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Total Polyphenols, Flavonoids and Anti-oxidant Activity of Corn Silk (*Stigma maydis*) as Influenced by Drying Condition and Extraction Solvent

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Abstract

Corn silk, the yellowish thread-like strands, is a waste material from corn cultivation. Corn silk bioactive components such as polyphenols and flavonoids provide benefits that can be tapped as potential natural anti-oxidant product for healthcare applications. The study aimed to determine the effect of different drying methods on colour parameters and that of different extraction solvents on total polyphenols, flavonoids and anti-oxidant activity of corn silk. Corn silk samples were either lyophilized or tray-dried at 40 and 60^{0}C. Bioactive compounds from powdered corn silk sample were extracted using 80 per cent ethanol, methanol, water or acetone. Colour analysis revealed that tray drying caused more browning of the sample compared to lyophilizing. Significantly higher ($p < 0.05$) Total phenolic content (TPC) and Total flavonoid content (TFC) were observed in 80 per cent ethanolic extract of lyophilized sample (35.86 ± 0.83 mg GAE and 38.05 ± 0.22 mg RE /g sample) followed by 60^{0}C (20.31 ± 0.19 mg GAE and 20.56 ± 0.32 mg RE /g sample) and 40^{0}C (5.68 ± 0.04 mg GAE and 8.88 ± 0.02 mg RE /g sample) tray dried sample. In line with this, antioxidant activities by DPPH (2,2-diphenyl-1-picryl-hydrazyl), ABTS+(azinobistetrazolium sulfate cation) and FRAP (Ferric ion reducing antioxidant power) models, were also respectively affected by drying methods. TPC, TFC and antioxidant capacity was found to be in decreasing order with the corresponding solvents used: 80 per cent ethanol > methanol > aqueous > acetone. Correlation analysis presented a significantly positive correlation ($p< 0.01$) of anti-oxidant activity with TPC and TFC. The study revealed that lyophilization was the most effective drying method with highest yield of bioactive compounds in 80 per cent ethanol as the solvent. The results provide the evidence required for utilization of corn silk as a potential source of natural antioxidants.

Keywords : Corn silk, Polyphenols, Flavonoids, Colour analysis, DPPH, ABTS, FRAP antioxidants

Healthy individuals exhibit an equilibrium between the natural antioxidative defense system and the reactive oxygen species (ROS), generated from both living organism's internal environment and exogenous sources. Disruption of this equilibrium leads to ROS-induced oxidative damage, contributing to aging and diseases like heart disease, hypertension, cognitive issues and cancer (Halliwell & Gutteridge, 1984). Meanwhile, lipid oxidation, triggered by free radicals, is a key factor in food deterioration during processing and storage (Thitileadecha *et al.*, 2008). Natural antioxidants, particularly plant phenolics and flavonoids, are safe and bioactive (Mohsen and Ammar, 2009). Traditional medicine's benefits often stem from these antioxidants, which counteract radicals and peroxidation (Maksimovic and Kovacevic, 2003). Consequently, interest has grown in exploring plant extract antioxidants for human consumption (Chua *et al.*, 2008). Extracts from phenolic-rich

plants gain traction in the food industry, preserving lipid quality and nutritional value. Studies suggest that diets rich in natural antioxidants like flavonoids and phenolics, abundant in plants, hold promise in preventing oxidative stress-related ailments such as cancer, atherosclerosis, aging and arthritis (Behera *et al.*, 2008; Halliwell, 2007 and Rios *et al.,* 2009).

Corn silk, the yellowish thread like strands from the female flower of maize, is a waste material from corn cultivation and is available in abundance. Corn silk bioactive components such as polyphenols and flavonoids provide many benefits that can be tapped as potential natural products for healthcare applications (Hu *et al.,* 2010). The pharmacological effects of corn silk, such as antioxidant (Liu *et al.,* 2011 and Jia *et al.,* 2020), anti-inflammatory (Wang *et al.,* 2012 and Sarfare *et al.,* 2022), diuretic activities (Velazquez *et al.,* 2005 and Guo *et al.,* 2018), anti-diabetic (Guo *et al*., 2009; Zhao *et al.*, 2012 and Chaudhary *et al.,* 2022), antibacterial activities (Abirami *et al.,* 2021 and Azevedo *et al.,* 2022), antifungal (Nessa *et al.,* 2012 and Morshed & Islam, 2015), antitumor (Yang *et al.,* 2014 and Li *et al.,* 2020) and anti-obesity activities (Chaiittianan *et al.,* 2016 and Oh *et al.,* 2021) have been shown to be attributed to the bioactive compounds it contains.

Drying is a very common preservation method used in foodstuffs and the quality of the final products is strongly dependent on the technique and the process variables used (Doymaz, 2005). Drying has also been reported to cause altered physico-chemical properties and bioactive compound profile of foods (Demirhan and Ozbek, 2010). Hot-air drying is one of the most frequently used operations for food dehydration. A major disadvantage associated with hot-air drying is that the longer duration of drying at high temperature, may cause serious damage to the colour and bioactive compounds in dried products (Sharma and Prasad, 2001). Conventionally dried products are generally of low quality compared to that of their fresh counterparts. Since freeze drying is based on the dehydration by sublimation of a frozen product, it is found to better retain the colour and heat-labile bioactive compounds (Valadez-Carmona *et al.,* 2017). Recovery of antioxidant compounds from plant materials is typically accomplished through different extraction techniques taking into account their chemistry and uneven distribution in the plant matrix. Solvent extraction is the most frequently used technique for isolation of plant antioxidant compounds (Sultana *et al.,* 2009). However, the extract yields, polyphenolic contents and resulting antioxidant activities of the plant materials are strongly dependent on the nature of extracting solvent and method, due to the presence of different antioxidant compounds of varied chemical characteristics and polarities that may or may not be soluble in a particular solvent (Sultana *et al.,* 2009 and Jakopic *et al.,* 2009).

Though phytochemical constituents like total phenolic and flavonoid content and antioxidant activities of corn silk have been reported, little is known about the effect of different drying methods and the solvent used for extraction on the recovery of these compounds. The present study was therefore formulated with an objective to study the effect of different drying methods on total polyphenols, flavonoids and anti-oxidant activity of corn silk extracted using different solvents.

Material and Methods

Collection and Drying of Sample

Silk from the corn variety Syngenta 5414 were harvested in silking stage (7 days after the emergence) and collected from processing unit of Namdhari industries, Bengaluru. Corn silk samples were separated from corn stalks and peels and were then washed with potable water.

The samples were either freeze-dried using VirTis AdVantage Wizard 2.0 benchtop lyophilizer (-40ºC and 96 mTorr) or tray dried at 40 and 60ºC until constant weight was obtained. Dried corn silk samples were ground, sieved through BSS-72 mesh sieve (210 microns) and stored in airtight pouches at -20ºC until further analysis.

Colour Analysis

The colour of powdered corn silk was estimated using reflecting colorimeter (Konica Minolta/CM-5). The

samples were kept in colorimeter cuvettes and readings were taken in triplicates. The instrument was calibrated using a white reference standard tile (Laikhuram and Vijayalaxmi, 2022). The L* value is a measure of lightness/brightness, ranging from 0 (black) to 100 (white). The a* value is a measure of greenness/redness, ranging from-60 (green) to +60 (red) and the b* values is a measure of bluishness/ yellowness, ranging from -60 (blue) to +60 (yellow). The C value, also known as chroma or saturation, represents the purity or intensity of the colour. The H value, also known as hue, represents the dominant wavelength of the colour.

Extraction

The solvents 80 per cent ethanol, methanol, acetone and water were employed to extract the bioactive compounds from corn silk. The powdered sample was suspended in solvents at the ratio of 1:20 (weight/ volume). The suspension in air-tight falcon tubes was subjected to isothermal mixing by an Eppendorf Thermo Mixer at 45°C for 24 hours at 700 rpm. The tubes were then centrifuged at 13000 rpm for 20 min at 15°C. The supernatant was filtered by Whatman paper (no. 1) and the pellet was subjected to second round of extraction, following the same protocol. The filtrate was pooled and evaporated using a vacuum concentrator (Eppendorf) at 40ºC to remove the solvent. The residue was reconstituted with distilled water and vortexed to obtain the required concentration.

Estimation of Total Phenolic Content (TPC)

Total phenolic content was determined by Folin-Ciocalteu (FC) reagent method as described by Harika *et al.* (2017). To 0.1 - 1 mL of sample extract (50 mg/ mL), 0.5 mL of FC reagent and 2 ml of 20 per cent sodium carbonate was added and diluted to 10 mL with distilled water. After 30 min of incubation at room temperature the absorbance against blank was determined at 760 nm. Gallic acid (20, 40, 60, 80 and 100 µg/ mL) was used for the preparation of standard curve and the amount of total phenolic compound in the sample extract was determined from the equation $y = 0.0086x + 0.0804$; $R^2 = 0.9976$. The results were expressed as gallic acid equivalent (GAE)/g of sample.

$$\text{Standard equivalents} = \frac{\text{Value from standard graph} \times \text{total volume of extract obtained (mL)}}{\text{Volume of aliquot (mL)} \times \text{weight of the sample taken for extraction (mg)}} \quad \text{.....(x)}$$

Estimation of Total Flavonoid Content (TFC)

Total flavonoid content was determined by Aluminum Chloride Colorimetric method as described by Thaiwong and Chaiwong (2020). To 0.1-1 mL of sample extract (50 mg/ mL), 1 mL of 10 per cent Aluminium chloride and 1M Potassium acetate was added and the volume was made up to 5 mL with 80 per cent ethanol. After 30 min of incubation at room temperature the absorbance against the blank was determined at 415 nm. Rutin (20, 40, 60, 80 and 100 µg/ mL) was used for the preparation of standard curve and the amount of total flavonoid compound in the sample extract was determined from the equation $y = 0.0037x + 0.0378$; $R^2 = 0.9959$. The results were expressed as rutin equivalent (RE)/g of sample using the equation (x)

Free Radical Scavenging Capacity/ Antioxidant Activity

Free radical scavenging capacity of extracts was determined against different types of free radicals including 2, 2-diphenyl-1-picryl-hydrazyl (DPPH), azinobistetrazolium sulfate cation (ABTS+) and Ferric Ion Reducing Antioxidant Power (FRAP). The percentage inhibition was calculated and plotted as a function of the concentration of standard (Ascorbic acid at 10, 20, 30, 40 and 50 µg/ mL) and antioxidant activity was expressed as milligrams of ascorbic acid equivalents (AAE) per gram of sample (dry weight) using the equation (x).

$$\text{Radical scavenging activity (\% inhibition)} = \left(1 - \frac{\text{Absorbance of sample}}{\text{Absorbance of control}}\right) \times 100$$

DPPH Radical Scavenging Capacity

Antioxidant activity of the corn silk extract was measured using the DPPH free radical scavenging activity (Sarepoua *et al.,* 2013). To 0.2 mL of corn silk extract (0.5 mg/ mL), volume was made up to 1 mL using methanol and 4 mL of 0.2 mM freshly prepared methanolic solution of DPPH was added. The solution was allowed to stand for 30 min in the dark conditions and absorbance was recorded at 517 nm.

ABTS Radical Scavenging Assay

The ABTS radical cation decolourization test was done according to Singh *et al*. (2022). The reaction between 7 mM ABTS in water and 2.45 mM potassium persulfate (1:1) produced the ABTS + cation radical, which was kept in the dark at room temperature for 12-16 h before use. By diluting the ABTS + solution with 80 per cent ethanol, an absorbance of 0.700 at 734 nm was obtained. The absorbance was measured 5 min after the initial mixing of 30 µL of plant extract (0.5 mg/ mL), being made up to 1mL using distilled water, with 4 mL of diluted ABTS + solution. The control containing all reagents except the extract fraction was used as a blank.

Ferric Ion Reducing Antioxidant Power (FRAP)

The FRAP assay was carried out following Zhang *et al*. (2017). The working solution was prepared by mixing 25 mL of 300 mM acetate buffer (pH 3.6), 2.5 mL TPTZ solution (10 mM TPTZ in 40 mM HCl), and 2.5 mL of 20 mM $FeCl_3 \cdot 6H_2O$ solution. The mixture was incubated at 37°C before use. A 30 µL of extract (0.5 mg/ mL) was made up to 4 mL volume using distilled water and was mixed with 1 mL of working solution. Absorbance was measured at 593 nm using a spectrophotometer after 15 minutes' incubation.

Statistical Analysis

The experiments were carried out in triplicate. The data were analyzed statistically using SPSS software (IBM, SPSS Statistics 16.0). The results were expressed as mean ± standard deviation. Following one-way ANOVA, Duncan's multiple range test was employed for post-hoc analysis.

Results and Discussion

Colour Analysis

The colour parameters of corn silk either lyophilized or tray dried at 40 and 60 °C are presented in Table 1. The values revealed that drying methods significantly ($p<0.05$) affected the colour parameters. Changes in the values of L, a and b signify a reduction in lightness, an increase in redness and a decrease in yellowness respectively. This indicates more browning of the samples from tray drying as opposed to freeze drying (Fig. 1). This could be attributed to the effect of enzymatic browning which occurred under the conditions prevailing during the drying process, favouring the colour change (Fadimu *et al.,* 2018). Freeze drying uses sublimation to dehydrate the product at a very low temperature, which prevents browning processes and yields better colour retention (Rafiq *et al.,* 2019). The increased browning at 40ºC when compared at 60ºC, could be attributed to prolonged duration of drying and longer availability of time for browning reaction to occur. No significant difference was observed in saturation

Table 1

Effect of drying condition on colour parameters of corn silk powder

Drying condition	L^*	a^*	b^*	c*	h^o
Lyophilized	63.32 ± 0.46 ^{a}	3.48 ± 0.07 ^{a}	18.33 ± 0.27 ^{a}	18.65 ± 0.25 ^{a}	79.23 ± 0.37 ^{a}
Tray dried 60^0C	50.58 ± 1.11 ^{b}	6.77 ± 0.16 ^{b}	17.17 ± 0.20 ^{b}	18.45 ± 0.13 ^{a}	68.49 ± 0.69 ^{b}
Tray dried 40^0C	40.55 ± 1.05 ^{c}	7.64 ± 0.17 ^{c}	15.67 ± 0.38 ^{c}	17.43 ± 0.28 ^{c}	63.98 ± 1.02 ^{c}

Values with different letters within the same column differed significantly ($p < 0.05$)

(a) (b) (c)

Fig. 1: Corn silk powder obtained by (a) lyophilization (b) tray drying at 60^{0}C and (c) tray drying at 40^{0}C.

(c*) between freeze dried sample and tray dried sample (60ºC).

Total Polyphenol and Flavonoid Content

Total polyphenolic contents (TPC) of different dried corn silk samples, expressed as mg of gallic acid per gram of dry sample, are given in Table 2. TPC values in the corn silk extracts were significantly different ($p < 0.05$) and were related to the drying methods. The lyophilized corn silk sample exhibited the highest TPC value compared to the tray dried samples. Among the tray dried samples, better retention of polyphenols was observed at 60ºC than 40ºC. It is known that thermal processing is the most critical factor that may influence the amount of the phenolic compounds. Kubra and Rao (2012) reported that heat energy may cause the breakdown of the cellular constituents leading to a higher release of polyphenols from the matrices, which may explain the high content of TPC obtained at 60°C in the current study.

The total flavonoid content (TFC) exhibited a trend similar to that of TPC where lyophilized sample better retained the flavonoids. As observed from the data in Table 2, the TFC values are significantly ($p<0.05$) higher at higher drying temperature. Our results are in accordance with those of An *et al.* (2016) and Cherrat *et al.* (2019) who reported that high drying temperatures contribute to the destruction of cellular constituents, which release the flavonoids and make them available during extraction. On the other hand, drying time is found to decrease as drying temperature increases (Azam and Pandey, 2021) and a shorter exposure time during the drying process makes it advantageous in terms of flavonoid preservation.

The results of TPC and TFC demonstrated that the choice of varying polarities solvent had influence on the extractability of bioactive compounds. Better extraction of these compounds was observed in 80 per cent ethanol and methanol compared to aqueous and acetone extracts. These findings were supported

TABLE 2

Total Polyphenol and Flavonoid Content of corn silk extracts

Sample	Solvent	TPC (mg GAE/ g of sample)	TFC (mg RE/ g of sample)
Lyophilized	80% Ethanol	35.86 ± 0.83 ^{a}	38.05 ± 0.22 ^{a}
	Methanol	24.89 ± 0.11 ^{b}	36.64 ± 0.27 ^{b}
	Aqueous	16.19 ± 0.05 ^{d}	14.87 ± 0.10 ^{e}
	Acetone	5.40 ± 0.02 ^{h}	7.82 ± 0.01 ^{h}
Tray dried 60^{0}C	80% Ethanol	20.31 ± 0.19 ^{c}	20.56 ± 0.32 ^{c}
	Methanol	13.58 ± 0.12 ^{e}	20.10 ± 0.32 ^{d}
	Aqueous	8.41 ± 0.08 ^{f}	8.13 ± 0.10 ^{g}
	Acetone	1.16 ± 0.02 ^{j}	3.84 ± 0.00 ^{j}
Tray dried 40^{0}C	80% Ethanol	5.68 ± 0.04 ^{h}	8.88 ± 0.02 ^{f}
	Methanol	3.57 ± 0.08 ^{i}	8.37 ± 0.11 ^{g}
	Aqueous	6.56 ± 0.08 ^{g}	6.24 ± 0.19 ^{i}
	Acetone	0.79 ± 0.01 ^{j}	3.47 ± 0.05 ^{j}

TPC: Total Polyphenol Content; TFC: Toatl Flavonoid Content
Values with different letters within the column differed significantly ($p < 0.05$)

by previous studies, where significant effect of different extraction solvents was observed on yields of TPC (Chavan *et al.,* 2013; Dailey & Vuong, 2015; Do *et al.,* 2014 and Sulaiman *et al.,* 2014). However, the extraction yields of TPC and TFC differed depending on the types of solvent used. In a study conducted by Nurhanan and Wan Rosli (2012), the highest polyphenol content in corn silk was exhibited by methanol extract (101.99 mg GAE/g) compared to that of ethanol (93.43 mg GAE/g), water (35.34 mg GAE/g) and ethyl acetate extract (6.70 mg GAE/g). The differences can be attributed to variation in polarities of the solvents, which selectively extract different hydrophobic or hydrophilic phenolic compounds in the sample, thus highlighting the importance of investigating and identifying the optimal extraction solvent for each sample type (Ngo *et al.,* 2017).

Anti-Oxidant Activity

Phenolic compounds are a class of antioxidant agents due to their redox properties, which allow them to act as reducing agents, hydrogen donors and singlet oxygen quenchers (Chang *et al.,* 2001). The flavonoids, which contain hydroxyl groups, show antioxidant activity through scavenging or chelating processes, have considerable effects on human nutrition and health. In this study, antioxidant activities of the extracts from corn silk were evaluated by using *in vitro* antioxidant models including 2, 2-diphenyl-1-picryl-hydrazyl (DPPH), azinobistetrazolium sulfate cation (ABTS+) and Ferric Ion Reducing Antioxidant Power (FRAP). The relationship between the antioxidant activity and the total content of phenol and flavonoids was also studied.

The ability of corn silk extracts to quench reactive species by hydrogen donation was measured through the DPPH radical scavenging activity assay. As a kind of stable free radical, DPPH can accept an electron or hydrogen radical to become a stable diamagnetic molecule, which is widely used to investigate radical scavenging activity. The antioxidants can react with DPPH, a deep-violet coloured stable free radical, converting it into a yellow coloured α, α-diphenyl-β-picrylhydrazine. Quantifying the discolouration of reaction mixture indicates the radical-scavenging ability of the antioxidant (Braca *et al.,* 2001).

DPPH free radical scavenging activity of corn silk extracts was found highest in lyophilized sample ($p< 0.05$), ranging from 4.19 ± 0.01 to 8.50 ± 0.00 mg AAE /g dry sample, whereas, that of 60 and 40ºC tray dried corn silk extracts ranged from 1.49 ± 0.02 to 8.46 ± 0.00 and from 0.56 ± 0.01 to 7.65 ± 0.01 mg AAE /g dry sample respectively (Table 3).

Total antioxidant activity was also measured using the ABTS radical scavenging activity test. The ABTS radical produced by converting ABTS-e to ABTS+ interacts swiftly with electron/hydrogen donors to produce colourless ABTS. The ABTS activity for corn silk powder, as shown in Table 4, was highest in lyophilized sample (5.33 ± 0.06 to 16.28 ± 0.03 mg AAE /g dry sample), followed by tray dried sample at 60ºC (3.87 ± 0.03 to 15.50 ± 0.07 mg AAE /g dry sample) and 40ºC (2.11 ± 0.08 to 6.70 ± 0.09 mg AAE /g dry sample).

As significant as reducing power, the ferric ion reducing-antioxidant power (FRAP) assay is frequently utilized as a measure of phenolic antioxidant activity. The ability of samples to decrease Fe(III)-TPTZ to Fe(II)-TPTZ was used to determine their antioxidant capacity (Tabel 5). In line with the above two models, corn silk powder showed a FRAP activity of 6.01 ± 0.05 to 12.24 ± 0.03 mg AAE /g dry sample in lyophilized sample, 1.54 ± 0.05 to 9.42 ± 0.05 and 0.67 ± 0.04 to 4.87 ± 0.05 mg AAE /g dry sample in samples tray dried at 60 and 40^{0}C, respectively.

Lyophilized corn silk samples with enhanced anti-oxidant activity, as shown by all the three anti-oxidant models, might be attributable to higher preservation of polyphenols and flavonoids compared to tray dried samples. Senphan (2019) has also reported a better retention of antioxidant activity in freeze dried corn silk sample than in tray dried sample. In general, tray drying process depletes naturally existing antioxidants in raw plant materials and longer drying durations result in a larger loss of bioactive compounds (Lim and Murtijaya, 2007).

TABLE 3

DPPH free radical scavenging activity of corn silk extracts

Sample	Solvent	% inhibition	mg AAE /g dry sample
Lyophilized	80% Ethanol	93.76 ± 0.03	8.50 ± 0.00 [a]
	Methanol	93.11 ± 0.07	8.44 ± 0.01 [b]
	Aqueous	55.83 ± 0.53	4.93 ± 0.05 [d]
	Acetone	47.93 ± 93	4.19 ± 0.01 [f]
Tray dried 60^{0}C	80% Ethanol	93.31 ± 0.05	8.46 ± 0.00 [ab]
	Methanol	92.93 ± 0.32	8.42 ± 0.03 [b]
	Aqueous	40.78 ± 0.26	3.52 ± 0.02 [g]
	Acetone	19.23 ± 0.24	1.49 ± 0.02 [i]
Tray dried 40^{0}C	80% Ethanol	84.71 ± 0.08	7.65 ± 0.01 [c]
	Methanol	53.54 ± 0.21	4.72 ± 0.02 [e]
	Aqueous	39.86 ± 0.44	3.43 ± 0.04 [h]
	Acetone	9.37 ± 0.07	0.56 ± 0.01 [j]

Values with different letters differed significantly ($p < 0.05$)

All four antioxidant assays revealed that antioxidant capacity is in decreasing order with the corresponding solvents used: 80 per cent ethanol > methanol > aqueous > acetone. The differences in impact of solvents on antioxidant capacity of corn silk in the current study can be explained by the variation of bioactive groups extracted by different solvents. Polyphenols and flavonoids contributed differently to the antioxidant power as these groups presented differing correlation with antioxidant capacity (Table 6). Table 6 shows that the antioxidant properties had a strong positive correlation ($p<0.01$) with TPC and TFC, revealing the contribution of phenolic compounds and flavonoids to the anti-oxidant potential exhibited by corn silk.

TABLE 4

ABTS radical scavenging activity of corn silk extracts

Sample	Solvent	% inhibition	mg AAE /g dry sample
Lyophilized	80% Ethanol	98.56 ± 0.07	16.28 ± 0.03 [a]
	Methanol	96.11 ± 0.13	15.88 ± 0.02 [b]
	Aqueous	34.28 ± 0.36	5.72 ± 0.06 [f]
	Acetone	31.93 ± 0.35	5.33 ± 0.06 [g]
Tray dried 60^{0}C	80% Ethanol	93.78 ± 0.41	15.50 ± 0.07 [c]
	Methanol	83.96 ± 0.59	13.88 ± 0.10 [d]
	Aqueous	27.87 ± 0.19	4.66 ± 0.03 [h]
	Acetone	23.01 ± 0.19	3.87 ± 0.03 [j]
Tray dried 40^{0}C	80% Ethanol	40.24 ± 0.53	6.70 ± 0.09 [e]
	Methanol	23.95 ± 0.10	4.02 ± 0.02 [i]
	Aqueous	17.42 ± 0.32	2.95 ± 0.05 [k]
	Acetone	12.31 ± 0.51	2.11 ± 0.08 [l]

Values with different letters differed significantly ($p < 0.05$)

TABLE 5
FRAP activity of corn silk extracts

Sample	Solvent	% inhibition	mg AAE /g dry sample
Lyophilized	80% Ethanol	84.13 ± 0.03	12.24 ± 0.03 [a]
	Methanol	82.98 ± 0.05	11.22 ± 0.04 [b]
	Aqueous	78.81 ± 0.17	8.46 ± 0.09 [d]
	Acetone	72.97 ± 0.14	6.01 ± 0.05 [e]
Tray dried 60^{0}C	80% Ethanol	80.48 ± 0.08	9.42 ± 0.05 [c]
	Methanol	80.38 ± 0.01	9.36 ± 0.01 [c]
	Aqueous	67.21 ± 0.07	4.46 ± 0.02 [g]
	Acetone	45.32 ± 0.64	1.54 ± 0.05 [i]
Tray dried 40^{0}C	80% Ethanol	68.97 ± 0.20	4.87 ± 0.05 [f]
	Methanol	67.14 ± 0.20	4.44 ± 0.05 [g]
	Aqueous	65.61 ± 0.27	4.12 ± 0.05 [h]
	Acetone	31.77 ± 0.84	0.67 ± 0.04 [j]

Values with different letters differed significantly ($p < 0.05$)

The results revealed that lyophilization is the most effective method due to associated advantages including better colour preservation. The study also demonstrated that the solvents play an important role in the extraction of bioactive compounds from corn silk. Among the solvents studied, 80 per cent ethanol was found to best serve as the solvent for extraction of phenolic compounds and flavonoids. The anti-oxidant activity, as exhibited by all the three study models, was significantly correlated with total phenolic content and total flavonoid content. Potent anti-oxidant activity exhibited by corn silk makes this plant material highly valuable for use as a natural source of polyphenols, potentially contributing to the development of value-added, functional and nutraceutical products. The present study provides comparative results and offers a better comprehension of the influence of drying methods and solvent employed for extraction on total polyphenols, flavonoids and anti-oxidant activity of corn silk. The evidence required for utilization of corn silk as a source of low-cost natural antioxidant was also presented through the results. The study, therefore, demonstrated that utilization of corn silk for commercial production of functional food is worth-exploring to convert waste agricultural products into value-added products.

TABLE 6
The correlation coefficients between the contents of TPC, TFC and antioxidant activities of corn silk extracts

	TPC		TFC	
	r	p	r	p
DPPH	0.754	<0.01	0.792	<0.01
ABTS	0.872	<0.01	0.915	<0.01
FRAP	0.926	<0.01	0.922	<0.01
TFC	0.956	<0.01		

TPC – Total Phenolic Content; TFC – Total Flavonoid Content

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