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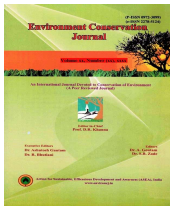

Analysis of pharmacognostical standardization, antioxidant capacity and separation of phytocompounds from five different vegetable peels using different solvents

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ABSTRACT

Vegetables are one of the most preferred food commodities and can be consumed either raw or as processed due to their health-promoting nutrients. In the present work, analysis of pharmacognostical standards, antioxidant capacity, and separation of phytocompounds through thin layer chromatography (TLC) from cabbage, cauliflower, pea, carrot, and potato peels were carried out. Microscopic analysis revealed the presence of wood fibers, trichomes, crystals, and annular xylem vessels in the vegetable peels. Physicochemical analysis showed that all the vegetable peel samples which were analysed have low (7.08%-10%) moisture content. The total ash content of vegetable peels varied in cauliflower peels (1.95±0.58) to the peels of pea (19.86±1.9). The content of acid insoluble ash varied from 1.46±0.63 to 3.09±0.59 in cauliflower and pea. Potato peel has the lowest water-soluble ash content (1.16±1.90) as compared to other peels. The highest pH value was found in the peels of pea (7), while the lowest pH was found in the peels of cabbage (4). Among all extracts, the petroleum ether extract has shown the greatest yield (5.6±0.45). The fluorescence analysis showed various colours like green, brown, pale green, and yellow under different chemical treatments. Different types of pri-secondary metabolites were detected in small, moderate, and high amounts and notified to provide numerous health benefits to humans. In case of DPPH assay, aqueous extract of cauliflower has shown the low value of IC_{50} (24.82 µg/ml) in comparison to standard, suggested the higher antioxidant activity of the extract. Among all the extracts, aqueous and methanol extracts of cauliflower have shown the better reducing and total antioxidant activity in comparison to standard. TLC profiling of methanolic extract of cabbage and cauliflower peels revealed the presence of different compounds of varying R_f values. Above results indicate that the food waste consists of valuable components and may be utilized as noticeable and cheap source in pharmaceuticals for the treatment of several life-threatening diseases.

Introduction

Due to the change in diet habits and increasing population, processing and production of horticultural crops, mainly vegetables, have been remarkably noticed as growing tool to fulfil the demands (Schreinemachers *et al*., 2018). Several studies suggested that vegetables are low in calories and rich in selected minerals, antioxidants, and fibres. It has been found in some of the researches that vegetables are rich in potassium and have relatively low sodium content. Due to all these

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amazing benefits, vegetables hold a unique contribution in a healthy diet (Chauhan *et al*., 2021). Recent studies suggest that diseases like gastric cancers and cardiac problems are protected in a better way by including vegetables in our diet. The anti-inflammatory and antiproliferative capacities of the phytochemicals and antioxidants makes them effective for the prevention of cancer and inflammation (Gazdik *et al*., 2008; Sarkar *et al*., 2022). The phytochemicals present in vegetable peels can also be utilized as food additives, colouring agents, biopesticides, fragrances, flavours, agrochemicals, and pharmaceuticals (Saha *et al*., 2012). But now a days, the scenario is changing and the agroindustrial wastes, mainly the vegetable peels, have started gaining more attention than previous days because they have potential to provide multiple benefits to the society in the field of medicine. However, the main obstacle, which has stopped the promotion of uses of vegetable peels in the developed nations, is no proper evidence of documentation. Therefore, the aim of present study was to evaluate the pharmacognostical standards, antioxidant activity, and presence of different bioactive phytoconstituents of the five different vegetable peels.

Material and Methods

Collection of plant materials

Vegetables including Cabbage (*Brassica oleracia* var. Capitata), Cauliflower (*Brassica oleracea* var. Botrytis), Pea (*Pisum sativum)*, Carrot (*Daucus carota* subsp. Sativus) and Potato (*Solanum tuberosum* L.) were obtained from the local wholesale market and their inedible part such as peels were separated with a peeler or knife. Then the vegetable peels were collected, washed, and shade dried, respectively.

Preparation of plant extracts

The shade dried samples were powdered with the help of grinder. Twenty-five grams of each sample was macerated sequentially using 100 ml of different solvent [petroleum ether (PET), chloroform (CH), methanol (ME), and water (AQ)]. Each extract of vegetable peels was air dried by the help of rotatory evaporator. After drying, the extracts were kept in the desiccator for one or two days and then were kept in the air tight containers at 5˚C for further use (Sharma and Janmeda, 2017).

Organoleptic and microscopic study

Different vegetable peel samples were examined morphologically and various microscopic characters were determined after the staining of samples as described by Janmeda and Sharma (2013).

Physicochemical analysis

Physicochemical parameters such as moisture content, total ash content, acid insoluble ash content, water soluble ash content, pH of 1% and 10% solution and extractive value were determined by the method of Mushtaq *et al*. (2014). Fluorescence was observed at different wavelengths of UV-Visible light as reported by Sharma and Janmeda (2013).

Phytochemical evaluation

Different phytochemicals from the different samples of vegetable peels were determined by using the standard methods (Saxena *et al.,* 2013; Banu and Cathrine, 2015).

Determination of *in vitro* antioxidant activity

2, 2-Diphenyl-1-picrylhydrazyl scavenging activity (DPPH)

DPPH assay was determined by using the protocol of Chaudhary and Janmeda (2022) with slight modifications. To one ml (0.2-0.5 mg/ml) of sample and ascorbic acid (standard), 4 ml of DPPH solution (25 mg/ml) which was prepared in methanol was added. The solutions were shaken and allowed to incubate in dark for 30 min. After 30 min, the absorbance of the solution was recorded at 517 nm using methanol as blank by the help of the below mentioned formulae:

$$Inhibition\ concentration\ (\%) = \left(Absorbance\ of\ control - \left(Absorbance\ of \frac{test\ sample}{Absorbance} of\ control \right) \right) \times 100$$

Ferric reducing antioxidant power (FRAP)

The reducing power of a sample was determined by using the FRAP assay (Benzie and Strain, 1999). Briefly, the FRAP reagent was prepared by mixing the acetate buffer (300 mM, pH 3.6), a solution of 10 mM TPTZ in 40 mM HCl, and 20 mM $FeCl_3$ at 10:1:1 (v/v/v). A potential antioxidant can reduce the ferric ion to the ferrous ion and resulted in the formation of blue coloured complex, whose absorbance was increased at 593 nm.

Total antioxidant capacity determination (TAC)

Phosphomolybdate method was applied to determine the total antioxidant capacity (TAC) of

the different samples (Prieto *et al.,* 1999). An aliquot of 0.4 ml (mg/ml) of each sample was mixed with 4 ml of reagent (4 mM ammonium molybdate, 0.6 M sulphuric acid, 28 mM sodium phosphate) solution. Then the mixture was shaken and was incubated at 95°C for 90 min in the water bath. Finally, the absorbance of the sample was recorded at 765 nm against the blank sample.

Thin layer chromatography (TLC)

TLC of the selected extracts was carried out with various solvent phase by using silica gel. For TLC analysis, Silica gel 60 F254 TLC (Merck, Germany) plates were utilized. The marking on the plate were made with the help of soft pencil. Glass capillaries were utilized to load the 1-µl of sample on TLC plate and then the plate was allowed to run in the presence of different solvent system. When the solvents reached to a certain height on the TLC plates, we removed the plate from the TLC chamber and allowed it to dry. Then the bands were observed in iodine chamber and on UV transilluminator. The movement of the analyte was expressed by its retention factor (R_f) values which was calculated by the help of below mentioned formulae (Gujjeti and Mamidala, 2013).

$$R_f = \frac{\text{Distance travelled by the solute}}{\text{Distance travelled by the solvent from TLC plates}}$$

Where, R_f is retention factor

Statistical analysis

All the assays and test were performed in triplicates and their outcomes were expressed as mean ± standard deviation (SD).

Results and Discussion

Organoleptic evaluation

Organoleptic evaluation and characteristic features of powdered drug of all five samples of vegetable peels are listed in Table 1 and Figure 1. The quality of vegetable peels mainly comprises of five primary attributes, 1) taste, 2) odour, 3) adulteration, 4) colour, 5) texture and the examination of these primary characteristics is generally very useful in the development of new products and in determining the product standards (Shewfelt, 1993).

Powder microscopic analysis

Powder microscopy is used to determine the specific microscopic characters after staining it with different staining solutions. The adulterants can be detected by doing a comparative study with authenticated sample (Amponsah *et al*., 2014).

Cabbage peel

The very fine powder of vegetable peels was mounted in glycerine and was stained with iodine and phloroglucinol. Microscopic analysis revealed the presence of wood fibers, trichomes, crystals, and annular xylem vessels from the cabbage peel as shown in Figure 2.

Cauliflower Peel

Powder microscopic analysis of cauliflower peel revealed the presence of different types of fibers and crystals as shown in Figure 3.

Pea Peel

The powder of pea peel shows the presence of fibers, wood fibers, different types of crystal, and xylem vessels as shown in Figure 4.

Carrot Peel

The microscopic analysis of powder revealed the presence of parenchyma, fibers, trichomes, and calcium oxalate crystals from the carrot peel as shown in Figure 5.

Potato Peel

Powder microscopic analysis revealed the presence of wood fibers, simple fibers, trichome, crystals, and spiral xylem vessel as shown in Figure 6.

Physicochemical properties of different vegetable peels

The physicochemical parameters of five different vegetable peels were determined in order to detect any type of adulteration and improper handling of plant material. Lower content of moisture represents the higher stability and less chances of microbial growth that ultimately increases the shelf life of product (Alam and us Saqib, 2015).

Results showed that all the vegetable peel samples which were analysed have low moisture content as shown in Table 2. One of the other parameters is ash content that gives information regarding the presence of organic, inorganic and any other impurities in the sample (Alam and us Saqib, 2015). The total ash content of vegetable peels varied from 1.95±0.58 in cauliflower peels to 19.86±1.9 in the peels of pea as shown in Table 2. The results of acid insoluble (Table 2) and water soluble ash content (Table 2) of different vegetable

Table 1: Organoleptic Characters of different vegetable peel powder

Samples	Taste	Odour	Adulteration	Colour	Texture
Cabbage	Bitter	Characteristic	Nil	Moss green	Rough
Cauliflower	Sweet and Sour	Characteristic	Nil	Bronze	Rough
Pea	Bitter	Characteristic	Nil	Moss green	Rough
Carrot	Sour	Characteristic	Nil	Sage green	Fibrous
Potato	Sour	Characteristic	Nil	Cider colour	Smooth
Powder drug	Cabbage	Cauliflower	Pea	Carrot	Potato
Color	Brown	Brown	Light brown	Dark brown	Brown
Odour	Characteristic				

Figure 1: Morphological features and characteristics of cabbage, cauliflower, pea, carrot, and potato vegetable peels.

peels as obtained in this study do not favor the results obtained by Parmeswaran and Murthi (2014). According to some guidelines, the adsorption, distribution, metabolism, excretion, and toxicity (ADMET) are greatly affected by the varying pH conditions. The acceptable pH value of trees, grasses, vegetables, and fruits is 4.0-7.5 (Prakash *et al*., 2019). The pH values observed in the present study were between 4 and 7 (Table 2). The pH values obtained are quite similar with those obtained by Nasreen and Qazi (2012).

Determination of extractive values

Extractive values were found to be useful in evaluating the chemical constituents and solubility of that specific constituents in particular solvent (Gupta *et al*., 2012). The percentage yields of PET, CH, ME, and AQ extracts of different vegetable peel samples are presented in Table 3 and in Figure 7.

Fluorescence analysis of different vegetable peel powder

The fluorescence analysis is utilized as a tool to determine the constituent and chemical nature of the herbal drug. The observations of fluorescence analysis of cabbage, cauliflower, pea, carrot, and potato are presented in Table 4, and 5.

Phytochemical screening

The phytochemical screening of different extracts of vegetable peels is shown in Table 6, and 7. This screening helps in determining the presence of various pharmacologically active compounds (Pandiyan and Illango, 2022). The results of present study revealed that protein, carbohydrate, cardiac glycosides, steroids, terpenoids, fats and oils are present in these vegetable peels. These secondary metabolites help in providing the defence mechanism to plant, and in turn provide numerous health benefits to humans (Sharma *et al*., 2022).

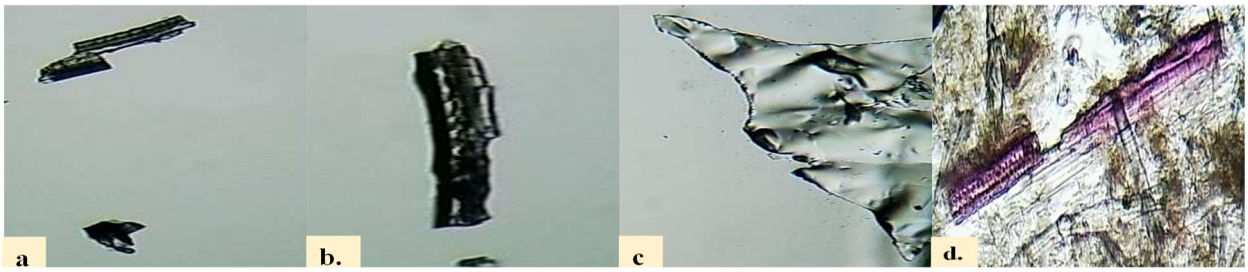

Figure 2: Powder microscopic analysis of cabbage peel. a. wood fibers, b. trichomes, c. crystals, d. annular xylem vessels.

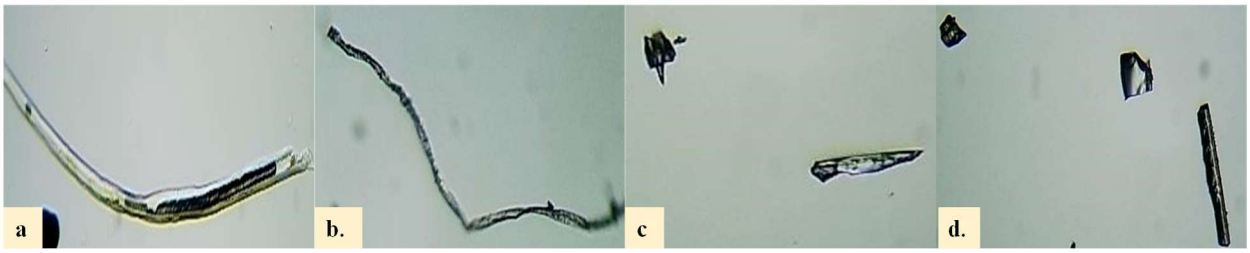

Figure 3: Powder microscopic analysis of cauliflower peel. a. fibers with lumen, b. fibers, c. & d. crystal.

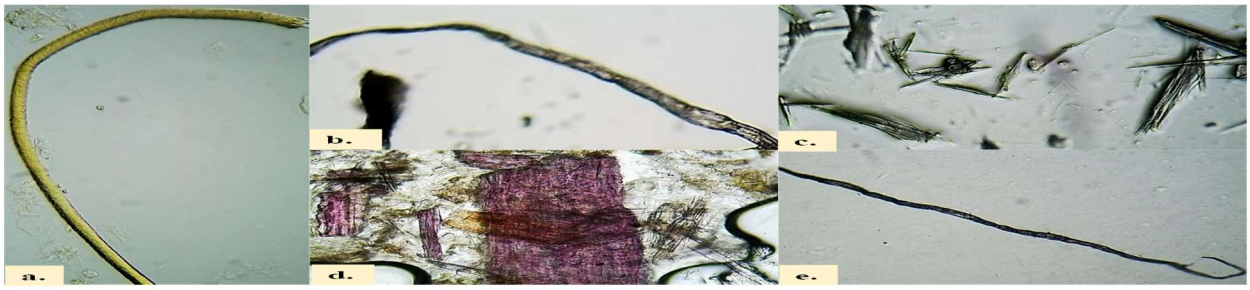

Figure 4: Powder microscopic analysis of pea peel. a. & b. fibers, c. different types of crystals, d. wood fibers, e. xylem vessels

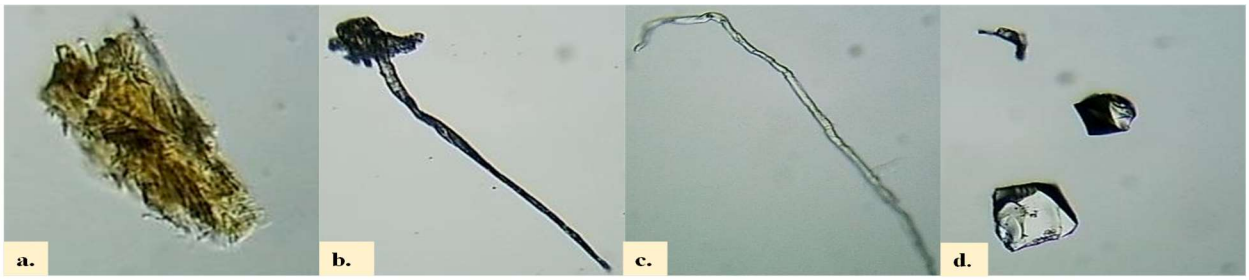

Figure 5: Powder microscopic analysis of carrot peel. a. parenchyma, b. fibers, c. trichomes, d. calcium oxalate crystal.

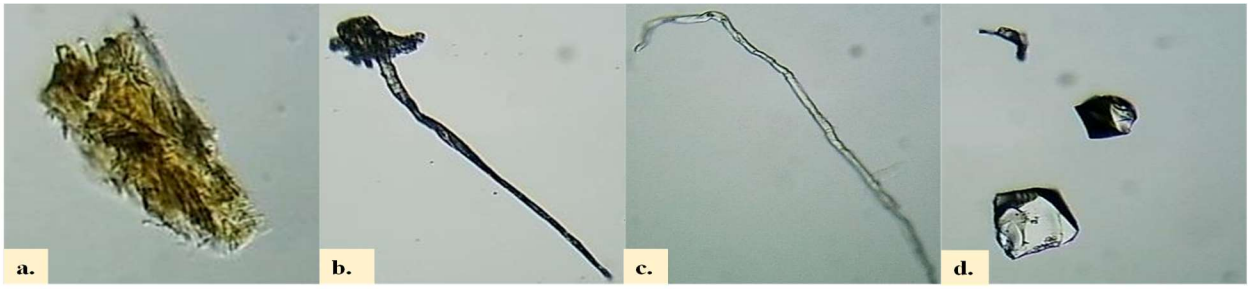

Figure 6: Powder microscopic analysis of Potato peel. a. wood fibers, b. fibers, c. trichomes, d. crystals, e. spiral xylem vessels.

Table 2: Physicochemical properties of different vegetable peels

Peel Powder	Moisture content %	Total ash content %	Acid insoluble ash content %	Water soluble ash content %	pH 1%	pH 10%
Cabbage	7.86	4.61±2.88	2.45±1.40	4.1±2.62	5.56±0.42	4.0±0.10
Cauliflower	7.52	1.95±0.58	1.46±0.63	1.81±0.51	6.36±0.20	4.9±0.10
Pea	7.08	19.86±1.90	3.09±0.59	16.31±1.88	5.91±0.10	5.7±0.10
Carrot	8.30	8.91±2.30	2.41±0.15	3.52±1.98	5.30±0.10	4.8±0.10
Potato	10.00	3.06±1.88	1.62±1.02	1.16±1.90	5.9±0.9	4.5±0.10

Note: Mean ± SD

Table 3: Preliminary phyto-profile of different vegetable peel extracts

Vegetable samples	Solvent	P.I.	B.P. of solvents (°C)	Colour	Consistency	Nature	% yield ± SD
Cabbage	PET	0.0	60-80	Olive green	Sticky	Solid	1.69±0.1
	CH	4.1	61.2	Fern green	Sticky	Solid	2.9±0.51
	ME	5.1	64.2	Olive green	Sticky	Semi- solid	3.7±0.11
	AQ	9.0	100	Greenish brown	Dry	Solid	3.9±0.21
Cauliflower	PET	0.0	60-80	Army green	Sticky	Solid	2.08±1.11
	CH	4.1	61.2	Sacramento green	Sticky	Solid	2.1±0.13
	ME	5.1	64.2	Fern green	Sticky	Semi-solid	3.12±0.12
	AQ	9.0	100	Army green	Dry	Solid	4.01±0.13
Pea	PET	0.0	0.0	Moss green	Dry	Solid	5.6±0.45
	CH	4.1	4.1	Crocodile green	Dry	Solid	2.01±1.12
	ME	5.1	5.1	Fern green	Sticky	Semi-solid	4.5±0.19
	AQ	9.0	9.0	Army green	Dry	Solid	4.9±1.1
Carrot	PET	0.0	60-80	Brick red	Sticky	Solid	1.19±0.2
	CH	4.1	61.2	Brick red	Dry	Solid	1.09±0.3
	ME	5.1	64.2	Brick red	sticky	Semi-solid	2.01±0.1
	AQ	9.0	100	Brownish red	sticky	Solid	1.1±0.22
Potato	PET	0.0	0.0	Ivory brown	Dry	Solid	0.34±0.6
	CH	4.1	4.1	Tortilla brown	Dry	Solid	0.67±0.4
	ME	5.1	5.1	Ivory brown	Sticky	Semi- solid	3.2±1.1
	AQ	9.0	9.0	Dark brown	Dry	Semi- solid	4.08±1.9

Note: PET: Petroleum ether, CH: Chloroform, ME: Methanol, AQ: Aqueous

Antioxidant potential of vegetable peels

DPPH scavenging assay

DPPH assay measured the antioxidant potential of plant extracts which reduces the DPPH free radicals to hydrazine with the change of violet colour to yellow colour and reduction in absorbance at 517 nm in a concentration dependent manner (Hossen *et al*., 2021; Chaudhary and Janmeda, 2022). The inhibitory concentration of different extracts like PET extract, CH extract, ME extract and AQ extracts of cabbage (CB), cauliflower (CA), pea (PE), carrot (CT) and potato (PT) is listed in Table 8. The IC_{50} values of DPPH assay was in the following order: CAAQ>ST>PTAQ>CBAQ> CTAQ> PEME>PEAQ> CBME>CACH>CBPET> CTME> PTME>PECH>PTCH>CAPET>PTPET>PEPET>CAC H>CBCH>CTCH. Among all extracts, CH extract of CT has shown the highest IC_{50} value whereas the AQ extract of CA has shown the low value of IC_{50} in comparison to standard, suggested the higher antioxidant activity of the extract. Kalpna *et al*. (2011) reported the IC_{50} value of 200 µg/ml and 380 µg/ml from the acetone and methanol extract of *Solanum tuberosum* whereas Biswas *et al*. (2021) reported the

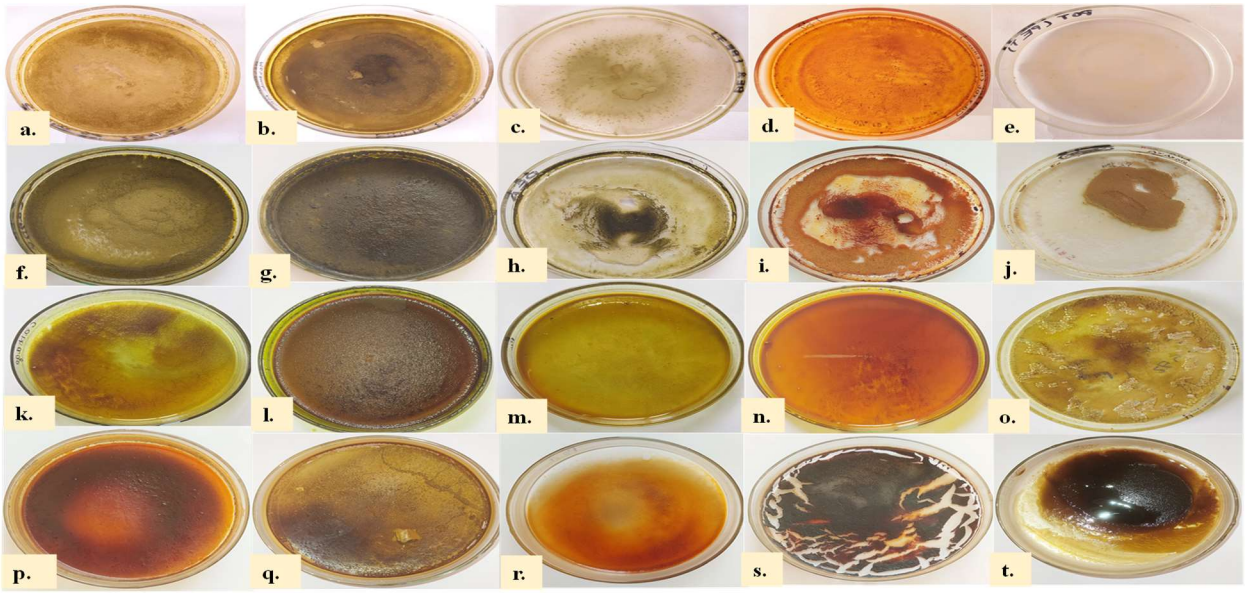

Figure 7: Sequential extracts of different vegetable peels. (a.-e.) petroleum ether extract, (f.-j.) chloroform extract, (k.-o.) methanol extract, (p.-t.). Aqueous extract of cabbage, cauliflower, pea, carrot, and potato.

Table 4: Fluorescence characteristics of cabbage, cauliflower and pea peels

Reagents used	Cabbage			Cauliflower			Pea		
	Visible	High UV (366 nm)	Low UV (254 nm)	Visible	High UV (366 nm)	Low UV (254 nm)	Visible	High UV (366 nm)	Low UV (254 nm)
HCl	Light green	Purple	Dark army green	Reddish brown	Purple	Dark army green	Reddish brown	Purple	Dark army green
H_2SO_4	Light green	Purple	Light green	Brown	Black	Light green	Brown	Black	Light green
HNO_3	Light green	Purple	Light green	Black	Violet	Light green	Black	Violet	Light green
Picric acid	Light green	Purple	Green	Light green	Light brown	Green	Light green	Light brown	Green
Ethyl acetate	Light green	Purple	Dark green	Charcoal black	Black	Dark green	Charcoal black	Black	Dark green
Glacial acetic acid	Light green	Purple	Dark brown	Light green	Brown	Dark brown	Light green	Brown	Dark brown
Methanol	Light green	Purple	Dark green	Light green	Purple	Dark green	Light green	Purple	Dark green
Chloroform	Light brown	Purple	Dark green	Light brown	Purple	Dark green	Light brown	Purple	Dark green
Water	Light brown	Purple	Army green	Reddish orange	Purple	Army green	Reddish orange	Purple	Army green
Benzene	Dark brown	Purple	Dark black	Dark brown	Black	Dark black	Dark brown	Black	Dark black
NaOH	Light green	Purple	Dark green	Reddish yellow	Brown	Dark green	Reddish yellow	Brown	Dark green
$FeCl_3$	Lighr green	Purple	Dark green	Lighr green	Purple	Dark green	Lighr green	Purple	Dark green
NH_4OH	Light green	Purple	Dark green	Light green	Purple	Dark green	Light green	Purple	Dark green
Iodine	Light green	Purple	Dark green	Light green	Purple	Dark green	Light green	Purple	Dark green
Powder	Brown	Purple	Greenish brown	Reddish brown	Purple	Greenish brown	Reddish brown	Purple	Greenish brown

Table 5: Fluorescence characteristics of peels of carrot and potato

Reagents used	Carrot			Potato		
	Visible	High UV (366 nm)	Low UV (254 nm)	Visible	High UV (366 nm)	Low UV (254 nm)
HCl	Dark brick red	Purple	Blackish brown	Dark brick red	Fluorescent purple	Blackish brown
H_2SO_4	Dark brick red	Dark purple	Blackish brown	Dark brick red	Dark purple	Blackish brown
HNO_3	Brown red	Dark purple	Blackish brown	Brown red	Dark purple	Blackish brown
Picric acid	Brown red	Dark purple	Dark brown	Brown red	Dark purple	Dark brown
Ethyl acetate	Brown red	Purple	dark green	Brown red	Purple	Fluorescent dark green
Glacial acetic acid	Brown red	Purple	Dark green	Brown red	Purple	Dark green
Methanol	Brick red	Purple	Dark brown	Brick red	Purple	Dark brown
Chloroform	Brick red	Purple	Dark brown	Brick red	Purple	Dark brown
Water	Reddish brown	Purple	Blackish brown	Reddish brown	Purple	Blackish brown
Benzene	Reddish brown	Purple	Blackish brown	Reddish brown	Fluorescent purple	Blackish brown
NaOH	Reddish brown	Purple	Blackish brown	Reddish brown	Fluorescent purple	Blackish brown
$FeCl_3$	Green	Purple	Green	Fluorescent green	Fluorescent green	Fluorescent green
NH_4OH	Light brown	Purple	Green	brown	Cream	Green
Iodine	Light brown	Purple	Green	Light brown	Fluorescent purple	Green
Powder	Light brown	Purple	Green	Light brown	Fluorescent purple	Ivory

Table 6: Phytochemical screening of cabbage, cauliflower and pea

S.No	Test	Cabbage				Cauliflower				Pea			
		PET	CH	ME	AQ	PET	CH	ME	AQ	PET	CH	ME	AQ
Proteins													
1.	**Millon's test**	-	-	-	+	-	-	-	-	-	-	-	+
2.	**Sulphur containing protein**	-	-	-	+	-	-	-	++	-	-	-	++
Carbohydrates													
3.	**Fehling's test**	-	-	+	+	-	-	+	-	-	-	-	+
4.	**Benedict's test**	-	-	+	+	-	+++	-	-	-	-	+	-
Fats and oil													
5.	**Filter paper test**	-	-	-	-	-	-	++	-	-	-	-	+
Alkaloids													
6.	**Mayer's test**	-	-	-	-	-	-	-	-	-	-	-	+
7.	**Tannic acid test**	+	-	+	+	_	-	+	+	-	-	+	+
Flavonoids													
8.	**Sulphuric acid test**	++	+	-	+	-	-	-	+	-	+	-	-
9.	**Alkaline reagent test**	+	-	++	++	-	-	++	++	-	+	++	++
Phenol and tannins													
10.	**Ferric chloride test**	-	-	-	-	-	-	+	+	-	-	+	-
11.	**Nitric acid test**	-	-	-	+	-	-	-	+	-	-	+	+
Cardiac glycosides													
12.	**Legal's test**	-	-	+	++	-	-	+	+	-	-	++	++
13.	**Keller-killiani test**	+	++	+	++	+	+	-	+	++	+	++	++
Steroids													
14.	**Salkowski test**	-	-	-	-	-	-	-	-	-	-	-	+
Saponin													
15.	**Foam test**	-	-	-	-	++	-	-	-	-	-	-	+
16.	**Olive oil test**	-	-	-	-	+	-	+	-	-	-	+	-

Terpenoids													
17.	**Salkowski test**	++	++	-	-	++	++	-	-	++	+	-	+
Anthocyanins													
18.	**Hydrochloric acid test**	+	++	-	++	++	+	+	+	++	+	+	+

PET: Petroleum ether, CH: chloroform, ME: Methanol, AQ: aqueous

Table 7: Phytochemical analysis of carrot and potato

S.No.	Test	Carrot				Potato			
		PET	CH	ME	AQ	PET	CH	ME	AQ
Proteins									
1.	**Millon's test**	++	-	+	+	-	-	-	++
2.	**Sulphur containing protein**	-	++	-	+	++	+	-	-
Carbohydrate									
3.	**Fehling's test**	-	+	-	-	-	-	-	-
4.	**Benedict's test**	-	-	+++	+	-	-	++	++
Fats and oil									
5.	**Filter paper test**	-	-	-	-	-	-	-	-
Alkaloids									
6.	**Mayer's test**	+	+	++	+	-	-	-	-
7.	**Tannic acid test**	+	+	++	++	+	+	+	+
Flavonoids									
8.	**Sulphuric acid test**	-	-	-	-	-	-	-	-
9.	**Alkaline reagent test**	-	-	+	++	++	++	++	++
Phenol and tannins									
10.	**Ferric chloride test**	-	-	+	+	-	-	-	-
11.	**Nitric acid test**	-	-	+	+	-	-	-	+
Cardiac glycosides									
12.	**Legal's test**	-	-	+	+++	-	-	++	+
13.	**Keller-killiani test**	+	+	-	-	+	_	_	_
Steroids									
14.	**Salkowski test**	-	-	+	+	-	-	-	-
Saponin									
15.	**Foam test**	-	-	+	+	+	+	-	-
16.	**Olive oil test**	+	-	-	+	++	+	-	-
Terpenoids									
17.	**Salkowski test**	+	+	+	+	+	+	-	-
Anthocyanins									
18.	**Hydrochloric acid test**	++	-	+	+	_	++	-	++

PET: Petroleum ether, CH: chloroform, ME: Methanol, AQ: aqueous

Table 8: IC_{50} values of DPPH, FRAP, and TAC assay of different vegetable peel extracts

Different vegetable peel samples	DPPH Values (µg/ml)					FRAP Values (µMFe(II)/g)					TAC Values (µg/ml)				
	PET	CH	ME	AQ	ST	PET	CH	ME	AQ	ST	PET	CH	ME	AQ	ST
Cabbage	49.28	85.76	43.31	29.28	26.7	44.2	51.2	52.2	42.2	30.8	78.9	75.8	36.2	34.3	28.3
Cauliflower	69.792	84.69	46.29	24.82	26.7	50.22	43.22	41.2	39.22	30.8	74.8	58.2	24.4	31.2	28.3
Pea	80.312	61.11	31.87	34	26.7	61.2	89.34	48.3	41.2	30.8	59.2	87.32	49.3	35.9	28.3
Carrot	62.35	92.75	51.6	31.23	26.7	58.2	62.5	49.2	48.7	30.8	68.5	81.8	55.9	35	28.3
Potato	79.1	64.2	56.11	28.3	26.7	71.22	42.33	45.2	44.22	30.8	94	91.3	36.66	35	28.3

Note: ST: standard, PET: petroleum ether, CH: chloroform, ME: methanol, AQ: aqueous

Table 9: TLC analysis of methanolic extract of cabbage and cauliflower

Vegetable peel samples	Solvent	Ratio	No. of spots	No. of spots	No. of spots	Total Spots	RF Value
			Visible	I.C	UV		
Cabbage	M:n-H:EA	1:3:1	2	3	2	3	0.38, 0.56, 0.81
Cabbage	C:M	8:2	1	2	2	2	0.12, 0.56
Cabbage	DCM:M	8:2	1	2	2	2	0.66, 0.79
Cauliflower	C:M	8:2	0	2	2	2	0.51, 0.53
Cauliflower	DCM:M	8:2	0	3	3	3	0.88, 0.34, 0.65
Cauliflower	M:n-H:EA	1:3:1	0	0	0	0	0

M: methanol, nH: n-Hexane, EA: ethyl acetate, I.C: iodine chamber, and UV: ultraviolet

DPPH radical scavenging activity of 13.34 ± 0.11 mg AAE/g DW from the peel of *Solanum tuberosum*. The IC_{50} value of methanol and acetone extract was found to be 859 µg/µL and 76 µg/µL in the case of carrot peel (John *et al*., 2017).

FRAP assay

FRAP assay is based on the reduction capability of an antioxidants to reduce ferric ion into ferrous (Chaudhary and Janmeda, 2022). Results of FRAP activity of different extracts of all five vegetable peels are shown in Table 8 and Figure 9. The reducing power of the sample was found to be in the following order: ST>CAAQ>CAME>PEAQ>CBAQ>PTCH>CACH>CBPET>PTAQ>PTME>PEME>CTAQ>CTME>CAPET>CBCH>CBME>CTPET>PEPET>CTCH>PTPET>PECH. Among all extracts, the AQ and ME extract of CA showed the better antioxidant activity than the other solvent system but it was lower than the standard BHT.

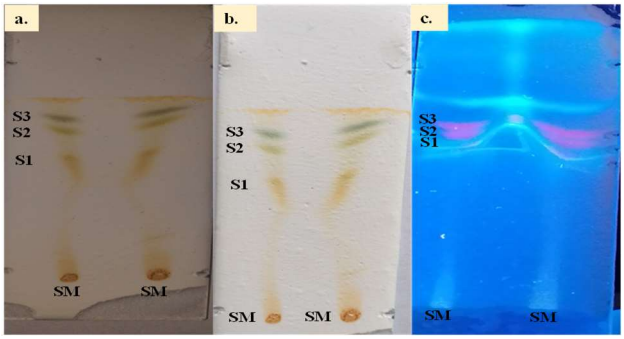

Figure 8: Thin layer chromatogram of ME extract of cabbage peel. Solvent system: methanol: n Hexane: ethyl acetate (1:3:1), a. visible, b. iodine chamber, c. ultraviolet. SM: sample.

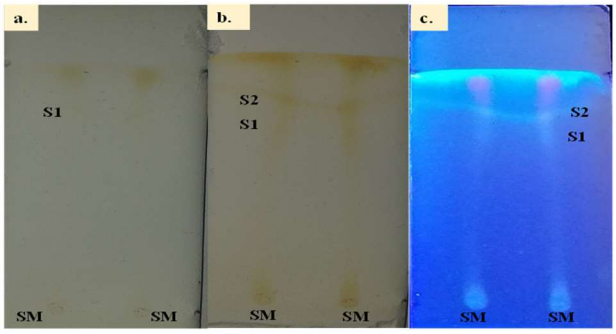

Figure 10: Thin layer chromatography of ME extract of cabbage peel. Solvent system: Dichloromethane : Methanol (8:2), a. visible, b. iodine chamber, c. ultraviolet. SM: sample.

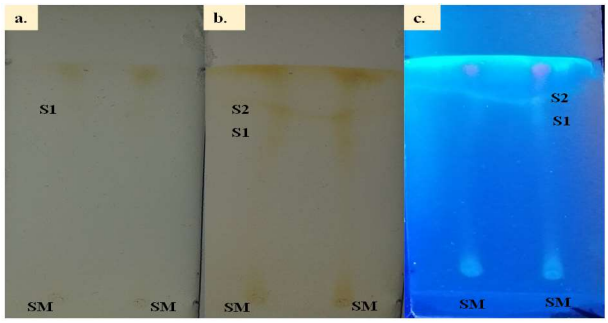

Figure 9: Thin layer chromatography of ME extract of cabbage peel. Solvent system: Chloroform: Methanol (8:2), a. visible, b. iodine chamber, c. ultraviolet. SM: sample.

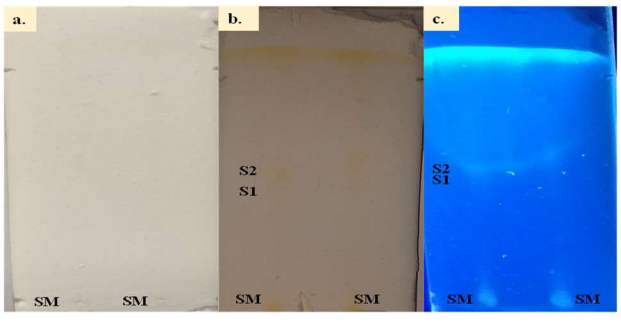

Figure 11: Thin layer chromatography of ME extract of cauliflower peel. Solvent system: Chloroform: Methanol (8:2), a. visible, b. iodine chamber, c. ultraviolet. SM: sample.

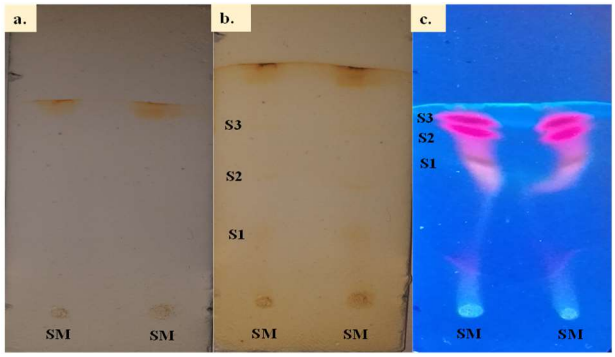

Figure 12: Thin layer chromatography of ME extract of cauliflower peel. Solvent system: Dichloromethane: Methanol (8:2), a. visible, b. iodine chamber, c. ultraviolet. SM: sample.

Nguyen *et al*. (2016) reported the reducing power of hexane, water, ethanol, and methanol extracts of a carrot peel and it was found to be 0.31, 4.82, 8.88, and 15.31 mg TE/g dry weight. FRAP assay revealed the 18.61 mmol/100g of antioxidant activity in case of potato peels extract (Rowayshed *et al.,* 2015). Though antioxidant activity of vegetables is influenced by geographical area, cultivar, harvest and storage time but variability can be seen in content between fresh vegetables and its by-products. The by-products of cabbage and cauliflower contain 20 and 15 times more reducing ability than the peels of potato and pea i.e., 20 ± 0.22 mM. Similarly, the peels of carrot have 5-30 times higher antioxidant potential and higher reducing ability than their edible parts (John *et al.,* 2017).

TAC Assay

TAC assay is based on the antioxidant activity of plant extract on the reduction of Mo(VI) to Mo(V) and subsequent generation of green coloured complexes of phosphate/Mo(V) at acidic pH. Results of TAC activity of different extracts of all five vegetable peels was found to be in the following order: CAME>ST>CAAQ>CBAQ> CTAQ>PTAQ>PEAQ>CBME>PTME>PEME>CTME> CACH>PEPET>CTPET>CAPET>CBCH>CBPET>CA CH>PECH>PTCH>PTPET (Table 8 and Figure 10). Among all extracts, the IC_{50} value of AQ extract of CA and CB was found to be low which indicated the higher antioxidant activity of this extract in comparison to standard.

Thin layer chromatography

The observations from thin layer chromatography analysis of methanolic extract of cabbage and cauliflower are listed in Table 9. TLC of methanolic extract of cabbage revealed the presence of 3 compounds with R_f values of 0.38, 0.56, and 0.81 respectively in a solvent phase of Methanol: n-Hexane: Ethyl acetate (1:3:1) as shown in Figure 8. In another solvent system i.e., Chloroform: Methanol (8:2), and Dichloromethane: Methanol (8:2), two spots were observed with R_f value of 0.12, 0.56, 0.66, and 0.79 respectively (Figure 9 and 10).TLC of methanolic extract of cauliflower revealed the presence of 2 spots of R_f value 0.51, and 0.53 (Figure 11) in solvent phase of Chloroform: Methanol (8:2). Three spots with R_f value of 0.34, 0.65, and 0.88 were observed in a solvent system of Dichloromethane: Methanol (8:2) as shown in Figure 12. and no spot was observed in the case of Methanol: n-Hexane: Methanol (1:3:1) respectively. These R_f values provide valuable information regarding the isolation of these phytochemicals in the isolation process by using an appropriate solvent system for further pharmacological applications.

Conclusion

In the present work, different pharmacognostical standardization parameters and antioxidant assays were applied to determine the quality, safety, and antioxidant potential of the five different vegetable peels. The results obtained from the present study would be useful in determining the crude extract of different peels as a potent source of antioxidants. These are economic and natural sources of antioxidants that can be utilized for the prevention of different human ailments. TLC profiling of phytochemicals showed the good separation and on the sensitivity. However, further studies are needed on isolation, identification, and characterization of specific phytocompound before it can be utilized as a novel source of antioxidant. This opens the scope for the future application of vegetable waste for different therapeutic purposes.

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Conflict of interest

The authors declare that they have no conflict of interest.

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