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Screening of Phytochemical, Antimicrobial and Antioxidant Activities in Extracts of Some Fruits and Vegetables Consumed in Turkey

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Abstract
Antioxidant and antimicrobial activities of ethanol extracts of leaves, seeds and roots of 48 fruits and vegetables belonging to different families were investigated. Also, the phytochemical constituents were established in samples. Antimicrobial activity tests were carried out using agar disc diffusion methods with ten microbial species and only two fungi strains. The extracts showed high antibacterial activity against all the strains tested. It was observed that the plant extracts were more active against Gram-negative bacteria than against Gram-positive bacteria. The antioxidant properties of extracts were appraised by means of different antioxidant tests, including total phenolic content, 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging and metal chelating activities. Phytochemical analysis revealed the presence of carbohydrates, saponins, flavonoids, glycosides, tannins, phenols and alkaloids in the extracts. When the protein content in samples was analyzed, the largest values were obtained at 36.80% and 34.89% for *Brassica oleracea acephala* (Black Cabbage) and *Corylus avellana* (Hazelnut), respectively.
Keywords─ Antimicrobial activity, antioxidant activity, phytochemicals, vegetables, fruits

1. Introduction

Little intake of fruit and vegetables is a significant risk factor that can contribute to the global rise of chronic diseases. A great number of biologically active phytochemicals have been defined in herb, such as grains, nuts, legumes, vegetables, and fruits. From these food groups, vegetables and fruit play an important role in human nutrition. The nutritional content of vegetables and fruits varies considerably, containing useful amounts of protein and little fat and calories, while being bulky and filling, and include different quantities of vitamins such as vitamin A, vitamin K, vitamin B6, provitamins, and dietary minerals, carbohydrates, trace elements and fiber. In addition to all these, they possess a wide range of other phytochemicals (bioactive non-nutrient herbal compounds). These biologically effective components have benefits to human health beyond fundamental nutrition [1]. They have been asserted to have antioxidant, antibacterial, antifungal, antiviral, anticarcinogenic properties, and have assisted in detoxication of enzymes and activation of the immune system. Their antioxidant activity is also related to their ability to quench reactive oxygen species. The oxidative damage of cellular components due to reactive oxygen species that are continuously generated in normal physiological processes as well as under the influence of external factors leads to many chronic diseases such as cancer, diabetes, cardiovascular, Alzheimer's, arthritis, paralysis and other health problems related to functional decline related to increasing age. The antioxidants detected in several fruits and vegetables can prevent these diseases by fighting the reactive oxygen species. So it is very important to enrich our daily nutrients with agricultural products that are rich in phenolic compounds and organic acids, including cereal grains, vegetables, fruits, and oil seeds to protect against such diseases. Antioxidants in the form of polyphenols (phenolic acids, flavonoids) and terpenoids (carotenoids) have beneficial effects via different mechanisms, such as 'scavenging' free radicals, through direct reaction with them, by improving the dissimilation of free radicals to compounds with very low reactivity, by chelating pro-oxidant metals, and by preventing or promoting the activity of some enzymes [2].

Fruits and vegetables can be evaluated as natural antimicrobials. Even though chemical-based preventive measures for human consumption by government agencies, yet such approaches still menace our health. Thus, scientific communities have paid more attention to the potential antimicrobial activities of natural products. There have also been records of plants with a preventive effect against microorganisms. Nevertheless, there is little data regarding the relative antibacterial activity of common vegetables and fruits on common potency pathogens and resisting strains [3].

Furthermore, fruit and vegetable consumption during childhood appears to be preventive against cancer in adulthood [4]. There is also progressive proof that fruit and vegetable consumption in children may oppose a range of childhood diseases. In a research of over 20,000 children in six Central European countries, a connection was discovered between respiratory system symptoms and low fruit and vegetable intake [5].

The aim of this study was to determine the phytochemical constituents, in vitro antimicrobial activity and antioxidant potential of ethanol extracts from various parts of forty-eight different kinds of fruits and vegetables that are consumed daily in many countries.

2. Materials and Methods

2.1. Chemical reagents

All chemicals were purchased from Sigma (USA), Aldrich (Milwaukee, USA), Fluka Chemie (Buchs, Switzerland) and Merck (Germany).

2.2. Plant materials

Forty eight different fruit and vegetable samples were purchased and collected from grocery section of a well-known supermarket in Turkey in January-February 2017. The scientific names and tested parts of the forty-eight fruits and vegetables studied are detailed in Table 1. The identification of these samples was verified by means of Flora of Turkey [6].

2.3. Preparation of Extracts

The plant samples were washed with distilled water and cut with a blender into small pieces. They were covered and air-dried under room temperature and then, 10 grams of dried fruit and vegetables (leaves, fruits, seeds and roots) were weighed in separate beakers, soaked in 50 ml ethanol, properly sealed with aluminum foil and then left at ambient temperature for 24 hours. The obtained solutions were filtered through a 0.45µm membrane filter. The filtrates were evaporated by using a rotary evaporator at 40 °C. The extracts were stored at 4 °C. Stock solutions were prepared by dissolving one gram of each extract in 1 mL of ethanol [7].

2.4. Preparation of Bacteria and Fungi Isolates

The antibacterial activity of plant samples was evaluated against *Pseudomonas aeruginosa* ATCC®27853, *Proteus vulgaris* ATCC®7829, *Escherichia coli* ATCC®25922, *Clostridium perfringens* ATCC 313124, *Salmonella enterica* ATCC 14028, *Bacillus subtilis* B209, *Micrococcus luteus* B1018, *Staphylococcus aureus* ATCC 6538 and *Listeria monocytogenes* ATCC®7677. The bacterial species were grown on Mueller Hinton Agar (MHA, Merck) or in Mueller Hinton Broth (MHB, Merck). The in vitro antifungal activity of samples was evaluated against *Aspergillus niger* ATCC®9642 and *Candida albicans* ATCC®10231. The bacterial and fungal strains were obtained from ATCC (American Type Culture Collection, Rockville, Maryland). Sabouraud Dextrose Broth (SDB, Difco) or Sabouraud Dextrose Agar (SDA, Oxoid) were used for the growth of fungi.

2.5. Disc Diffusion Assay

Antimicrobial effectiveness was measured in compliance with the method followed by Ronald [8]. MHA medium (Merck, 40 mL) was poured into each petri dish for the bacteria, while SDA medium (Oxoid, 40 mL) was used for the fungi. All bacterial strains were grown in MHB medium (Merck) for 24 h at 37 °C, while the fungal strains were grown in SDB medium (Difco) at 27 °C for 48 h. After incubation, the cultures were diluted with broth medium. The final bacterial and fungal cell concentrations were adjusted to 10^8 and 10^7 cells/mL, respectively by measuring spectrophotometrically at OD (600 nm). 100 µl of each diluted suspension was spread over agar media. Afterwards, sterile paper discs (6 mm diameter, Oxoid, CT09988) were placed on agar and loaded with load 25 µL of each plant sample (20 mg/mL). As a positive control, Nystatin was used for the fungi while Ampicillin and Cephazolin were used for the bacteria. Ethanol and acetone were also used as negative controls. The plates were incubated for 24 hours at 37 °C and 27 °C for bacterial and fungal strains, respectively. After incubation, the average diameter of three readings of the clear zone surrounding the disc was taken as the measure of the inhibitory level of the plant extract against the test organisms and recorded as a mean ± SD.

2.6. Antioxidant Tests

2.6.1. Determination of Total Phenols

Total phenolic content (TPC) of the extracts was measured by use of Folin–Ciocalteu's phenol reagent with regard to the method defined by Singleton and Rossi [9]. Total phenolic content values of the studied materials were expressed as mg gallic acid equivalents (GAE) per g of fresh material.

2.6.2. DPPH Radical Scavenging Activity

Stable DPPH radical was purchased and used to determine DPPH free radical scavenging activity. When DPPH reacts with any antioxidant in an extract that contains a hydrogen donor, it gets reduced, and results in a decrease in absorbance at 517 nm which can be monitored using a spectrophotometer [10]. The scavenging capacity of the extract (1 mg/mL) was calculated using the following equation.

$$\text{Scavenging capacity (\%)} = (\text{Absorbance}_{\text{Blank}} - \text{Absorbance}_{\text{Sample}}) / \text{Absorbance}_{\text{Blank}} \times 100$$

2.6.3. Metal Chelating Activity
The ability of the ethanolic plant extracts to chelate ferrous ions competing with ferrozine was evaluated as reported by Dinis et al. [11]. The metal chelating ability of the extract (1 mg/mL) was calculated using the following equation.

Chelating activity (%)= $(\text{Absorbance}_{\text{Blank}} - \text{Absorbance}_{\text{Sample}}) / \text{Absorbance}_{\text{Blank}} \times 100$

2.7. Phytochemical Tests
Phytochemical tests of the materials were analyzed after extraction with ethanol. The phytochemical determination methods used were adapted from previous works on herbal analysis [12]. The method defines biologically active non-nutrimental compounds which contribute to the flavor, color and other features of plant parts. Examples of these are carbohydrates, flavonoids, glycosides, tannins, phenols, alkaloids, saponin etc.

2.7.1. Molisch's Test
1 mL of alcoholic extract was dissolved in 3 mL distilled water. 3 mL of aqueous extract was added to 2 ml of Molisch's reagent and mixed thoroughly. Then, 2 mL of conc. H_2SO_4 was poured carefully down the side of the test tube. At the interphase, a violet ring was evaluated as the existence of carbohydrates.

2.7.2. Fehling's Test
1 mL of alcoholic extract was dissolved in 1 mL distilled water. 1 mL of Fehling's (A+B) solution was added into 1 mL of the aqueous extract. It was shaken and heated on a water bath. A red precipitate was showed existence of reducing sugars.

2.7.3. Benedict's Test
1 mL of alcoholic extract was dissolved in 1 mL distilled water. 1 mL of the aqueous extract was placed in a test tube and 2 mL of Benedict's reagent was added. The solution was then heated in a boiling water bath for three minutes. The formation of a reddish precipitate indicated the presence of reducing sugar.

2.7.4. Moore's Test
To about 2 mL of sample solution, an equal volume of 5% NaOH solution was added and then boiled for 2-5 minutes in a water bath. The solution turned yellow and then reddish-brown due to the formation of a condensation product of the sugar.

2.7.5. Seliwanoff's Test
1 mL of the test sample was appearance which confirmed the presence of carbohydrates.

2.7.6. Ferric Chloride Test
A few drops of 10% ferric chloride solution were added to 2 mL of filtrate. A green-blue or violet coloration indicated the presence of a phenolic hydroxyl group.

2.7.7. Lead Acetate Test
1 mL of alcoholic extract was dissolved in 1 mL distilled water. 1 mL of 10% lead acetate solution was added to 1 mL of the aqueous extract. The formation of a yellow precipitate was evaluated as a positive result for flavonoids.

2.7.8. Sodium Hydroxide Test
1 mL of alcoholic extract was dissolved in 1 mL distilled water. 10% sodium hydroxide solution was added into the aqueous solution. A yellow color indicated the presence of glycosides.

2.7.9. Keller-Kiliani Test
2 mL of glacial acetic acid containing one drop of 5% $FeCl_3$ solution was added into 2 mL of each extract. Then the mixture was added to a test tube containing 1 mL of concentrated H_2SO_4. A brown ring at the interphase was an important marker for the presence of a deoxy sugar, characteristic of cardenolides.

2.7.10. Tannins Test
1 mL of alcoholic extract was dissolved in 2 mL distilled water and a few drops of 1% ferric chloride solution followed by the addition of 1 ml of potassium ferrocyanide. The formation of blue-black, green or blueish-green precipitate was an indication of the presence of tannins.

2.7.11. Phenols Test
1 mL of alcoholic extract was dissolved in 2 mL distilled water. A few drops of 5% ferric chloride solution was added into 2 mL of the aqueous extract. A dark green color indicated the presence of phenolic compounds.

2.7.12. Alkaloids Test
1 mL of alcoholic extract was dissolved in 3 mL distilled water. On a steam bath, 3 mL of aqueous extract was stirred with 3 mL of 1% aqueous HCl and then filtered. After which Dragendorff's reagent was added to 1 mL of filtrate placed in a test tube. The appearance of orange red precipitate turbidity was accepted as a positive result. Wagner's reagent was added another 1 mL of the aqueous extract. The presence of a yellow or brown colored precipitate indicated the presence of alkaloids.

2.7.13. Saponins Test
A small amount of alcoholic extract was dissolved in 10 mL of distilled water in a test tube. The test tube was stoppered and shaken vigorously for about 30 sec. The test tube was left in a horizontal position statically and monitored for 30 minutes. If a "honey comb" forth persisted over the surface liquid, then the sample was expected to contain saponins.

2.7.14. Protein Test
The nitrogen substance of a sample was measured using a LECO System (LECO FP- 528, LECO Corporation, MI, USA). EDTA, supplied from LECO Corporation,

was used as standard. The protein substance of a sample was derived from nitrogen by multiplying it by a nitrogen-protein conversion factor of 5.30.

3. Results and Discussion

3.1. Screening for Antimicrobial Activity

The antimicrobial activity of 48 ethanolic extracts from different samples of fruits and vegetables was investigated in vitro against nine human pathogenic bacteria and two fungi. Diffusion disc plates on agar method is extensively used to investigate the antimicrobial activity of plant extracts. The obtained results as illustrated in Table 1 proved that some extracts especially those of *Allium sativum* (garlic), *Citrus reticulate* (mandarin), *Corylus avellana* (hazelnut), *Juglans regia* (walnut), *Punica granatum* (pomegranate), *Actinidia deliciosa* (kiwi), *Lactuca sativa* (lettuce), *Persea americana* (avocado), *Ananas comosus leaf* (pine apple) and *Petroselinum crispum* (parsley) demonstrated very high antibacterial and antifungal activity against all the strains tested. However, the extracts of *A. sativum* (garlic), *P. granatum* (pomegranate), *Brassica oleracea* (cabage), *A. deliciosa* (kiwi), *L. sativa* (lettuce) and *Allium cepa* (onion), showed exclusively yet significant antifungal activity against both *A. niger* and *C. albicans*. Moreover, these materials showed high antimicrobial activity against the bacteria tested. All fruits and vegetables used in the study showed significant antimicrobial effects.

The highest antimicrobial activity was demonstrated by *A. sativum* (garlic) and *P.crispum* (parsley). Among the 48 ethanolic extracts from the different fruit and vegetable screened, the largest inhibitory zones were observed with the extracts of *C. reticulata* -mandarin- (20-23, 16 mm in line 15), *J. regia* -walnut- (20-23, 17mm in line 41), *A. deliciosa* -kiwi- (20-22, 19mm in line 25) and *L. sativa* -lettuce- (18-19, 22mm in line 3) against, the following bacterial strains *L. monocytogenes*, *C. perfringens* and *B. subtilis*, and the two fungal pathogens *C. albicans* and *A. niger*. The plant extracts were more effective against Gram-negative bacteria than against Gram-positive ones (Table 1). *C. perfringens, P. vulgaris* and *S. enterica* were the most sensitive organisms against all fruit and vegetable extracts for Gram-negative bacteria, while *L. monocytogenes* and *B. subtilis* were the most sensitive among Gram-positive bacteria, and *C. albicans* for fungi.

Fifty distinct plants were tested for their antimicrobial activity against Gram-positive bacteria, Gram-negative bacteria, and fungi in a previous work [13]. Of all the tested plants, the authors found that *A. sativum* (garlic), a species belonging to the onion genus, demonstrated encouraging results as it showed a crucial inhibition effect against all tested pathogenic bacteria and fungi. This result is similar to the results revealed by our work. While herbs and spices have been well examined and recorded for their antimicrobial activity, lately fruits and vegetable have been given more attention because they have thousands of biologically active phytochemicals [1]. Thus, a great deal of fresh fruits and vegetables has recently been accepted as having antimicrobial activity against distinct pathogenic and spoilage microbes. Fruits and vegetables usually include phenolics and organic acids that are accepted as having antimicrobial activity. For instance, the greatest antimicrobial effect of *Capsicum annum* (pepper) was attributed to the presence of coumaric acids from phenolic compounds [14]. Flavonoids from bergamot peel, a byproduct of citrus fruit processing, was revealed to be active against Gram-negative bacteria (*E. coli*, *P. putida*, *S. enterica*) and the antimicrobial effect of flavonoids was enhanced after enzymatic deglycosylation [15]. Similar results were recorded in our study and citrus fruit (*C. reticulate*-mandarin) showed highly antimicrobial activity against Gram-positive bacteria (*B. subtilis, C. perfringens* and *L. monocytogenes*) and Gram-negative bacteria (*P. vulgaris* and *S. enterica*).

The antibacterial potency of hazelnut and walnut extracts have been examined. They revealed a high antimicrobial activity against selected bacteria and fungi [16, 17]. Besides, the extracts obtained from them displayed strong antioxidant potency. In our study similar findings were obtained. Both of them may be good antimicrobial sources especially against *E. coli*, *S. enterica* and *B. subtilis* (21-26 mm line 40 and 41 in Table 1), Pomegranate juice was found to prevent the growth of *E. coli* O157:H7. The methanolic extract of pomegranate peel was also found to possess antimicrobial potency against Gram-positive bacteria, Gram-negative bacteria, and fungi because of the presence of phenolics and flavonoids [18]. Similarly, we have reported that ethanolic extracts from *P. granatum* (pomegranate) possess antimicrobial potency against Gram-positive bacteria, Gram-negative bacteria, and fungi (24-21 mm - line 22 in Table 1).

Eleven tested bacteria were more or less inhibited by extract concentrations of 25 µL of each sample (20 mg/mL. On the other hand *C. albicans* was not inhibited by the same concentration, yet it was inhibited by pomegranate extracts). *L. monocytogenes* was the most susceptible bacterial strain to to garlic extracts. Garlic (*A. sativum*) extract also demonstrated an extensive range of antimicrobial efficiency. Allicin, an organosulfur compound existing in garlic, acts as a growth inhibitor for both Gram-positive and Gram-negative bacteria including *Helicobacter pylori*, *Proteus*, *Klebsiella*, *Staphylococcus*, *Streptococcus*, *Salmonella* and *E. coli* [19]. The antibacterial potency of garlic could be due to the effect of allicin, diallyl thiosulfinic acid or diallyl disulfide [20]. These results are similar with the results of our present work (line 35 in Table 1). These secondary metabolites have different utilities including antimicrobial features against pathogenic and spoilage microbes.

Table 1 Antimicrobial activities of studied fruit and vegetables

No	***Scientific name* (Common name)**	**Edible parts tested**	***C.p***	***E.c***	***S.e***	***L.m***	***S.a***	***P.a***	***P.v***	***A.n***	***C.a***	***M.l***	***B.s***
1	*Anethum graveolens* (Dill)	leaf	1.856±0.051	1.52±0.010	1.600±0.00	1.600±0.00	1.786±0.005	1.683±0.011	1.683±0.011	0.833±0.057	0.600±0.00	1.683±0.011	1.823±0.04
2	*Petroselinum crispum* (Parsley)	leaf	2.120±0.026	1.323±0.005	1.950±0.051	1.823±0.005	1.723±0.005	2.120±0.026	2.020±0.026	1.623±0.005	0.970±0.00	1.823±0.005	1.950±0.051
3	*Lactuca sativa* (Lettuce)	leaf	1.986±0.005	1.786±0.005	1.786±0.005	1.786±0.005	1.873±0.005	1.563±0.005	1.986±0.005	2.220±0.026	0.920±0.00	1.786±0.005	1.853±0.047
4	*Spinacia oleracea* (Spinach)	leaf	1.430±0.00	1.200±0.00	1.950±0.051	1.650±0.051	1.354±0.00	1.550±0.051	1.850±0.051	0.940±0.00	0.600±0.00	1.670±0.051	1.650±0.051
5	*Brassica oleracea var. acephala* (Black Cabbage)	leaf	1.573±0.005	0.863±0.055	1.523±0.005	1.426±0.24	1.310±0.00	1.523±0.005	1.523±0.005	0.940±0.00	0.863±0.055	1.286±0.005	1.44±0.24
6	*Brassica oleracea var. capitata f. rubra* (Red Cabage)	root	1.21±0.017	1.100±0.00	1.21±0.017	0.950±0.00	0.600±0.00	1.350±0.00	1.150±0.00	1.830±0.051	0.600±0.00	1.650±0.051	1.350±0.051
7	*Brassica oleracea var. italica* (Broccoli)	leaf	1.21±0.017	1.81±0.017	1.333±0.057	1.263±0.057	1.856±0.051	1.856±0.051	1.456±0.051	1.626±0.05	2.00±0.00	1.42±0.010	1.42±0.010
8	*Capsicum annuum var. annuum* (Stuffed Pepper)	fruit	1.233±0.57	0.863±0.055	0.940±0.00	1.033±0.057	0.600±0.00	0.850±0.00	1.333±0.057	1.100±0.00	0.600±0.00	0.940±0.00	0.600±0.00
9	*Capsicum annuum var.* (Charleston Pepper)	fruit	1.786±0.005	1.476±0.02	1.523±0.005	1.656±0.05	1.486±0.02	1.633±0.057	1.33 ±0.57	1.523±0.005	1.133±0.057	1.486±0.02	1.656±0.05
10	*Capsicum annuum* (Green Pepper)	fruit	1.21±0.017	1.100±0.00	1.786±0.005	1.21±0.17	1.29±0.17	1.390 ±0.29	1.526±0.005	0.600±0.00	0.600±0.00	1.390 ±0.29	1.40 ±0.29
11	*Capsicum annuum var.* (Red Pepper-chilli)	fruit	1.266±0.005	0.600±0.00	1.256±0.005	1.100±0.00	0.600±0.00	1.100±0.00	0.950±0.00	1.266±0.005	0.600±0.00	0.970±0.00	1.100±0.00
12	*Citrus sinensis* (Orange)	fruit	1.523±0.005	1.133±0.057	1.193±0.057	1.133±0.057	1.650±0.051	1.950±0.051	0.600±0.00	1.476±0.02	1.153±0.057	1.786±0.005	1.633±0.057
13	*Citrus paradise* (Grapefruit)	fruit	1.42±0.24	1.886±0.005	1.786±0.005	1.786±0.005	1.100±0.00	1.42±0.24	1.786±0.005	1.786±0.005	1.42±0.24	1.32±0.24	1.42±0.24
14	*Citrus limon* (Lemon)	fruit	0.926±0.046	1.423±0.005	1.233±0.057	2.320±0.026	1.686±0.005	1.52±0.010	1.786±0.005	1.52±0.010	1.233±0.057	1.42±0.24	1.42±0.24
15	*Citrus reticulata* (Mandarin)	fruit	2.320±0.026	1.662±0.010	1.856±0.051	2.320±0.026	1.563±0.005	1.876±0.051	2.020±0.026	1.626±0.025	1.233±0.057	1.926±0.046	2.320±0.026
16	*Malus domestica* (Green Apple)	fruit	1.100±0.00	1.400±0.00	1.100±0.00	0.950±0.00	0.600±0.00	0.780±0.00	1.15±0.24	1.35±0.24	0.830±0.00	1.32±0.24	1.27±0.24
17	*Malus domestica* (Red Apple)	fruit	1.110±0.00	1.410±0.00	1.100±0.00	0.950±0.00	0.600±0.00	0.780±0.00	1.10±0.24	1.33±0.24	0.830±0.00	1.30±0.24	1.25±0.24
18	*Malus domestica* (Muscatel Apple)	fruit	1.296±0.005	0.983±0.057	1.21±0.017	1.42±0.24	1.45±0.24	1.22±0.24	1.32±0.24	1.37±0.24	0.700±0.00	1.200±0.00	1.100±0.00
19	*Pyrus communis* (Lemon Shaped Pear)	fruit	0.833±0.057	0.600±0.00	0.600±0.00	1.100±0.00	1.100±0.00	1.000±0.00	1.100±0.00	0.600±0.00	0.760±0.00	1.100±0.00	0.600±0.00
20	*Pyrus anatolica var.* (Pear)	fruit	1.423±0.005	0.600±0.00	0.600±0.00	1.133±0.057	1.523±0.005	1.033±0.057	0.600±0.00	0.600±0.00	0.600±0.00	1.133±0.057	1.333±0.057
21	*Musa cavendishii* (Banana)	fruit	1.626±0.025	1.626±0.025	1.526±0.025	1.626±0.025	1.426±0.025	1.726±0.025	1.626±0.025	1.526±0.025	0.730±0.00	1.22±0.24	1.25±0.24
22	*Punica granatum* (Pomegranate)	fruit	1.720±0.24	1.540±0.034	1.640±0.034	1.940±0.034	1.930±0.034	1.126±0.025	2.320±0.026	1.823±0.04	1.873±0.04	1.863±0.04	2.020±0.026
23	*Solanum melongena* (Eggplant)	fruit	1.343±0.005	0.600±0.00	1.233±0.057	1.033±0.057	1.42±0.24	0.600±0.00	0.600±0.00	0.926±0.046	0.926±0.046	0.600±0.00	0.926±0.046
24	*Cucumis sativus* (Cucumber)	fruit	1.133±0.057	1.133±0.057	0.950±0.00	1.133±0.057	1.256±0.005	1.133±0.057	1.296±0.005	1.100±0.00	0.600±0.00	1.133±0.057	1.133±0.057

25	*Actinidia deliciosa* (Kiwi)	fruit	1.853±0.047	1.42±0.24	2.086±0.005	1.986±0.005	1.553±0.005	1.986±0.005	2.220±0.026	1.986±0.005	1.320±0.00	1.686±0.005	1.786±0.005
26	*Cucurbita pepo* (Marrow)	fruit	0.600±0.00	0.600±0.00	1.266±0.005	0.600±0.00	0.600±0.00	0.600±0.00	0.600±0.00	0.600±0.00	0.600±0.00	0.600±0.00	0.600±0.00
27	*Cydonia oblonga* (Quince)	fruit	2.020±0.026	1.42±0.24	1.380±0.00	1.986±0.005	1.773±0.005	1.673±0.005	1.986±0.005	1.786±0.005	0.600±0.00	1.543±0.005	1.686±0.005
28	*Lycopersicon esculentum* (Tomato)	fruit	1.133±0.057	0.600±0.00	0.940±0.00	1.350±0.00	0.600±0.00	0.863±0.055	1.100±0.00	1.100±0.00	0.600±0.00	1.100±0.00	1.206±0.005
29	*Brassica oleracea var. botrytis* (Cauliflower)	fruit	1.786±0.005	1.300±0.00	1.466±0.005	1.583±0.005	1.573±0.005	1.466±0.005	1.566±0.005	1.100±0.00	0.600±0.00	1.266±0.005	1.366±0.005
30	*Persea american* (Avocado Cernel)	seed	1.873±0.005	1.853±0.005	1.950±0.051	1.626±0.05	2.120±0.026	1.666±0.05	1.786±0.005	1.100±0.00	0.600±0.00	1.853±0.005	1.796±0.005
31	*Persea americana* (Avocado)	fruit	1.033±0.057	1.333±0.057	1.823±0.005	1.52±0.010	1.49±0.24	1.786±0.005	1.46±0.24	1.950±0.051	0.726±0.046	1.786±0.005	1.786±0.005
32	*Allium cepa* (Onion)	leaf	0.600±0.00	0.780±0.00	0.600±0.00	0.700±0.00	1.5526±0.25	0.600±0.00	0.600±0.00	1.290±0.00	1.270±0.00	0.600±0.00	0.600±0.00
33	*Allium cepa* (Red Onion)	leaf	1.446±0.02	1.170±0.00	1.31±0.017	1.436±0.02	1.853±0.005	1.39 ±0.57	1.29±0.017	1.033±0.57	2.220±0.026	1.426±0.02	1.21±0.017
34	*Allium cepa* (White Onion)	leaf	1.920±0.051	1.39 ±0.57	1.893±0.005	1.786±0.005	1.626±0.05	1.786±0.005	1.950±0.051	0.940±0.00	1.416±0.02	1.960±0.051	1.786±0.005
35	*Allium sativum* (Garlic)	fruit	1.823±0.04	2.320±0.026	1.950±0.051	2.220±0.026	1.626±0.025	2.320±0.026	2.120±0.026	1.886±0.005	1.186±0.005	1.886±0.005	1.823±0.005
36	*Allium porrum* (Leek)	leaf	1.52±0.010	1.62±0.010	1.42±0.010	1.82±0.010	1.52±0.010	1.62±0.010	1.72±0.010	1.406±0.02	1.406±0.02	1.506±0.02	1.656±0.02
37	*Vitis aestivalis* (Black Grape)	fruit	1.523±0.005	1.133±0.057	1.31±0.017	1.853±0.005	1.33 ±0.57	1.476±0.02	1.24±0.017	1.446±0.02	1.083±0.57	1.326±0.05	1.436±0.02
38	*Ananas comosus* (Pine Apple)	leaf	1.853±0.005	1.786±0.005	1.873±0.005	1.950±0.051	1.633±0.057	1.823±0.005	1.433±0.057	1.786±0.005	1.26±0.017	1.786±0.005	1.786±0.005
39	*Ananas comosus* (Pine Apple)	fruit	1.853±0.005	1.28±0.017	1.476±0.02	1.523±0.005	1.523±0.005	1.523±0.005	1.133±0.057	1.476±0.02	1.32±0.57	1.523±0.005	1.523±0.005
40	*Corylus avellana* (Hazelnut)	seed	1.853±0.005	2.120±0.026	2.220±0.026	2.020±0.026	1.683±0.011	1.903±0.011	1.983±0.011	1.783±0.011	1.37±0.24	1.756±0.005	2.220±0.026
41	*Juglans regia* (Walnut)	seed	2.020±0.026	2.220±0.026	2.320±0.026	0.860±0.00	1.883±0.011	2.020±0.026	2.220±0.026	1.726±0.005	1.112 ±0.72	2.260±0.010	2.240±0.010
42	*Daucus carota* (Carrot)	root	1.100±0.00	1.180±0.00	1.100±0.00	1.200±0.00	1.626±0.025	1.126±0.025	1.123±0.025	0.600±0.00	0.600±0.00	0.9340±0.00	1.200±0.00
43	*Raphanus sativus* (Pink Radish)	root	0.940±0.00	0.600±0.00	1.380±0.00	1.100±0.00	1.200±0.00	0.600±0.00	0.600±0.00	0.600±0.00	0.600±0.00	0.800±0.00	0.600±0.00
44	*Nigra radicula* (Black Radish)	root	1.100±0.00	1.160±0.00	1.550±0.00	1.570±0.00	1.300±0.00	1.523±0.005	1.323±0.005	0.600±0.00	0.780±0.00	1.42±0.24	1.520±0.24
45	*Apium graveolens* (Celery)	root	0.600±0.00	0.600±0.00	1.100±0.00	1.100±0.00	1.42±0.24	1.133±0.057	1.100±0.00	1.100±0.00	1.523±0.005	0.863±0.055	0.600±0.00
46	*Solanum tuberosum* (Potato)	root	1.723±0.005	1.42±0.24	1.353±0.057	1.52±0.010	1.333±0.057	1.523±0.005	1.233±0.057	1.363±0.057	0.826±0.046	1.42±0.24	1.786±0.005
47	*Brassica napobrassica* (White Turnip)	root	1.033±0.057	0.863±0.055	1.31 ±0.57	1.093±0.57	1.133±0.057	1.033±0.57	1.406±0.02	0.863±0.055	0.600±0.00	0.600±0.00	0.600±0.00
48	*Barssica camperstris Subsp. Rapa* (Red Turnip)	root	1.540±0.034	1.340±0.034	1.730±0.034	1.853±0.047	1.340±0.00	1.853±0.047	1.786±0.005	0.863±0.055	0.600±0.00	1.42±0.24	1.523±0.005
	Ampicillin		4.316±0.028	1.500±0.00	3.540±0.034	2.400±0.00	1.00±0.00	2.926±0.046	2.900±0.00	NT	NT	0.600±0.00	3.56±0.00
	Cephazolin		4.316±0.028	1.500±0.00	3.516±0.040	3.313±0.023	0.600±0.00	2.433±0.028	0.600±0.00	NT	NT	3.573±0.023	3.826±0.109
	Nystatin		NT	NT	NT	NT	NT	NT	NT	1.600±0.00	1.500±0.00	NT	NT
	Solvents		-	-	-	-	-	-	-	-	-	-	-

-: no inhibition, NT: Not tested, ***P.a:*** *P. aeruginosa* ATCC®*27853*, ***P.v:*** *P. vulgaris* ATCC®7829, ***E.c:*** *E. coli* ATCC®25922, ***L.m:*** *L. monocytogenes* ATCC®7677, ***C.a:*** *C. albicans* ATCC®10231, ***C.p****: C. perfringens* ATCC 313124, **S.*e****: S. enteric* ATCC 14028, ***B.s:*** *B. subtilis* B209, ***M.l:*** *M. luteus* B1018, ***S.a:*** *S. aureus* ATCC 6538, ***A.n:*** *A. niger* ATCC®9642

Natural antimicrobials obtained from plants have been well known for a long time, but only scientifically verified in the last 30 years. Therefore, there is increasing relevance in finding natural antimicrobials in food products to prohibit or restrain microbial growth and also to extend shelf life. Generally, plants have a much greater inhibition effect against Gram-positive than Gram-negative bacteria. The potency against both kinds of bacteria may be indicative of the existence of broad spectrum antibiotic compounds or simply general metabolic toxins. The antimicrobial potency of the plant is attributed to the chemical structure and concentration of their active constituents [21].

Different chemical components exist in plants with antimicrobial effect which includes organic acids, phenolics, glucosinolates, thiosulfinates, flavonoids and saponins. However, the main components in plants with antimicrobial activity are the phenolic compounds such as isoflavonoids, acids, ketones, aldehydes, aliphatic alcohols and terpenes [22]. Another study reported that the antibacterial potency of 46 extracts from spices and herbs was attributed to the phenolic components [23].

Researchers have found that all the tested samples have strong antibacterial activity against *S. anatum, E. coli, S. aureus, L. monocytogenes* and *B. cereus*. The antimicrobial potency of red cabbage was proposed to be due to the fact that red cabbage is rich in anthocyanins, phenolic compounds. The antimicrobial activity of red cabbage in our study was only observed against *A. niger* (18 mm). Flavonoids and saponins are abundant in leaves, flowers, stems, seeds, nuts, vegetables and fruits. The antimicrobial potency of flavonoids and saponins obtained from certain plants such as *Bersama engleriana* (Melianthaceae) has been demonstrated when extracted from wood, leaves, stem bark and roots [24]. It has also been recorded that rosmarinic acid has anti parasitic, antiviral, antifungal, and antibacterial activity. Furthermore, the existence of a hydroxyl group in the phenolic compound might affect their antimicrobial efficiency. The hydroxyl groups bind to and interact with the active site of the enzymes hence altering their metabolism. The degree of steric hindrance and the lipid solubility of the phenolic compounds might determine their antimicrobial potency [18].

Furthermore, we decided to use crude extracts for the antimicrobial activity of the phenolic compounds in the examined vegetables and fruit for the following reasons. First, the antimicrobial activity of the phenolic compounds has been accepted. They act by inducing leakage of cytoplasmic components such as glutamate, protein or phosphate, and potassium from the bacteria, which may be due to disruption of the cell peptidoglycan or from detriment to the cell membrane. Extracts may be more useful than isolated components because a bio-actively distinct component can alter its features in the existence of other compounds that are also present in an extract. Research has indicated that the additive and complementary effects of the phytochemicals in fruits and vegetables are liable for their bioactive features, and the benefits of a diet rich in fruits and vegetables is based on the complex mixture of phytochemicals existing in all foods [25].

3.2. Screening for Antioxidant Activity

Total phenolic content of the ethanolic plant extracts was calculated as GAE. The obtained results are listed in Table 2. The total phenolic content varied between 0.237 and 136.658 mg GA/g of fresh material for *Cucumis sativus* (cucumber) fruit and *P. americana* (avocado kernel) seed, respectively, followed by *P. granatum* (pomegranate) fruit with the value of 101.060 mg GA/g of fresh material.

Applying several methods based on different reaction mechanisms to determine the antioxidant activity of a plant extract provides more certain results. Antioxidants may exhibit their useful effects by three different processes such as hydrogen atom transfer, single electron transfer and metal chelation. Except that a variety of phytochemicals including and the associated variety in chemical moieties, also require this [26]. Therefore, the current study determined the antioxidant activities of the extract according to DPPH free radical scavenging and metal chelating assay.

As expected, the DPPH free radical scavenging activities of avocado *P. americana* (avocado kernel) seed and *P. granatum* (pomegranate) fruit were rather high compared to standard antioxidants such as butylated hydroxyanisole, ascorbic acid and gallic acid. The literature also supports that pomegranate juice contains high levels of antioxidants, higher than other juices and beverages, e.g. red wine, grape, blueberry, blackberry, cranberry and apple juice [27]. Furthermore, there is good correlation (R^2=0.7918) between the total phenolic content values and calculable DPPH free radical scavenging activity values. Such a high correlation was not observed in the ability to form a chelate. This is not surprising because it is known that phenolic acids contribute to DPPH free radical scavenging activity. Yet the other antioxidative characteristics result from the synergistic effect of the mixture of total phenolic acids and other antioxidant components [26].

According to Gordon, chelating agents, which constitute σ-bonds with metal, are potent as secondary antioxidants because they reduce the redox potency, therefore, stabilizing the oxidized form of a metal ion [28]. In this study, *A. cepa* (red onion), *Brassica oleracea var. acephala* (black cabbage) and *Brassica oleracea var. botrytis* (cauliflower) demonstrated the highest chelating ability. Cauliflower (*B. oleraceae L. var. botrytis*) is rich in bioactive compounds including glucosinolates, phenolic compounds and vitamins. Glucosinolates are particularly abundant in Brassica vegetables such as cabbage and cauliflower and are believed to be bioactive compounds responsible for many of the biological effects attributed to them [29].

The antioxidative activities of all kinds of plants depend on several factors such as cultivar, maturity, and agronomic and environmental conditions during cultivation. Apart from geographical and seasonal variables, genotype is the predominant factor for determining the type and concentration of the antioxidant compounds [30]. In Table 2, the total phenolic contents and antioxidative activities of the studied fruit and vegetables are illustrated conclusion, all these results are promising indicators that fruits and vegetables have health benefits.

3.3. Screening for Phytochemical Constituents

The ethanolic extracts obtained from 48 plants were analyzed for their phytochemical constituents such as alkaloids, flavonoids, carbohydrates, glycosides, proteins, saponins, tannins and phenols as summarized in Table 3. These findings are in accord with Apple et al reported. In that vegetables have an intensive supply of phytochemicals which have a preservative and curative impact essential to precluding illnesses and sustaining good health, by means of stimulating enzymes in the liver to make some carcinogens become innocuous and also assist the body to stimulate others [31].

Quantitative analysis of the extracts reveals that the *B. oleracea var. acephala* (black cabbage) and *C. avellana* (hazelnut) contain higher protein content when compared to the other plant materials as shown in Table 2. It is well-known that *Brassica oleraceae acephala* (black cabbage) has a high nitrogen content, while *C. avellana* (hazelnut) has rich protein content [32].

Epidemiological works have indicated that regular nourishment from fruits and vegetables is correlated with a lower risk of chronic non-communicable diseases. However, the simple truth is that the nutritious impacts of fruits and vegetables do not only account for the observed health benefits found in studies. They also have the augmented and concomitant effects of preventing chronic diseases. Therefore, for an optimal balanced diet, consumers should include a wide variety of fruits, vegetables, whole grains and other plant foods in their daily nutrition [25].

4. Conclusion

20 mg/mL of whole extracts had remarkable antimicrobial activity against Gram-positive and Gram-negative bacteria when compared with standard and strong antimicrobial compounds like ampicillin, cephazolin, and nystatin. In addition, it was observed that Gram-negative organisms are generally more sensitive to our plant materials than Gram-positive organisms.

Table 2 Total phenolic contents, antioxidant activities and protein and nitrogen contents of studied fruit and vegetables

No	Scientific name of plant	Edible parts tested	Total phenolic content (mg GA/g dry extract)	DPPH free radical scavenging capacity of the 1 mg/mL extract (scavenging%)	Chelating activity of the 1 mg/mL extract (chelating %)	N [%]	Protein [%]
1	*Anethum graveolens* (Dill)	leaf	5.355	40.3	-	3.184	16.874
2	*Petroselinum crispum* (Parsley)	leaf	3.898	-	3.2	2.910	15.423
3	*Lactuca sativa* (Lettuce)	leaf	0.772	-	11.9	1.197	6.345
4	*Spinacia oleracea* (Spinach)	leaf	2.026	-	22.8	3.328	17.637
5	*Brassica oleracea var. acephala* (Black Cabbage)	leaf	2.459	0.9	63.8	6.942	36.795
6	*Brassica oleracea var. capitata f. rubra* (Red Cabage)	root	5.327	23.9	26.5	5.155	27.321
7	*Brassica oleraceae var. italica* (Broccoli)	leaf	5.854	20.7	45.5	3.498	18.541
8	*Capsicum annuum var. annuum* (Stuffed Pepper)	fruit	3.088	7.1	36.2	1.975	10.470
9	*Capsicum annuum var.* (Charleston Pepper)	fruit	2.831	11	42.0	2.765	14.654
10	*Capsicum annuum* (Green Pepper)	fruit	2.758	9.9	7.0	2.239	11.867
11	*Capsicum annuum var.* (Red Pepper-chilli)	fruit	3.137	0.9	19.7	2.429	12.873
12	*Citrus sinensis* (Orange)	fruit	7.338	3.3	4.2	1.400	7.421
13	*Citrus paradise* (Grapefruit)	fruit	4.804	4.8	1.2	0.877	4.650
14	*Citrus limon* (Lemon)	fruit	11.326	20.5	13.1	1.398	7.410
15	*Citrus reticulata* (Mandarin)	fruit	9.905	13.5	6.0	1.293	6.852
16	*Malus domestica* (Green Apple)	fruit	3.277	13.5	-	0.482	2.555
17	*Malus domestica* (Red Apple)	fruit	5.025	39	-	0.450	2.384

18	*Malus domestica* (Muscatel Apple)	fruit	2.790	12	-	0.294	1.558
19	*Pyrus communis* (Lemon Shaped Pear)	fruit	7.575	9.3	4.8	0.656	3.476
20	*Pyrus anatolica var.* (Pear)	fruit	1.873	5.6	10.2	0.623	3.301
21	*Musa cavendishii* (Banana)	fruit	1.310	2.8	13.1	1.617	8.568
22	*Punica granatum* (Pomegranate)	fruit	101.060	91.6	30.1	2.026	10.740
23	*Solanum melongena* (Eggplant)	fruit	6.707	8.7	24.3	0.519	2.752
24	*Cucumis sativus* (Cucumber)	fruit	0.237	-	-	1.154	6.116
25	*Actinidia deliciosa* (Kiwi)	fruit	4.311	19.1	24.0	1.125	5.963
26	*Cucurbita pepo* (Marrow)	fruit	1.619	-	22.8	2.458	13.025
27	*Cydonia oblonga* (Quince)	fruit	7.375	26.1	-	1.274	6.750
28	*Lycopersicon esculentum* (Tomato)	fruit	0.870	2.9	28.7	1.110	5.884
29	*Brassica oleracea var. Botrytis* (Cauliflower)	fruit	6.116	-	60.5	2.368	12.549
30	*Persea american* (Avocado Cernel)	seed	136.658	90.3	3.8	2.564	13.587
31	*Persea americana* (Avocado)	fruit	4.982	6.4	13.2	3.390	17.967
32	*Allium cepa* (Onion)	leaf	2.242	4.8	38.7	0.294	1.556
33	*Allium cepa* (Red Onion)	leaf	3.464	1.9	74.8	0.841	4.458
34	*Allium cepa* (White Onion)	leaf	4.532	-	9.8	1.104	5.850
35	*Allium sativum* (Garlic)	fruit	1.722	-	-	1.599	8.473
36	*Allium porrum* (Leek)	leaf	1.621	0.3	-	3.670	19.452
37	*Vitis aestivalis* (Black Grape)	fruit	23.903	69.6	13.7	0.916	4.854
38	*Ananas comosus* (Pine Apple)	leaf	1.477	-	16.3	0.616	3.266
39	*Ananas comosus* (Pine Apple)	fruit	1.860	0.3	5.6	1.042	5.523
40	*Corylus avellana* (Hazelnut)	seed	24.721	89.2	-	6.583	34.890
41	*Juglans regia* (Walnut)	seed	47.174	91.4	26.5	3.266	17.308
42	*Daucus carota* (Carrot)	root	1.641	-	11.1	0.751	3.978
43	*Raphanus sativus* (Pink Radish)	root	0.579	-	-	0.682	3.612
44	*Nigra radicula* (Black Radish)	root	2.480	-	-	0.708	3.752
45	*Apium graveolens* (Celery)	root	3.017	-	26.5	0.257	1.361
46	*Solanum tuberosum* (Potato)	root	1.992	-	20.9	2.633	13.957
47	*Brassica napobrassica* (White Turnip)	root	0.413	-	0.9	0.976	5.174
48	*Barssica camperstris Subsp. Rapa* (Red Turnip)	root	0.792	-	18.5	1.557	8.254
	Butylated Hydroxyanisole			92.7			
	Ascorbic Acid			92.8			
	Gallic acid			91.8			

The antioxidant activity estimations, including total phenolic content, DPPH free radical scavenging capacity and metal chelating activity show that, in particular, the values of *P. granatum* (pomegranate), *P. americana* (avocado), *J. regia* (walnut), *C. avellana* (hazelnut), *B. oleracea var. botrytis* (cauliflower), and *A. cepa* (red onion) are remarkably high in comparison to different standards such as BHA, ascorbic acid and gallic acid.

Crude plant extracts represent a good/rich source for phytochemicals such as alkaloids, flavonoids, carbohydrates, glycosides, saponins, tannins, and proteins. Hence, fruits and vegetables should be included in daily nutrition. Besides, fruit and vegetable consumption has been correlated with improvement in pulmonary function and children's immune system. Therefore, the outcomes of this study show that most of the ethanolic extracts of 48 fruits and vegetables can serve as easily accessible sources of natural antioxidants and as a probable dietary supplement or in the drug industry.

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Table 3 Phytochemical profiles of extracts of studied fruits and vegetables

Phtochemical Components			Carbohydrates					Flavonoids		Glycosides		Tannin	Phenol	Alkaloids		Saponin
No	***Scientific name* (Common name)**	**Tests** / **Edible parts tested**	**Molisch**	**Fehling**	**Benedict**	**Moore**	**Seliwanoff**	**$FeCl_3$**	**$Pb(OAc)_2$**	**NaOH**	**Keller-Killani**	**$FeCl_3$**	**$FeCl_3$-$K_3Fe(CN)_6$**	**Dragendorff's**	**Wagner's**	**Froth**
1	*A.nethum graveolens* (Dill)	leaf	++	-	-	-	-	++	++	++	+	-	++	+	+	-
2	*Petroselinum crispum* (Parsley)	leaf	++	-	-	-	++	++	++	++	+	-	++	+	+	-
3	*Lactuca sativa* (Lettuce)	leaf	++	++	++	++	++	++	++	++	++	-	++	+	+	++
4	*Spinacia oleracea* (Spinach)	leaf	++	++	++	-	++	++	++	++	++	++	++	-	-	-
5	*Brassica oleraceae var. acephala* (Black Cabbage)	leaf	++	++	++	++	++	++	++	++	++	++	++	+	+	-
6	*Brassica oleracea var. capitata f. rubra* (Red Cabage)	root	++	++	++	++	++	++	++	++	++	++	++	+	+	-
7	*Brassica oleracea var. italica* (Broccoli)	leaf	++	++	++	++	++	++	++	++	++	++	++	+	+	-
8	*Capsicum annuum var. annuum* (Stuffed Pepper)	fruit	++	++	++	++	++	++	++	++	++	-	++	+	+	++
9	*Capsicum annuum var.* (Charleston Pepper)	fruit	++	++	++	++	++	++	++	++	++	++	++	+	+	++
10	*Capsicum annuum* (Green Pepper)	fruit	++	++	++	++	++	++	++	++	++	++	++	+	+	-
11	*Capsicum annuum var.* (Red Pepper-chilli)	fruit	++	++	++	++	++	++	++	++	++	++	++	-	-	++
12	*Citrus sinensis* (Orange)	fruit	++	++	++	++	++	++	++	++	++	++	++	+	+	-
13	*Citrus paradise* (Grapefruit)	fruit	++	++	++	++	++	++	++	++	++	++	++	+	+	-
14	*Citrus limon* (Lemon)	fruit	++	++	++	++	++	++	++	++	++	++	++	+	+	++
15	*Citrus reticulata* (Mandarin)	fruit	++	++	++	++	++	++	++	++	++	++	++	+	+	++
16	*Malus domestica* (Green Apple)	fruit	++	++	++	++	++	++	++	++	++	++	++	+	+	++
17	*Malus domestica* (Red Apple)	fruit	++	++	++	++	++	++	++	++	++	-	++	+	+	++
18	*Malus domestica* (Muscatel Apple)	fruit	++	++	++	++	++	++	++	++	++	++	++	+	+	+
19	*Pyrus communis* (Lemon Shaped Pear)	fruit	++	++	++	++	++	++	++	++	++	-	++	+	+	-
20	*Pyrus anatolica var.* (Pear)	fruit	++	++	++	++	++	++	++	++	++	-	++	+	+	+
21	*Musa cavendishii* (Banana)	fruit	++	++	++	++	++	++	++	-	++	-	++	+	+	-
22	*Punica granatum* (Pomegranate)	fruit	++	++	++	++	++	++	++	++	++	++	++	+	+	++
23	*Solanum melongena* (Eggplant)	fruit	++	++	++	++	++	++	++	++	++	-	++	+	+	+
24	*Cucumis sativus* (Cucumber)	fruit	++	++	++	-	++	++	++	++	++	-	++	+	+	++
25	*Actinidia deliciosa* (Kiwi)	fruit	++	++	++	++	++	++	++	++	++	-	++	+	+	+
26	*Cucurbita pepo* (Marrow)	fruit	++	++	++	++	++	++	++	++	++	-	++	+	+	+

27	*Cydonia oblonga (Quince)*	fruit	++	++	++	++	++	++	++	++	++	++	++	+	+	-
28	*Lycopersicon esculentum* (Tomato)	fruit	++	++	++	++	++	++	++	++	++	-	++	+	+	++
29	*Brassica oleraceae var. Botrytis* (Cauliflower)	fruit	++	++	++	++	++	++	++	-	++	++	++	+	+	+
30	*Persea american* (Avocado Cernel)	seed	++	++	++	++	++	++	++	++	++	++	++	+	+	++
31	*Persea americana* (Avocado)	fruit	++	++	++	++	++	++	++	-	++	-	++	+	+	++
32	*Allium cepa* (Onion)	leaf	++	++	++	++	++	++	++	++	++	++	++	+	+	+
33	*Allium cepa* (Red Onion)	leaf	++	++	++	++	++	++	++	++	++	++	++	+	+	++
34	*Allium cepa* (White Onion)	leaf	++	++	++	++	++	++	++	++	++	++	++	+	+	++
35	*Allium sativum* (Garlic)	fruit	++	-	-	-	++	-	-	-	+	-	++	+	+	-
36	*Allium porrum* (Leek)	leaf	++	++	++	++	++	++	++	-	++	-	++	-	+	++
37	*Vitis aestivalis* (Black Grape)	fruit	++	++	++	++	++	++	++	++	++	++	++	+	+	+
38	*Ananas comosus* (Pine Apple)	leaf	++	-	++	-	++	++	++	++	+	++	++	+	+	-
39	*Ananas comosus* (Pine Apple)	fruit	++	++	++	++	++	++	++	++	++	-	++	+	+	++
40	*Corylus avellana* (Hazelnut)	seed	++	-	-	-	++	++	++	-	+	-	++	+	+	-
41	*Juglans regia* (Walnut)	seed	++	-	-	-	++	++	++	++	++	++	++	+	+	-
42	*Daucus carota* (Carrot)	root	++	++	++	++	++	++	++	++	++	-	++	+	+	-
43	*Raphanus sativus* (Pink Radish)	root	++	-	-	-	++	++	++	-	++	-	++	+	+	-
44	*Nigra radicula* (Black Radish)	root	++	++	++	++	++	++	++	++	++	-	++	+	+	++
45	*Apium graveolens* (Celery)	root	++	++	++	-	++	++	++	++	+	++	++	+	+	++
46	*Solanum tuberosum* (Potato)	root	++	++	++	-	++	++	++	++	++	-	++	+	+	++
47	*Brassica napobrassica* (White Turnip)	root	++	++	++	++	++	++	++	++	++	-	++	+	+	++
48	*Barssica camperstris Subsp. Rapa* (Red Turnip)	root	++	-	-	-	++	++	++	-	++	-	++	+	+	-

++highly positive; +moderately positive; -negative

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