μg/mL) was mixed with 2.5 mL of Folin-Ciocalteu reagent (0.2 N). This mixture was shaken well and was kept at room temperature for 5 min and then, 2 mL of sodium carbonate solution (75 g/L) was added. After 2 h of incubation in the dark, the absorbencies were measured at 760 nm against a water blank using a UV-Vis spectrophotometer. The same procedure was repeated by gallic acid solutions used as a standard for the calibration curve. The concentrations of the standard were set at 0, 0.02, 0.04, 0.06, 0.08 and 0.1 mg/mL. The determination was performed in triplicate and the results were expressed as terms of gallic acid equivalent (mg of GAE/g of extract).

2.3. Total flavonoid contents

The total flavonoid content of each leaf, pods, and seeds extract was determined using the Dowd method as described by Sawadogo et al. [22] with slight modification. In brief, 2 mL of 2% $AlCl_3$ in methanol was mixed with 2 mL of each extract (100 µg/mL), shacked well, and hold for 10 minutes. Absorption was read at 415 nm against a blank sample consisting of 2 mL of methanol and 2 mL of each extract without $AlCl_3$ using a UV-vis spectrophotometer. The same procedure was repeated by rutin solutions used as a standard for the calibration curve. The concentrations of the standard were set at 0, 0.02, 0.04, 0.06, 0.08 and 0.1 mg/mL. The determination was performed in triplicate and the results were expressed as terms of rutin equivalents (mg of RE/g of extract).

2.4. GC-MS analysis

Methanol extract from leaf, pod, and the seed of common bean was subjected to gas chromatography-mass spectrometry (GC-MS) analysis. The GC-MS was equipped with a DB-5MS column (30 m, 0.25 mm, and 0.25 µm) (Agilent Technologies, J & W Scientific Products, Folsom, CA, USA.). Helium gas was used as the carrier gas with a split ratio of 5:1. The temperature program was as follows: initial temperature of 50 ℃ without hold time and gradually increased to 300 ℃ at a rate of 10 ℃/min for 20 min of hold time. The injector and detector temperatures were set to 300 ℃ and 320 ℃, respectively. The mass spectra were scanned from 29 to 800 amu. The identification and characterization of chemical compounds in various crude extracts were based on the JEOL's GC-MS Mass Center System software, version 2.65a (JEOL Ltd., Tokyo, Japan).

2.5. Determination of free radical scavenging activity by DPPH method

The DPPH (2, 2-Diphenyl-1-picrylhydrazyl) assay is one of the most commonly employed methods because it is simple, efficient, and inexpensive. DPPH radical scavenging method was used to evaluate the antioxidant properties of each leaf, pods, and seeds bean extract. The standard procedure for the DPPH assay was performed based on Bakasso et al. [23] with minor modifications. The samples were added of 1.5 mL DPPH solution (80 µg /mL) to 0.75 mL various concentrations (6.25, 12.5, 25, 50, and 100 µg/mL) of each extract. The solution was mixed vigorously and left to stand at room temperature for 30 minutes in the dark after which its absorbance was measured spectrophotometrically at 517nm, the analysis was done in triplicate. A positive control (ascorbic acid) was prepared in the same way as samples, while the blank solution by adding 0.75 mL methanol to 1.5 mL of DPPH (80 µg/mL solution). The absorbance of blank, positive control, and samples were recorded.

The percentage of inhibition can be calculated using the formula:

$$\text{Inhibition (\%)} = (AB - AA/AB) \times 100 \quad (1)$$

Where AB is the absorbance of the control and AA is the absorbance of the test. EC_{50} (µg/mL) was defined as the half-maximal effective concentration of the amount of sample necessary to decrease the absorbance of DPPH by 50%. It was obtained by interpolation from the linear regression analysis.

2.6. Statistical analysis

The results were expressed as mean ± standard deviation of at least triplicate measurements. Analysis of variance (ANOVA) and Duncan's multiple range test were used for determining the significant differences at $P < 0.05$. All statistical analyses were carried out using the statistical program are SAS version 8.0 and Microsoft Excel 2010 software.

3. Results

3.1. Total phenolic and flavonoid contents

The content of total phenols in different extracts was presented in Table 1. The highest phenolic content was found in methanol extracts of pods (95.41 ± 1.18 mg GAE/g). Whereas methanol extracts of seeds contained considerably least content of phenols (6.87 ± 1.45 mg GAE/g).

The results of the total flavonoids contents determination of the examined plant extract are presented in Table 1. The highest flavonoid content was found in methanol extracts of leaves (44.59 ± 2.15 mg RE/g). Meanwhile, the methanol extract of seeds and pods contained less flavonoid content (9.29 ± 1.65 mg RE/g and 3.64 ± 0.87 mg RE/g, respectively).

Table 1. Total phenolic and total flavonoid contents of leaves, pods, and seeds of common bean.

Categories	Total phenolic content (mg GAE/g)	Total flavonoid content (mg RE/g)
Leaves	58.68 ± 1.81^{b}	44.59 ± 2.15^{a}
Pods	95.41 ± 1.18^{a}	3.64 ± 0.87^{b}
Seeds	6.87 ± 1.45^{c}	9.29 ± 1.65^{b}

All data are mean ± SD of triplicate (n = 3) analyses. Values with a different superscript in the same column differ significantly ($P < 0.01$).

3.2. GC-MS analysis

The chemical components in methanol extract from the leaves, seed, and pods of common bean were successfully analyzed using GC-MS in Figure 2. In total, 76 compounds were detected and presented in Table 2. Of these, the presence of 29, 18, and 29 various phytocompounds in methanol extract from the leaves, seed, and pods respectively. The methanol extract from pods presented the highest amount of phytocomponents compared to methanol extract from leaves and seed. The present study successfully identified the bioactive components present in methanol extract from leaves, pods, and seeds of the common bean by GC-MS included phenolics, flavonoids, fatty acids, amino acid, terpenoids, sterols, carbohydrates, alcohols, volatile oils, fatty acid ester, ester, amines, and others.

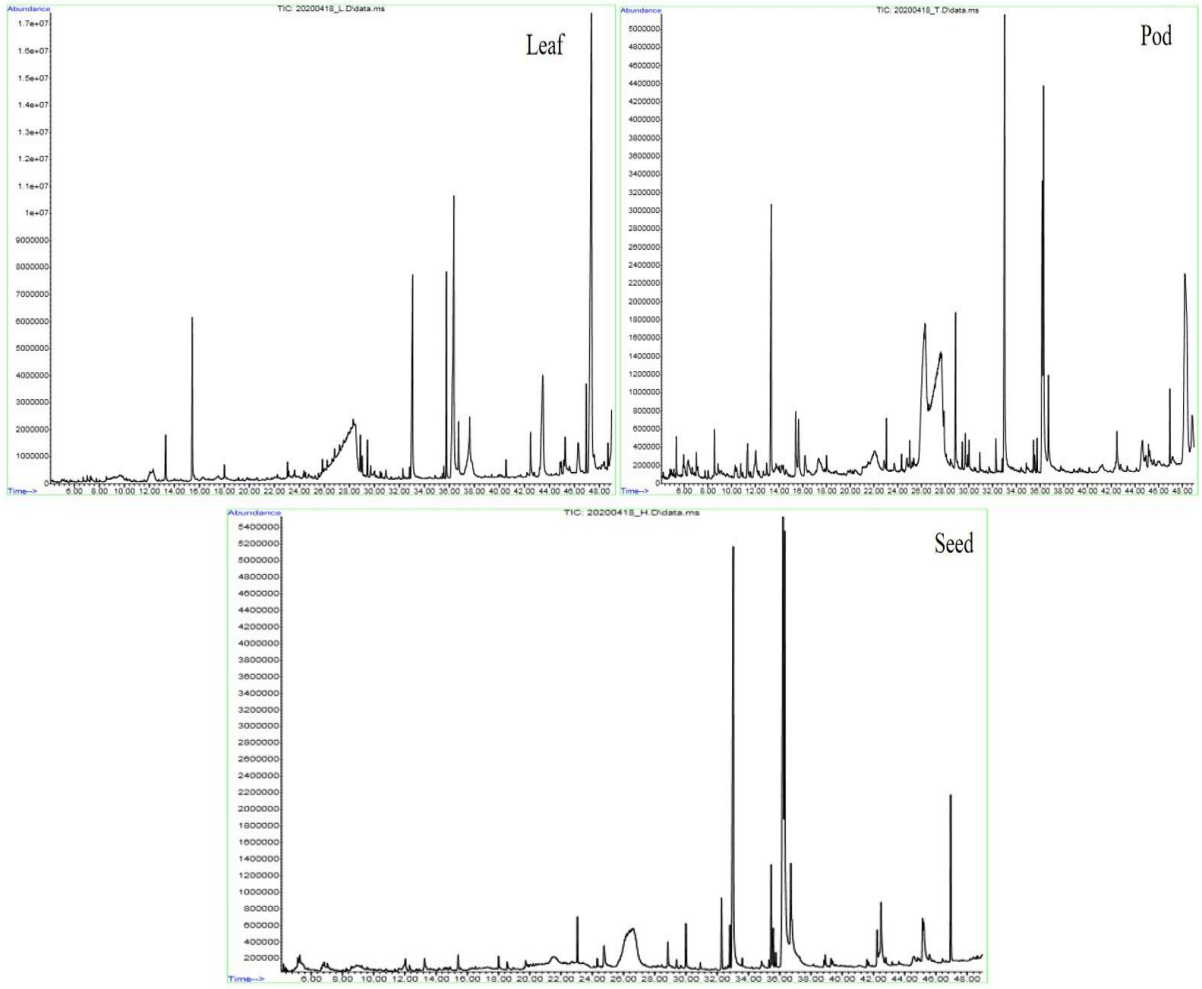

Figure 2. Mass Spectrometry of methanol extract from the leaves, seed, and pods of common bean.

Table 2. Chemical profile in methanol extract from the leaves, seed, and pods of common bean.

Peak number	Leaf	Pod	Seed	Chemical class
1	Desulphosinigrin	-	-	-
2	Butyrolactone	-	-	-
3	Cyclooctanone	-	-	-
4	Nanofin	-	-	-
5	Oxacyclododecan-2-one	-	-	-
6	8-Aminocaprylic acid	-	-	Amino acid lysine
7	Pebulate	-	-	Colorless oil
8	1,2-Benzenedimethanol	-	-	-
9	Bioallethrin	-	-	Ectoparasiticide

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Peak number	Leaf	Pod	Seed	Chemical class
10	Gibberellic acid	-	-	Pentacyclic diterpene
11	1,3,5-Triazin-2-amine, N-ethyl-4-methoxy-	-	-	-
12	Dodecanoic acid	-	-	Fatty acid
13	N-(2-Acetamido) iminodiacetic acid	-	-	Dicarboxylic acid
14	3-Hydroxy-β-damascone	-	-	-
15	Methoprene	-	-	Terpenoid
16	Gamolenic Acid	-	-	Fatty acid
17	γ-Tocopherol	-	-	Terpenoid
18	Phytol, acetate	-	-	Acyclic diterpene
19	Vitamin E	-	-	Terpenoid
20	Trilinolein	-	-	Fatty acid
21	Stigmasterol	-	-	Sterol
22	δ-Tocopherol, O-acetyl-	-	-	Terpenoid
23	Aspidofractinine-3-methanol, (2α,3β,5α)-	-	-	Alcohol
24	Butyrolactone	-	-	Ester
25	Cholesterol, 7-oxo-	-	-	-
26	p-Menthane-1,2,3-triol	-	-	Terpenoid
27	trans-Isoeugenol	-	-	Volatile oil
28	2-n-Propylthiane	-	-	-
29	4-Nonene	-	-	-
30	-	1H-Pyrrole, 2,4-dimethyl-	-	Volatile oil
31	-	2-t-Butyl-5-propyl-[1,3]dioxolan-4-one	-	-
32	-	l-Alanine, N-methoxycarbonyl-, butyl ester	-	Amino acid ester
33	-	β-D-Glucopyranose, 1-thio-,1-[N-hydroxy-5-(methylthio)pentanimidate]	-	Glycoside
34	-	2-Methyl-3-(methylthio)-1-propene	-	-
35	-	4-Cyclopentene-1,3-dione	-	-
36	-	(S)-(+)-2-Amino-3-methyl-1-butanol	-	Amino alcohol
37	-	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	-	Phenolic

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Peak number	Leaf	Pod	Seed	Chemical class
38	-	N-(N-Glycyl-glycyl)-glycine	-	Amino acid
39	-	3-Methyladipic acid	-	Fatty acid
40	-	Glycylsarcosine	-	-
41	-	Clindamycin	-	Phenolic
42	-	2-Propyl-tetrahydropyran-3-ol	-	Alcohol
43	-	dl-Lysine	-	Diamino acid
44	-	5-Hydroxymethylfurfural	-	Carbohydrate
45	-	Showdomycin	-	Phenolic
46	-	Nitrosothymol	-	-
47	-	β-D-Glucopyranoside, methyl	-	Carbohydrate
48	-	Acetic acid, 2,2'-[oxybis(2,1-ethanediyloxy)]bis-	-	-
49	-	Ingol 12-acetate	-	-
50	-	Acetamide, N-(4-ethoxy-3-hydroxyphenyl)-	-	-
51	-	1,2-Benzenedicarboxylic acid, butyl octyl ester	-	Ester
52	-	9,12-Octadecadienoic acid, methyl ester, (E,E)-	-	Fatty acid
53	-	9,12,15-Octadecatrienoic acid,(Z,Z,Z)-	-	Fatty acid
54	-	Octadecanoic acid	-	Fatty acid
55	-	α-Amyrin	-	Triterpene
56	-	3β-Myristoylolean-12-en-16β-ol	-	-
57	-	E-11-Methyl-12-tetradecen-1-ol acetate	-	-
58	-	HEPES	-	-
59		Thymol		
60	-	-	1H-Pyrrole, 2,4-dimethyl-	Phenolic
61	-	-	γ-Dodecalactone	Ester
62	-	-	Benzofuran, 2,3-dihydro-	Phenolic
63	-	-	Pyridine, 1,2,3,6-tetrahydro-1,2-dimethyl-	Pyridine
64	-	-	Tridecane	Alkane hydrocarbon

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Peak number	Leaf	Pod	Seed	Chemical class
65	-	-	Maltol	-
66	-	-	Isoglutamine	Gamma amino acid
67	-	-	Cycloate	Aliphatic amine
68	-	-	3-Butylindolizidine	Alkaloid
69	-	-	Dibutyl phthalate	Ester
70	-	-	Hexadecanoic acid, ethyl ester	Fatty acid ester
71	-	-	9,12-Octadecadienoic acid (Z,Z)-, methyl ester	Fatty acid ester
72	-	-	10-Octadecenoic acid, methyl ester	Fatty acid ester
73	-	-	9,12-Octadecadienoic acid (Z,Z)-	Fatty acid
74	-	-	β-Sitosterol	Sterol
75	-	-	Bacteriochlorophyll-c-stearyl	-
76	-	-	Glycerol 1-stearate	Ester

3.3. Antioxidant properties by DPPH

In this study, the DPPH radical scavenging potential of methanol extracts from the leaves, seed, and pods of common bean and ascorbic acid were represented in Table 3 and EC_{50} values result of different extracts were calculated by using concentration with mean percent inhibition of the DPPH radical curve of each different extracts also were presented in Table 3. From Table 3, all the extracts showed an inhibitory potential against DPPH free radical. The inhibitory percentages varied from 5.12 ± 0.35% for the seeds extract to 98.88 ± 0.03% for the vitamin C. The EC_{50} values of the antioxidant capacity varied significantly ($P < 0.01$) from 23.31 μg/mL for the vitamin C to 486.2 μg/mL for the seeds extract. As it was known, the lower the EC_{50} value the higher the antioxidant capacity of the plant extract. As can be seen from Table 3, the methanol extracts of leaves have the highest antioxidant capacity with inhibitory percentages are 48.74 ± 0.32% at a concentration of 100 μg/mL and EC_{50} value was 137.4 μg/mL compared to the other extracts and 6 times lower than vitamin C. The methanol extracts of seed had the lowest antioxidant capacity with inhibitory percentages was 13.99 ± 1.22% at a concentration of 100 μg/mL and EC_{50} value was 486.2 μg/mL compared to the other extracts and 21 times lower than vitamin C.

Table 3. Percentage inhibition of DPPH free radical scavenging activity and EC_{50} of ascorbic acid and plants extract common bean.

Treatment	DPPH inhibition (%)					EC_{50} Value (μg/mL)
	6.25 μg/mL	12.5 μg/mL	25 μg/mL	50 μg/mL	100 μg/mL	
Seeds	5.12 ± 0.35^{d}	6.07 ± 1.27^{d}	7.42 ± 0.67^{d}	9.78 ± 0.44^{d}	13.99 ± 1.22^{d}	486.2
Pods	14.19 ± 1.62^{c}	14.82 ± 1.28^{c}	16.94 ± 0.17^{c}	20.03 ± 0.69^{c}	25.93 ± 1.70^{c}	290.3
Leaves	45.60 ± 0.32^{a}	45.87 ± 0.59^{a}	46.20 ± 0.91^{b}	47.13 ± 0.05^{b}	48.74 ± 0.32^{b}	137.4
Vitamin C	36.18 ± 1.00^{b}	40.00 ± 1.79^{b}	55.16 ± 2.52^{a}	71.79 ± 1.41^{a}	98.88 ± 0.03^{a}	23.31

All data are mean ± SD of triplicate (n = 3) analyses. Values with a different superscript in the same column differ significantly ($P < 0.01$).

4. Discussion

The consumption of common bean (*Phaseolus vulgaris* L.) has been greatly connected with many physiological and health-promoting effects such as the prevention of cardiovascular diseases, obesity, diabetes mellitus, and cancers [10]. The antioxidant properties of phenolic compounds lie in their ability to neutralize free radicals and the chelation of transition metals, thus they counteract the initiation and propagation of oxidative processes [24]. In the present study, total phenolic acid and total flavonoid contents and antioxidant activity in vitro were determined for methanol extracts of leaves, seeds, and pods of common bean.

In the present study, the total phenolic contents of seeds were 6.87 ± 1.45 mg GAE/g (Table 1) whereas according to Yao et al. [13] reported that common bean contained 8.59 mg GAE/g total phenols, besides, according to Ombra et al. [25] reported that total phenolic content of the common bean in the range of 0.14–1.29 mg GAE/g. The total flavonoid content of seeds bean was 9.29 mg RE/g (Table 1) and was higher than the previously reported by Oomah et al. [26] for selected common bean in the range of 0.41–1.02 mg RE/g. The difference in the total contents of phenolic acid and flavonoid may be due to differences in the geographical region, environmental, climatic condition, and storage, and processing methods [27]. In addition, in the current study, the total contents of flavonoid and phenolic acid were different among leaves, pods, and seeds bean. These results showed that different levels of phenolic acids and flavonoids were influenced by the interaction between parts of plants. This finding is in agreement with that of Males et al. [28] who reported that *I. candida* contains higher phenolic compounds in leaves (1.031–1.423%) compared to stem (0.411–0.516%). Ghasemzadeh et al. [29] also recorded the total flavonoid and phenolic acid contents in the leaves were more than in the rhizomes, followed by contents in the stems. Elkhamlichia et al. [30] also confirmed that *Calycotome villosa* subsp. Intermedia had the total flavonoids contents in seeds. Previous studies by Ferry et al. [31] and Elattar and Virji [32] have shown that some flavonoids components such as quercetin, rutin had anticancer activities and were able to inhibit cancer cell growth. Therefore, the results of this study showed that flavonoids are important components of this plant.

Among the compounds discovered, several are reported as potential therapeutic agents. For instance, 9, 12-octadecadienoic acid, methyl ester is effective antihistamines, anti-coronary, insectifuge, and antieczemic [33]. Terpenoids have also been reported to exhibit antiplasmodial, antineoplastic, and antiviral activities [34]. Van Acker et al. [35] found other molecular parameters

related to electron distribution and structure, which correlate with the antioxidant action of vitamin E and its derivatives. Besides, flavonoids and phenolics are polyphenols that have been reported to possess great antioxidant properties due to the reducing ability of flavonoids when they play an important role in neutralizing free radicals and scavenging radicals or suppressing lipid peroxidation [26]. Vitamin P (Rutin) is a flavonol, it has demonstrated a number of pharmacological activities, including antioxidant, cytoprotective, vasoprotective, anticarcinogenic, neuroprotective, and cardioprotective activities [36–39], whereas showdomycin and clindamycin were known as an antibiotic [38].

Phenolic compounds restrain the formation of superoxide anion as well as the production of reactive oxygen species by inhibiting key enzymes such as protein kinase, xanthine oxidase, lipoxygenase, cyclooxygenase, S-transferase, glutathione, and NADH oxidase [26]. Moreover, in aqueous and lipophilic phases, these compounds also serve as hydrogen donating radical scavengers. The ability of flavonoids to complex with metal ions plays an important role in their antioxidant activity [24]. There is a specific relationship between flavonoid structures and their antioxidant activity as the larger the number of hydroxyl groups in the flavonoid nucleus, the greater would be the antioxidant activity [40].

According to [25] reported the common bean to have EC_{50} value in the range of 1570–55200 μg/mL. In this study, the EC_{50} value of seeds was 486.2 μg/mL whereas, the EC_{50} value of leaves was 137.4 μg/mL showed that the antioxidant activity of leaves bean higher than seeds (Table 3). Moreover, the total flavonoid contents of leaves bean also higher than seeds (Table 1). Hence, the different antioxidant activity might as well be due to the presence of phenolic compounds, especially the flavonoid contents in this plant. The antioxidant activity of phenolic compounds was based on several different mechanisms. It has the ability to scavenging of free radicals by single electron transfer and the hydrogen atoms in their hydroxyl groups, chelation of metal ions such as iron and copper, or inhibition of enzymes responsible for a free radical generation [26, 41].

From the determination of total phenolic contents, total flavonoid contents, and antioxidant activity in this study observed that the extracts of the pod bean showed the highest content of total phenolic; however, leaves bean although containing slightly fewer content of phenolic acid, exhibited higher total flavonoid content, and its highest the antioxidant capacity. The antioxidant capacity of phenolic compounds depends on the number and position of free OH groups [42], which means, the many free hydroxyl groups present in polyphenols, the higher their radical scavenging capacity. This reinforced the idea that the antioxidant potential could be linked strongly to the content of flavonoids in this plant.

5. Conclusions

Common bean could be a good source of natural antioxidants. In this study showed the methanol extracts from leaves, pods, and seeds of common bean exhibit good antioxidant ability on the DPPH radical scavenging potential, in which, the extracts of the leaves showed higher scavenging activities than the pods and seeds. Moreover, the total flavonoid content in extracts from leaves also higher than the pods and seed although the total phenolic acid content was found in extracts from extracts of pods higher than the leaves and seeds. Therefore, the results of this study showed that the positive relationship between total flavonoids content and antioxidant activities in this plant.

Conflict of interest

The authors declare that there is no conflict of interest.

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