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Total phenolic contents and antioxidant activity of corn tassel extracts

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ABSTRACT

Ground corn tassels, a by-product of corn, were used as a source of phenolic compounds. Water, ethanol, methanol, acetone, hexane, chloroform, butanol, petroleum ether and methylene chloride were evaluated as different polarity solvents to extract these phenolic compounds. Ethanol exhibited the highest extraction ability for such phenolic compounds, followed by methanol and water, where the total phenols were 0.1575%, 0.1125% and 0.0737%, respectively. Antioxidant activity of corn tassels ranged from 83.0% to 85.2%, 69.9% to 83.7%, 69.8% to 80.4%, 22.2% to 49.1% and 14.8% to 19.3% radical scavenging activity (% RSA) for ethanol, methanol, acetone, butanol and water extracts, respectively. The ethanolic extract of the corn tassels was successfully utilised to retard the oxidation of sunflower oil and the obtained induction period values were comparable to those of *tert*-butylhydroquinone (TBHQ).

1. Introduction

Corn (*Zea mays* L.) is one of the most widely planted crops in the world and the world production was estimated at 471 million tons (FAO, 1993). The production of maize in Egypt was estimated at 5.78 million tons in 2004/2005 (Anon, 2005). Corn tassels are a waste part of the plant, which could be considered as a great source of value products such as volatile oils (Buttery, Ling, & Teranishi, 1980), the flavonol glycosides of quercetin, isorhamnetin and kaempferol (Ceska & Styles, 1984) and lipids (Bianchi, Murelli, & Ottaviano, 1990). Phenolic compounds exhibit a wide range of physiological properties, such as antiallergenic, anti-artherogenic, anti-inflammatory, antimicrobial, antioxidant, antithrombotic and cardioprotective effects. (Balasundram, Sundram, & Samman, 2006). Currently, many studies have focused on agricultural and industrial wastes in the search for natural antioxidants (Bandoniene, Pukalskas, Venskutonis, & Gruzdiene, 2000). Jayaprakasha, Singh, and Sakariah, (2001) reported that grape seed extract exhibited good antioxidant activity in the preservation of food products. A methanolic extract prepared from peanut hulls preserved potato chips (Zia-ur-Rehman, Salariya, & Habib, 2003).

Literature revealed that no information exists about the utilisation of corn tassels as a source of phenolic compounds. Therefore, the objectives of this study were to evaluate corn tassels as a source of phenols using different extracting solvents to determine their antioxidant capacities.

2. Materials and methods

2.1. Materials

Corn tassels were obtained from the farm of the Faculty of Agriculture, Cairo University, Cairo, Egypt. Untreated sunflower oil (with no added antioxidants) was obtained from the Cairo Company for Oils and Soap (Cairo, Egypt), while, 1,1-diphenyl-2-picrylhydrazyl (DPPH) was purchased from Fluka Chemika (Buchs, Switzerland). All solvents and chemicals were of analytical grade and obtained from local suppliers.

2.2. Sample preparation

After collection, corn tassels were air dried, milled to a size of 1 mm, packaged in glass jars and stored at room temperature (25 °C) till use.

2.3. Chemical composition

Chemical composition (protein, fat, total carbohydrates and ash) of corn tassels were carried out according to AOAC (2000). The peroxide value (PV) of the sunflower oil was determined according to AOCS (1998). All analyses were carried out in triplicate.

2.4. Extraction of phenolic compounds

The total phenolic compounds (TP) of ground corn tassels were extracted using nine separate solvents (acetone, methanol, ethanol, water, hexane, chloroform, butanol, petroleum ether and methylene chloride) at solvent to corn tassels ratio of 10:1. Extraction

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was carried out using a shaking incubator at room temperature for 24 h followed by filtration through Whatman No.1 filter paper. The residue was re-extracted in the same manner and the two filtrates were combined. The total phenolic compounds of the different extracts was determined according to the Folin-Ciocalteu Method (Vernon, Orthofer, & Lamuela-Raventos, 1999), using gallic acid as standard. The ethanol extract was concentrated using a rotary evaporator at 55 °C to near dryness and then the total phenolic compounds were determined.

2.5. Determination of antioxidant activity

The 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay (Lee et al., 2003) was utilised with some modifications. The stock reagent solution was prepared by dissolving 24 mg of DPPH in 100 ml methanol and stored at −20 °C until use. The working solution was obtained by mixing 10 ml of the stock solution with 45 ml methanol to obtain an absorbance value of 1.1 ± 0.02 at 515 nm, using a spectrophotometer. The different corn tassel extracts (0.15 ml of each) were allowed to react with 3 ml of the DPPH solution for the desired time and then the absorbance was measured at 515 nm, at times 0, 5, 10, 15 and 20 min. The antioxidant activity of *tert*-butylhydroquinone (TBHQ), at concentrations of 50 and 200 ppm, was also determined. A control sample with no added extract was also analysed and the results were expressed as radical scavenging activity (% RSA)

$$\%\mathrm{RSA} = (A_{\mathrm{control}} - A_{\mathrm{sample}}) \times 100/A_{\mathrm{control}}. \quad (1)$$

A = absorbance at 515 nm

2.6. Application of the ethanolic corn tassels extract to sunflower oil

The antioxidant activity of the concentrated ethanolic extract was evaluated on a sunflower oil model system. The ethanolic corn tassels extract was dissolved in the oil at concentrations of 0, 1000, 2000, 3000, 4000 and 5000 ppm. Also, a sample with TBHQ (200 ppm) was prepared for comparison purposes. The mixtures were stored at −18 °C. Induction periods of the prepared extract samples (the time needed for the peroxide value to reach 20) were then determined by plotting the peroxide value (PV) of samples *vs.* time (Banias, Oreopoulou, & Thomopoulos, 1992).

2.7. Encapsulation of the concentrated phenolic compounds extract

Three grams of sodium carboxymethylcellulose (CMC) were well mixed with 3 ml of ethanolic extract and then tablets were formed by applying hydraulic pressure on the mixture.

2.8. Statistical analysis

The antioxidant activity data were statistically analyzed using one-way analysis of variance (Rao & Blane, 1985).

3. Results and discussion

3.1. Proximate composition of corn tassels

The results in Table 1 show the proximate analysis of corn tassels. This indicates that these unused parts of corn plant (corn tassels) could be used as a source of carbohydrate, fat and protein.

3.2. Total phenolic compounds as affected by the solvent used

The amount of TP determined in different solvent extracts of corn tassels is shown in Fig. 1. TP were determined by using

Table 1
Chemical composition of the corn tassels (dry weight bases)

Constituents	%
Protein	6.26
Fat	10.10
Ash	11.06
Total carbohydrates	70.26

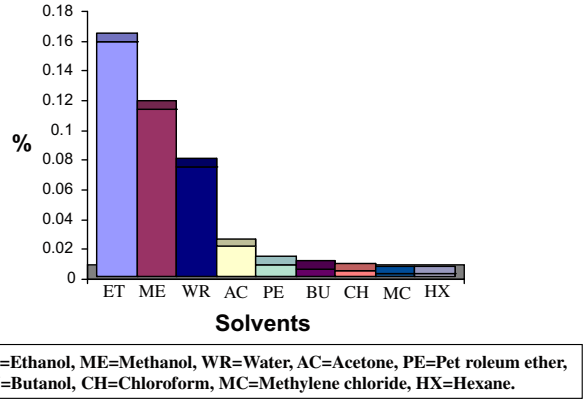

Fig. 1. Total phenolic compounds extracted from corn tassels using different solvents.

Folin-Ciocalteu reagent. Folin-Ciocalteu reagent reacts nonspecifically with phenolic compounds; it can also be reduced by a number of non-phenolic compounds, e.g., vitamin C, Cu(II), etc. Although the exact reaction of the reagent with the reducing species is not known, it is considered that a complex is formed between phosphomolybdic tungstate and the reducing species, phenolate ion, changing colour from yellow to blue, where absorbance at 755 nm is measured (Huang, Ou, & Prior, 2005). Results in Fig. 1 revealed that ethanol and methanol were better solvents than the others in extracting phenolic compounds from the corn tassels due to their polarity and good solubility for phenolic components from plant materials (Siddhuraju & Becker, 2003; Zhou & Yu, 2004).

Results in Fig. 1 showed that ethanol was the best solvent for extracting phenolic compounds, followed by methanol then water, where 0.1575%, 0.1125% and 0.0737% total phenolic compounds were obtained, respectively. The lower polarity solvents: acetone, petroleum ether, butanol, chloroform, methylene chloride and hexane showed much lower ability in extracting the phenolic compounds as compared to the polar solvents. Many phenolic compounds have been determined in different parts of the corn plant; however, their concentration was found to be highest in corn flour (White & Xing, 1997). Amount of TP (0.1575%) determined in the ethanolic extract of corn tassels in the present study was found to be lower than banana peels (0.91%) (Someya, Yoshiki, & Okubo, 2002) pomegranate peels (46.2%) (Negi, Jayaprakasha, & Jena, 2003) and rice bran (0.36%) (Iqbal et al., 2006), but greater than some other wastes, such as wheat bran (0.10%) (Zhou & Yu, 2004).

3.3. Antioxidant activity of corn tassels extracts

The DPPH radical is commonly used for the assessment of antioxidant potency *in vitro* and is foreign to biological systems (Zhou & Yu, 2004). DPPH is a very stable organic free radical with deep violet colour, which gives absorption maxima within the 515–528 nm range. Upon receiving a proton from any hydrogen donor, mainly from phenolics, it loses it chromophore and becomes yellow. By increasing the concentration of phenolic compounds or

degree of hydroxylation of the phenolic compounds, their DPPH radical scavenging activity also increases, and can be defined as antioxidant activity (Sanchez-Moreno, Larrauri, & Saura-Calixto, 1999). Because these radicals are very sensitive to the presence of hydrogen donors, the whole system operates at a very low concentration, a large number of samples can be tested in a short time (Iqbal et al., 2006; Zhou & Yu, 2004).

Data in Fig. 2 show the antioxidant activity (% RSA) of the different extracts of corn tassels. Significant ($p < 0.05$) differences between different extracts were observed at the 5th minute of the reaction. Results (Fig. 2) clearly indicate that all extracts exhibited antioxidant activity as follows: TBHQ-200 > TBHQ-50 > ethanol > methanol > acetone > butanol > water. The extracts which showed relatively high antioxidant activity (ethanol and methanol) contained the highest amount of total phenolic compounds (Fig. 1). It has been proven that antioxidant activity of plant extracts is mainly ascribed to the concentration of the phenolic compounds present in the plants (Heim, Taigliaferro, & Bobilya, 2002). Several studies showed good correlation between the total phenols and antioxidant activity (Huang et al., 2005; Javanmardi, Stushnoff, Locke, & Vivanco, 2003; Silva, Souza, Rogez, Rees, & Larondelle, 2006). From the aforementioned results, the phenolic compounds from both ethanolic and methanolic extracts of corn tassels proved their efficiency as antioxidants when compared to TBHQ. Therefore, these natural antioxidants could replace synthetic antioxidant in food products.

3.4. Effect of ethanolic corn tassels extract on induction period of sunflower oil

Results in Table 2 showed that the induction period of sunflower oil was increased by increasing the concentration of the

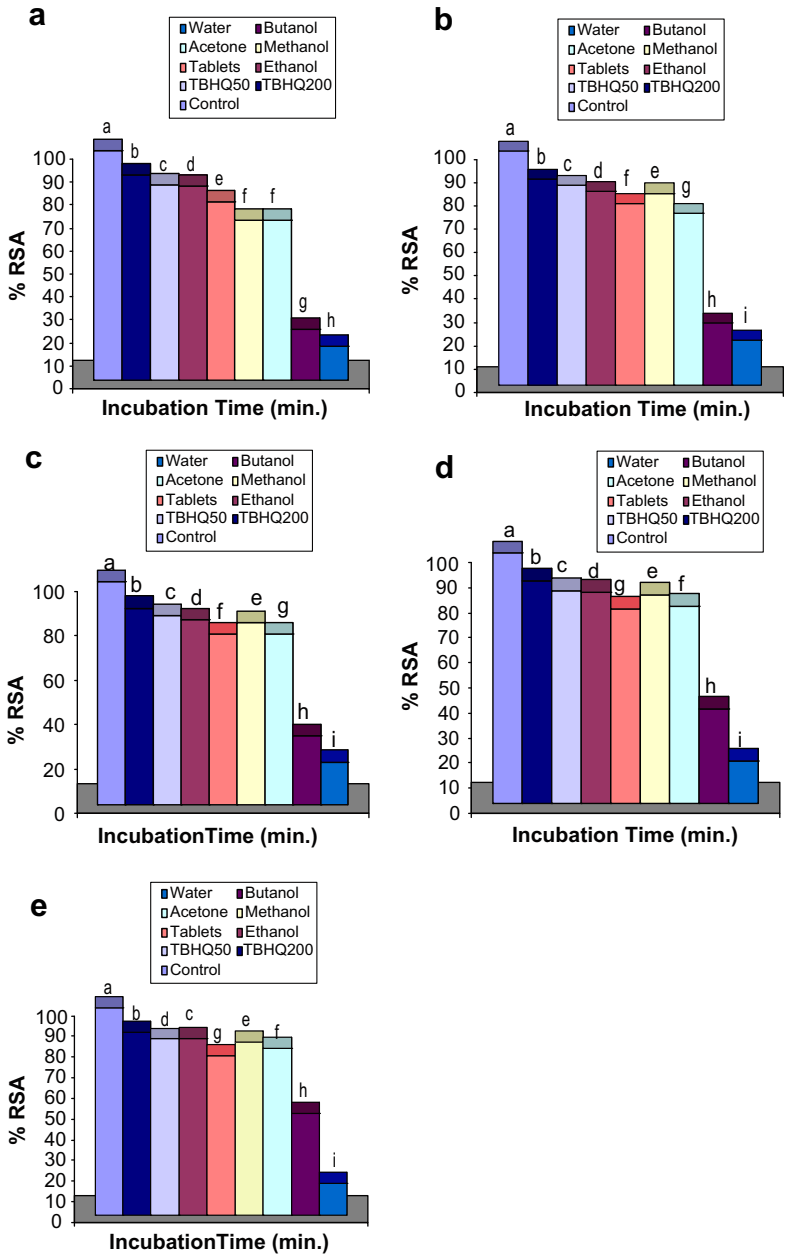

Fig. 2. The antioxidant activity (% RSA = radical scavenging activity) of different corn tassel extracts determined at room temperature; (a) time 0, (b) 5th min, (c) 10th min, (d) 15th min and (e) 20th min. Different letters indicate significant differences ($p < 0.05$).

Table 2
The effect of concentrations of ethanolic corn tassels extract on the induction period of sunflower oil

Ethanolic corn tassels extract (ppm)	Induction period (h)[a]	R.I.P.[b]
None	12.0	1.00
1000	12.5	1.04
2000	15.0	1.25
3000	25.0	2.08
4000	40.0	3.33
5000	40.0	3.33
TBHQ (200)	36.0	3.00

[a] Induction period: the time needed for peroxide value to become 20.0 at 75 °C.
[b] R.I.P.: relative induction period; induction period for control = 1.

ethanolic corn tassels extract from 1000 to 4000 ppm. Increasing the concentration of the ethanolic corn tassels extract up to 4000 ppm increased the induction period to 40 h, compared to 36 h in the case of TBHQ (200 ppm). These results show that ethanolic extract of corn tassels exhibited strong antioxidant activity, which was almost equal to synthetic antioxidants (TBHQ).

It can be concluded that corn tassels could be a valuable raw source of phenols and could be used to prolong the shelf life of fats and oils.

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