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Original Article

Effect of Solvent Polarity and Extraction Method on Phytochemical Composition and Antioxidant Potential of Corn Silk

Haq Nawaz[1*], Momna Aslam[1], Sidra Tul Muntaha[2]

ABSTRACT

Objectives: Corn silk is an underutilized part of corn which possesses great medicinal importance. The present study was planned to determine the phytochemical composition and antioxidant potential of corn silk extracts, obtained by different extraction methods using a series of solvents with increasing polarity. **Methods:** Three extraction methods 1) individual extraction in each solvent, 2) consecutive extraction in solvents of increasing polarity and 3) consecutive extraction of crude methanolic extract in solvents of increasing polarity and a series of five solvents with increasing polarity were used for extraction of phytochemicals. The extracts were analyzed for phytochemical composition and antioxidant potential. **Results:** Corn silk was found to contain a variety of bioactive phytochemical compounds including phenolic acids, flavonoids, ascorbic acid, tannins and cardiac glycosides. The corn silk phytochemicals were extracted more in high polarity solvents which showed comparatively good phytochemical composition and strong antioxidants potential. Regression analysis of experimental data showed a polarity dependent increase in extraction yield and phytochemical content and free radical scavenging capacity of extracts obtained by various extraction methods. **Conclusion:** The water extract obtained by individual extraction showed a comparatively high extraction yield and phytochemical content while that obtained by consecutive extraction of crude methanolic extract showed high ability to scavenge free radicals. The study advocates the corn silk as a good source of antioxidant phytochemicals and suggests the use of polar solvents and individual extraction method for extraction of corn silk phytochemicals.

Key words: Antioxidant potential, Corn silk, Extraction methods, Free radical scavenging capacity, Phytochemical composition, Solvent polarity.

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INTRODUCTION

The corn generally called as maize and botanically known as *Zia mays* L., is an important source of nutrition for human and animals throughout the world. Corn seeds play a significant role to overcome the malnutrition problem along with other well-known cereals. Corn silk, a coproduct of corn, is usually discarded as waste due to unawareness about its potential benefits. Corn silk has been traditionally used as an ingredient of tea for the treatment of various diseases. It is a good source of nutritional components including protein, carbohydrates, dietary fiber, vitamins and minerals. It contains a very low amount of crude fat which make it suitable for the preparation of fat free food formulations.[1–3]

Corn silk possesses high medicinal value due to the presence of diverse bioactive phytochemical compounds. It has been found to contain phenolic compounds, polyphenols, flavonoids, anthocyanins, carotenoids and vitamins of biological importance. Due to the presence of these phytochemical constituents, corn silk shows diversity in its biological activities which highlight its pharmaceutical importance. It has been found to show antioxidant, antimutagenic, antiproliferative, antidiabetic, antibacterial, antifungal, antihyperlipidimic, anti-inflammatory, antihyperglycemic, antidepressant, antihypertensive, antihyperlipidemic, antiadipogenic and anti-fatigue activities.[4–9] It has been also found to act as hepatoprotective, neuroprotective, diuretic and uricosuric.[10,11] Corn silk has been found to be non-toxic to human and can be used as a preferable ingredient in medicinal health promoting remedies.[12,13]

The complete extraction of the bioactive phytochemical compounds of different nature from plant material has ever remained a problem for researchers and manufacturers. Due to the diversity in the nature of phytochemical compounds, it is very difficult and uncertain to extract all the phytochemicals using a single extracting solvent or extraction method. The polar components are extracted in polar solvents while

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nonpolar ones are extracted in nonpolar solvents. Similarly, the extraction yield is also different while using different extraction methods such as individual extraction or consecutive extraction in a series of varying polarity solvents. Previously, various solvents such as water, acetone, alcohols, ethyl acetate and hexane have been used individually for the extraction of phytochemicals from corn silk.[7,14–18] The results were found to be different for different extracts which is confusing for the researchers and the students. It is, therefore, necessary to find out the best solvent system and extraction method for the extraction of phytochemicals from plant materials for research and pharmaceutical application.

The present study was planned to study the effect of solvent polarity and extraction method on extraction yield and free radical scavenging capacities of phytochemicals from corn silk. The study design included three extraction methods and a series of five extracting solvents increasing polarity. The study provides valuable data regarding the best extraction parameters to achieve high extraction yield of phytochemicals with good antioxidant properties. The study also highlights the pharmaceutical and medicinal value of corn silk obtained from the agricultural fields of Pakistan.

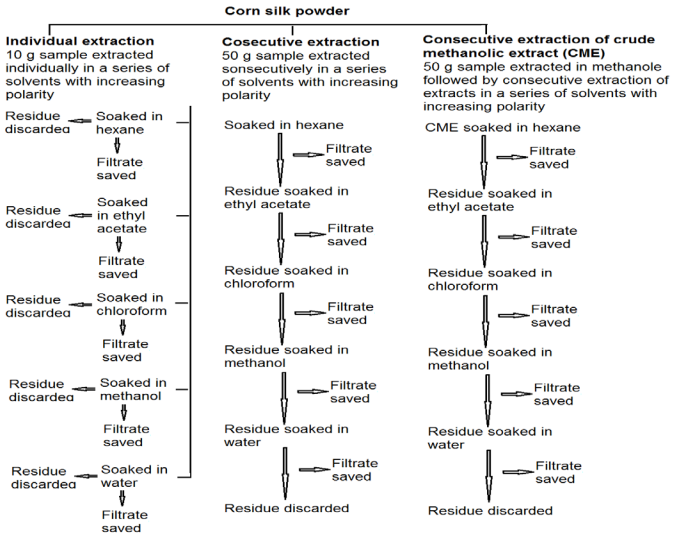

Figure 1: Scheme of experimental design.

MATERIALS AND METHODS

Sampling

The corn silk was collected from the corn fields (Crop season: Spring/Autumn2013, Variety: P.1543: Cultivation area: Chak No.1 Makhdoom Rashid) District Multan, Punjab, Pakistan. The corn silk was cleaned from dust and dried under shade at room temperature (25±5°C) until a constant weight and minimum moisture content (2±0.5%). The dried silk was grinded by pestle and mortar and sieved through a 100-mesh sieve to obtain a fine powder with a particle size <150 µm. The powdered sample was stored in air tight glass containers in sterile, thermally controlled and sunlight protected standard laboratory environment during the whole period of study.

Experimental design for extraction of phytochemicals

The corn silk powder (10 g) was extracted by three extraction methods including 1) individual extraction (IE), 2) consecutive extraction (CE) and 3) consecutive extraction of crude methanolic extraction (CECME). A series of 5 solvents with increasing polarity order in terms of their dipole moments (hexane: 0.0, ethyl acetate: 2.8, chloroform: 4.1, methanol: 5.1 and water: 9.2 D) was used for extraction by each method (Figure 1). The extracts were filtered with Whattman filter paper No. 42 and evaporated to dryness at 25±5°C. The percentage yield of each extract was calculated in terms of total extractable component (TEC):

$$\text{TEC}\,(\%) = \left(\frac{\text{Weight of extract}}{\text{Weight of sample}}\right) \times 100$$

The extracts were stored in air tight containers for phytochemical and antioxidant analysis

Phytochemical analysis

Phytochemical screening

The extracts were dissolved in methanol (solid-solvent ratio 1:100) and subjected to phytochemical screening tests using standard procedures (Edeoga, Okwu and Mbaebie, 2005; Idu, Obayagbona, Oshomoh and Erhabor, 2014; Tadhani and Subhash, 2006).

Total phenolic content

Total phenolic content (TPC) was determined as gram gallic acid equivalent/100 g dw. using previously described Folin-Ciocalteu method.[19] TPC was calculated from the regression equation (TPC = Abs. at 760nm/10.84) obtained from the standard curve (R^2= 0.992) of gallic acid.

Total flavonoid content

Total flavonoid content (TFC) was determined following the previously described method[20] with some modification. The extract (1 ml) was mixed with 30% ethanol (4 ml) and 5% $NaNO_2$ (0.3 ml). The reaction mixture was allowed to stand at room temperature (25±5°C) for 5 min followed by the addition of 10% $AlCl_3$ (2 ml), 4% NaOH solution (4 ml) and 30% ethanol 0.4 ml. After standing for 12 min, the absorbance of the mixture was recorded at 510 nm against a blank (reaction mixture without sample) using UV/Visible spectrophotometer (Jenvay-6405). TFC was calculated as g catechin equivalent/100g dw. using the regression equation obtained by the calibration curve of catechin (R^2= 0.986).

Total tannins content

Total tannins content (TTC) was determined by vanillin-HCl assay reported earlier.[21] TTC was calculated as g catechin equivalent/100g dw. using the regression equation obtained from a standard curve of catechin (R^2 = 0.988).

Ascorbic acid content

Ascorbic acid content (AAC) was determined by the previously described method using dichlorophenol indphenol as active reagent.[22] AAC was calculated as g/100 g dw.

Free radical scavenging capacity

Free radical scavenging capacity of extracts was determined against three different types of free radicals including 2, 2-diphenyl-1-picryl-hydrazyl (DPPH), azinobistetrazolium sulfate cation ($ABTS^+$) and hydroxyl radicals.

DPPH radical scavenging capacity

DPPH radical scavenging capacity (DPPH RSC) was determined by previously reported method.[23,24] The extract (1 ml) was mixed with 40µM DPPH solution (3ml) prepared in methanol and mixture was kept in dark for 30 min. The DPPH solution was taken as control. The absorbance was recorded at 517 nm and DPPH RSC was calculated as:

$$\text{DPPH RSC}(\%) = [(\text{Abs}_{\text{control}} - \text{Abs}_{\text{sample}}) / \text{Abs}_{\text{control}}] \times 100$$

ABTS radical scavenging capacity

2,2-azino-bis-tetrazolium sulphate cation radical scavenging capacity ($ABTS^+$ RSC) was estimated by the method described earlier.[25] Equal volumes of 7mM ABTS and 2.5mM potassium persulphate were mixed and kept in dark for 16 h. The reagent was diluted with 80% ethanol until its absorbance reached 0.7±0.05 at 734 nm. The extract (2 ml) was mixed with the prepared reagent (2 ml) and allowed to stand for six min. The mixture without sample was used as a control. The absorbance was recorded at 734 nm against a blank (without ABTS) and ABTS+ radical scavenging activity was calculated as:

$$\text{ABTS RSC (\%)} = [(\text{Abssample} - \text{Absblank})/\text{Abscontrol}] \times 100$$

Hydroxyl radical scavenging capacity

Hydroxyl radical scavenging capacity (HRSC) was determined by the method reported earlier[26] with some modifications. The extract (1 ml) was mixed with 9mM $FeSO_4$ solution (1 ml) and 9mM salicylic acid in 95% ethanol (1 ml). The reaction was initiated by adding 0.8mM H_2O_2 (1 ml) and the reaction mixture was allowed to stand for 30 min at 37°C in dark. The mixture without sample was used as a control and that without H_2O_2 as blank. The absorbance was recorded at 510 nm and HRSC was calculated as:

$$\text{HRSC (\%)} = [1 - \{(\text{Abs}_{\text{sample}} - \text{Abs}_{\text{blank}}) / \text{Abs}_{\text{control}}\}] \times 100$$

Standard solution of Butylated hydroxy toluene (BHT) was used for comparison.

Statistical analysis

The results were expressed as mean values ± standard deviation of three parallel replicates. The means were separated by one way analysis of variance (ANOVA) at confidence level $p \leq 0.05$ using Tukey's multiple range tests. The effect of solvent polarity was analyzed by regression analysis of experimental data.

RESULTS

Total extractable components

The results for total extractable components (TEC) of different extracts of corn silk are presented in Table 2. TEC of corn silk (g/100g dw) in solvents of varying polarity by different extraction methods ranged from 0.21±0.025 to 30.8±3.01 g/100 g dw. One-way analysis variance of the data showed a statistically significant difference ($p<0.05$) in TEC among extracts in various solvents. Water extract obtained from both IE and CE methods was found to be comparatively high in TEC while hexane extract obtained from each of the extraction methods was found to be low in TEC.

Phytochemical screening

Phytochemical screening of corn silk extract confirmed the presence of phenolic acids, flavonoids, ascorbic acid, tannins and cardiac glycosides (Table 1).

Phytochemical content

Total phenolic content (TPC), Total flavonoid content (TFC), total tannins content (TTC) and ascorbic acid content (AAC) of corn silk extracts obtained by various extraction methods ranged from 0.11±0.02 to 2.34±0.3, 0.03±0.005 to 1.65±0.12, 0.031±0.013 to 2.276±0.12 and 0.008±0.001 to 0.164±0.017 g/100 g dw respectively (Table 2). The phytochemical content of corn silk extracts in various solvents was found to be statistically different ($p<0.05$). Water extract obtained by IE was found to be comparatively high in TPC, TFC, TTC and AAC. The IE method showed comparatively higher extraction yield of each phytochemical in each solvent with some exceptions. However, the extracts in nonpolar solvents including hexane, ethyl acetate and chloroform obtained from each extraction method were found to be low in phytochemical content as compared to those in polar solvents.

Free radical scavenging capacity

DPPH RSC, $ABTS^+$ RSC and HRSC of corn silk extracts obtained by various methods were found to be in the range of 46.72±2-98±60, 5.3±0.5-86±6.03 and 10.2±0.5-95.8±6.5% respectively (Table 2). The scavenging capacity of corn silk extracts against each of the three radicals tested was found to be statistically different ($p<0.05$). The water extract obtained by CECME was found to be the best free radical scavenger among other extracts against DPPH (98±6.0%), ABTS (86±6.03%) and OH (95.8±6.5%) radicals. The hexane extract obtained by CE was found to possess comparatively poor scavenging capacity against each of the tested radical.

DISCUSSION

Phytochemicals are the naturally occurring bioactive compounds synthesized in plants. These are the non-nutritional or anti-nutritional compounds which have great medicinal and pharmaceutical significance. These compounds possess certain biological activities such as antimicrobial, anti-inflammatory, anticancer, cardio-protective and hepato-protective activities. Most of these phytochemicals act as antioxidants due to their hydrogen donating and reducing abilities. The antioxidants are known as free radical scavengers which terminate the free radical chain reactions, prevent oxidative stress and reduce the risk of cancer, cardiovascular damage and other associated diseases. The plants rich in antioxidant phytochemicals have good pharmaceutical and medicinal significance. The corn seeds and silk have both the nutritional and medicinal significance due to the presence of valuable nutrients and bioactive phytochemicals.

In the present study, the phytochemical composition and antioxidant profile in terms of free radical scavenging capacity of corn silk extracts obtained by various extraction methods using various solvents were studied. The initial round of the study was based on the selection of suitable extraction method and solvent to achieve maximum yield of the extracts. The regression analysis of the data showed an exponential increase in TEC (R^2 = 0.4816-0.9094) in response to an increase in the polarity of the extracting solvent following each of the extraction method (Figure 2). Comparatively higher TEC was observed in water extracts followed by methanolic extract obtained by individual extraction

Table 1: Phytochemicals screening of corn silk extracts obtained by different extraction methods.

Phytochemicals	Extraction method		
	*IE	CE	CECME
Tannins	+	+	+
Cardiac glycosides	+	+	+
Phenolic acid	+	+	+
Flavonoids	+	+	+
Ascorbic acid	+	+	+
Saponins	-	-	-

*+: Present, -: Absent; IE: Individual extraction, CE: Consecutive extraction, CECME: Consecutive extraction of crude methanolic extract.

Table 2: Experimental values of phytochemical composition and free radical scavenging activities of corn silk extracts.

	Solvent polarity (D)					*p*-value
	0	2.8	4.1	5.1	9	
			***TEC (g/100 g dw)**			
IE	0.44±0.022^{d}	1.4±0.20^{d}	4.8±0.50^{c}	15.2±2.10^{b}	30.8±3.01^{a}	0.000
CE	0.4±0.03^{c}	0.5±0.01^{c}	3.4±0.09^{c}	9.5±1.2^{b}	14.8±2.42^{a}	0.000
CECME	0.36±0.03^{c}	0.21±0.025^{c}	1.73±0.32^{b}	4.83±0.8^{a}	2.44±0.95^{b}	0.000
			TPC (g/100 g dw)			
IE	0.13±0.02^{d}	0.21±0.025^{d}	0.81±0.12^{c}	1.46±0.18^{b}	2.34±0.3^{a}	0.000
CE	0.16±0.03^{b}	0.11±0.02^{b}	0.22±0.04^{b}	0.81±0.13^{a}	0.85±0.23^{a}	0.000
CECME	0.17±0.02^{cd}	0.35±0.026^{a}	0.12±0.01^{e}	0.3±0.043^{ab}	0.23±0.07^{bc}	0.060
			TFC (g/100 g dw)			
IE	0.06±0.01^{c}	0.08±0.012^{c}	0.16±0.020^{c}	0.73±0.04^{b}	1.65±0.12^{a}	0.000
CE	0.03±0.005^{d}	0.05±0.007^{d}	0.19±0.05^{c}	0.95±0.03^{b}	1.43±0.13^{a}	0.000
CECME	0.12±0.02^{c}	0.22±0.03^{c}	0.43±0.08^{b}	0.65±0.089^{a}	0.67±0.11^{a}	0.000
			TTC (g/100 g dw)			
IE	0.468±0.035^{d}	0.934±0.052^{c}	0.895±0.07^{c}	1.86±0.09^{b}	2.276±0.12^{a}	0.000
CE	0.17±0.012^{b}	0.16±0.011^{bc}	0.216±0.015^{b}	0.076±0.03^{c}	0.369±0.098^{a}	0.034
CECME	0.068±0.01^{ab}	0.031±0.013^{b}	0.113±0.02^{ab}	0.14±0.05^{a}	0.131±0.08^{a}	0.057
			AAC (g/100 g dw)			
IE	0.035±0.002^{c}	0.038±0.004^{c}	0.106±0.01^{b}	0.102±0.015^{b}	0.164±0.017^{a}	0.000
CE	0.008±0.001^{d}	0.008±0.0015^{d}	0.02±0.005^{c}	0.05±0.0025^{b}	0.075±0.012^{a}	0.000
CECME	0.02±0.0023^{c}	0.024±0.004^{c}	0.03±0.0043^{c}	0.08±0.01^{b}	0.14±0.015^{a}	0.000
			DPPH RSC (%)			
IE	64.71±3.42^{c}	85.80±3.91^{b}	87±4.21^{ab}	93.5±5.02^{ab}	95.1±6.2^{a}	0.000
CE	46.73±2.1^{c}	48.72±3.3^{c}	61.7±4.50^{b}	80.4±4.12^{a}	87±7.1^{a}	0.000
CECME	84.1±5.80^{b}	96.3±7.40^{a}	94.8±5.32^{ab}	95.9±4.71^{a}	98±6.0^{a}	0.096
			ABTS+ RSC (%)			
IE	14.3±1.3^{d}	13.9±1^{d}	25.92±2.3^{c}	44±3.8^{b}	61.41±5^{a}	0.000
CE	5.3±0.5^{d}	6.35±0.45^{d}	14.76±1.6^{c}	25.9±2^{b}	33.4±2.9^{a}	0.000
CECME	28±2^{e}	49±3.5^{d}	62±5.8^{c}	72±4.7^{b}	86±6.03^{a}	0.000
			HRSC (%)			
IE	18.4±1.45^{d}	33±2.8^{c}	36±3^{c}	66±6^{b}	87±6.5^{a}	0.000
CE	10.2±0.5^{e}	27.4±2.5^{d}	39±3^{c}	55.2±5.5^{b}	67.3±8^{a}	0.000
CECME	12.8±1.2^{d}	18.5±1.4^{d}	52.5±4.5^{c}	78±6^{b}	95.8±6.5^{a}	0.000

*TEC: Total extractable components, TPC: Total phenolic content, TTC: Total tannins content: TFC: Total flavonoids content, AAC: Ascorbic acid content, DPPPH RSC: 2, 2-diphenyl 1-picrylhydrazyl radical scavenging capacity, ABTS RSC: 2, 2, Azino-bis-tetrazolium sulphate radical scavenging capacity, HRSC: hydroxyl radical scavenging capacity, IE: Individual extraction, CE: Consecutive extraction, CECME: Consecutive extraction of crude methanolic extract, dw: Dry weight.

method. The higher values of TEC in polar solvents and lower in nonpolar solvents suggest that majority of the extractable compounds of corn silk are polar in nature. Among the extraction methods, individual extraction method was found to be the best to achieve maximum extraction yields from corn silk while the consecutive extraction method was found to be the least reliable for the said purpose. It is, therefore, suggested that a combination of polar and nonpolar solvents in suitable proportion using individual extraction method is more favorable to obtain the desirable extraction yield from corn silk instead of using a single solvent or consecutive extraction.

The second round of the study was based on the qualitative and quantitative analysis of phytochemical compounds present in the corn silk extracts obtained by various extraction methods. Phytochemical screening of corn silk extracts confirmed the presence of a variety of bioactive antioxidant phytochemicals. The presence of phenolic acids, flavonoids, polyphenolics and ascorbic acid indicate that corn silk is a good source of antioxidants and may be preferably used for medicinal purpose.

The observed values of TPC, TFC, TTC and AAC in corn silk extracts obtained by different extraction methods make corn silk a good source of antioxidant phytochemicals and a strong candidate for pharmaceutical application. Statistical analysis of the experimental data showed a polarity dependent significant (p<0.05) exponential increase in TPC, TFC and TTC (Figure 3a-c) and linear increase in AAC (Figure 3d) of corn silk extracts obtained by individual extraction method (R^2 = 0.8606-0.8857).

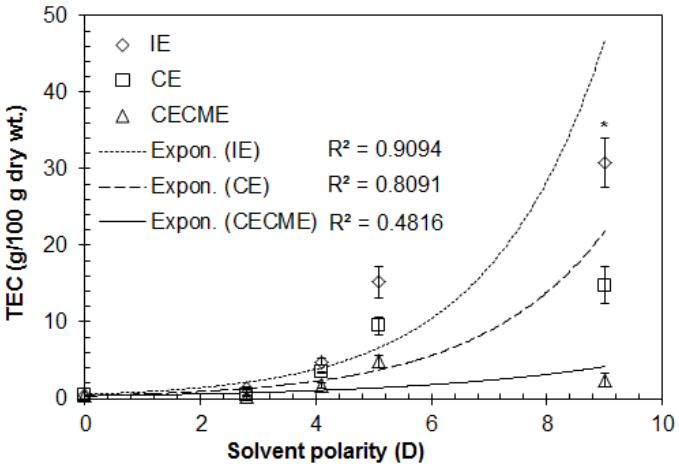

Figure 2: Polarity dependent variation in TEC of corn silk using different extraction methods.
TEC: Total extractable components, IE: Individual extraction, CE: Consecutive extraction, CECME: Consecutive extraction of the crude methanolic extract.
*Error bars on data points show the standard deviation of three parallel replicates of each data point.

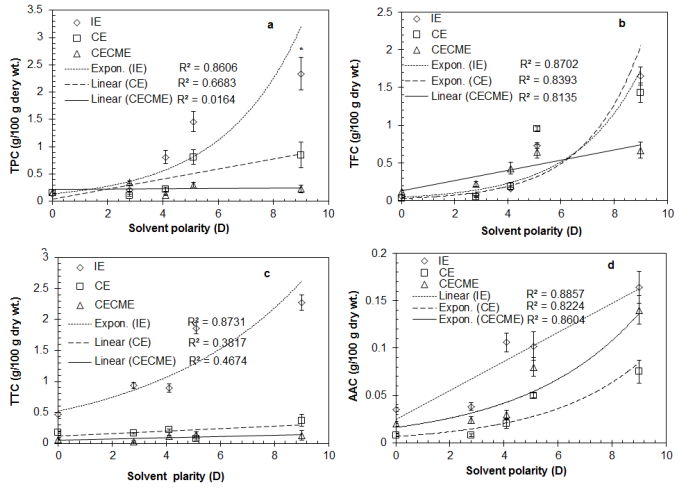

Figure 3: Polarity dependent variation in the phytochemical content of corn silk extracts obtained by different extraction methods.
TPC: Total phenolic content, TTC: Total tannins content, TFC: Total flavonoids content, AAC: Ascorbic acid content, IE: Individual extraction, CE: Consecutive extraction, CECME: Consecutive extraction of crude methanolic extract.
*Error bars on data points show the standard deviation of three parallel replicates of each data point.

The extracts obtained by consecutive extraction showed a polarity dependent significant linear increase in TPC and an exponential increase in TFC and AAC (R^2 = 0.8224-0.8393). However, the variation in TPC and TTC in response to a change in solvent polarity was found to be non-significant in extracts obtained by consecutive extraction of crude methanolic extract (Figure 3a, b). Water extract obtained from each of the extraction methods was found to be comparatively high in the studied phytochemical components. The water extract obtained by individual extraction was found to be the best in antioxidant phytochemicals among those obtained by other extraction methods. The results favor the use of polar solvents in a combination with the slight proportion of nonpolar solvents and individual extraction method for extraction and analysis of corn silk phytochemicals. The present results

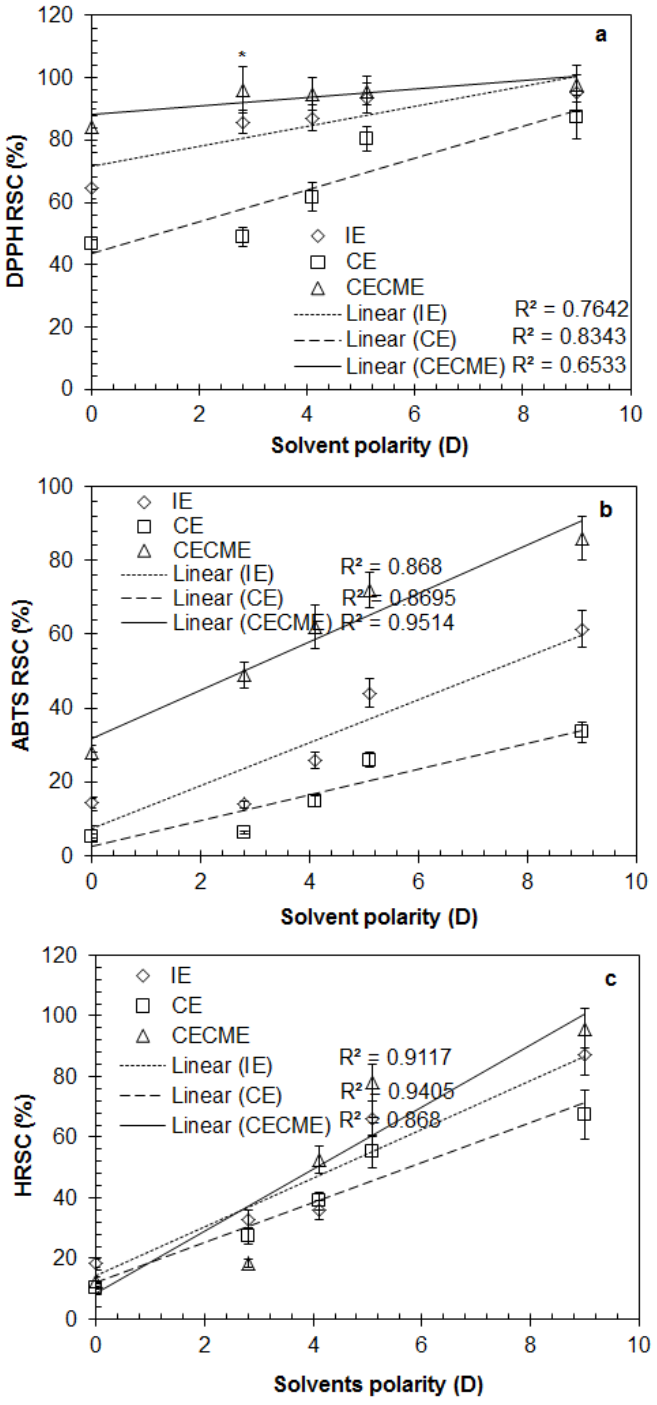

Figure 4: Polarity dependent variation in free radical scavenging capacity of corn silk extracts obtained by different extraction methods.
DPPPH RSC: 2, 2-diphenyl 1-picrylhydrazyl radical scavenging capacity, ABTS RSC: 2, 2, Azino-bis-tetrazolium sulphate radical scavenging capacity, HRSC: hydroxyl radical scavenging capacity, IE: Individual extraction, CE: Consecutive extraction, CECME: Consecutive extraction of the crude methanolic extract.
*Error bars on data points show the standard deviation of three parallel replicates of each data point.

for the phytochemical composition of corn silk extracts were found to be in range as reported earlier [1,15–17,27,28]

The antioxidant potential of corn silk extracts was determined in terms of free radical scavenging capacity against DPPH, ABTS and hydroxyl radicals. A polarity dependent significant linear increase (R^2 = 0.6533-0.9405) was observed in free radical scavenging capacity of corn silk extracts against all the three radicals tested (Figure 4a-c). Water extract obtained by each extraction method showed maximum scavenging capacity against each of the free radicals (DPPH: 87-98%, ABTS: 33-86% and OH: 67-95%). Among the extraction methods, consecutive extraction of the crude methanolic extract was found to be the best to show maximum scavenging of free radicals. Although this extraction method showed low extraction yield and phytochemical content yet it showed comparatively high antioxidant activity indicating the presence of a majority of the strong antioxidant phytochemicals in these extracts. The present results of free radical scavenging capacity of various extracts were found to be comparatively higher than those reported earlier.[15,29]

CONCLUSION

In conclusion, the corn silk was found to contain a variety of bioactive phytochemical compounds in significant concentration. The corn silk phytochemicals were extracted more in high polarity solvents indicating that the majority of phytochemical constituents of corn silk are polar in nature. The phytochemicals extracted in polar solvents were found to be comparatively strong antioxidants with high antiradical capacity. The water extract obtained by individual extraction method showed good extraction yield and phytochemical content while that obtained by consecutive extraction of crude methanolic extract showed high scavenging capacity against free radicals. The study advocates the corn silk as a good source of antioxidant phytochemicals and suggests the use of individual extraction method and polar solvents for the extraction of corn silk phytochemicals.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

ABBREVIATIONS

TEC: Total extractable components; **TPC:** Total phenolic content; **TTC:** Total tannins content; **TFC:** Total flavonoids content; **AAC:** Ascorbic acid content; **DPPPH RSC:** 2, 2-diphenyl 1-picrylhydrazyl radical scavenging capacity; **ABTS RSC:** 2, 2, Azino-bis-tetrazolium sulphate radical scavenging capacity; **HRSC:** Hydroxyl radical scavenging capacity; **IE:** Individual extraction; **CE:** Consecutive extraction; **CECME:** Consecutive extraction of crude methanolic extract.

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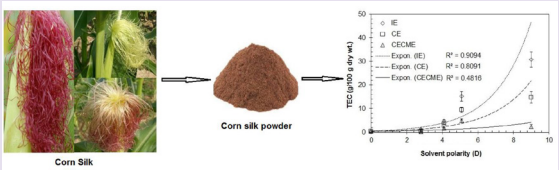
GRAPHICAL ABSTRACT



SUMMARY

- Effect of solvent polarity was found to be significant on the studied parameters.
- A polarity dependent increase in phytochemical content and free radical scavenging capacity was observed.
- The extracts in polar solvents showed higher values of phytochemical components and antioxidant capacity.
- The individual extraction method was found to be more suitable for the extraction of in corn silk phytochemicals.

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