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AN APPROACH FOR UTILIZATION OF AGRO-INDUSTRIAL WASTES OF SUGAR AND SWEETENERS CROPS FOR NATURAL ANTIOXIDANT PRODUCTION

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ABSTRACT

Proximate composition of agro-industrial wastes of sugar cane farm, sugar cane bagasse, sugar beet farm, sugar beet pulp, stevia, Jerusalem artichoke, chicory farm and chicory pulp were determined. Polyphenolic phytochemical content of these waste materials were extracted with hot aqueous methanol. Total phenolics content in the methanolic extract were determined. Phenolic compounds in each extract were identified with HPLC. Antioxidant activity of each methanolic extract was evaluated. The obtained results revealed that total phenolic contents of various waste materials were in range of 1.68 to 16.13 g/100 g of dry matter expressed as gallic acid equivalents and the highest amount was obtained in stevia wastes followed with sugar cane farm.. Identification analysis with HPLC revealed that there are at least seven of different phenolic compounds with different concentration in each methanolic extract except Jerusalem artichoke and chicory pulp which contained only one identified compound. Moreover the results of antioxidative activities of the obtained methanolic extracts showed that all of methanolic extracts had inhibited hydroperoxide formation in sunflower oil during storage at 60°C. The sugar cane and stevia extract had the highest inhibition effect on the hydroperoxide formation. Application such material as antioxidant may provide health promoting advantages to consumer as a natural antioxidant and maximize the utilization of such crops.
Keywords: Phenolic compounds, Sugar crop wastes, Antioxidant.

INTRODUCTION

Recently, much attention has been focused on utilization of agricultural and industrial wastes for bio-production. Sugar crops wastes has been used as a raw material to produce hydroxy methyfurfural, paper pulp, acoustic bards, pressed woods and agricultural mulch (Dominguez *et al.*, 1996). Sugar cane farm wastes such as cane tops and trash are known to be good fodder for ruminants, however, they are not used to a great extent. Filter mud, a waste product of the sugar factory is a plant nutrient source in its decomposed form. However, tons of filter mud are left in sugar mill yards. These waste products are considered only as animal feed and organic fertilizer (Dormido *et al.*, 2002). The sugar beet pulp, is a waste product of the sugar industry which is rich in ferulic acid. Ferulic and caffeic acid should be good candidates for successful employment as topical protective agents against UV radiation-induced skin damage. (Ferreira *et al.*, 1999). *Stevia rebaudiana* Bertoni leaves, Jerusalem artichoke tubers (*Helianthus tuberosus* L.) and chicory (*Chichorum intybus* L.) which considered as a sources of natural sweetener crops. Stevia is especially known for the sweetening principle contained in the leaves, which have attracted the attention of industrial produces because of their potential dietetic, alimentary and pharmaceutical interest (Jeppesen *et al.*, 2000). The leaves of stevia contain a complex mixture of labdone diterpens, tritespenes, stigmasteral, tannis, volatile oils and eight sweet diterpene glycosides (Domissarenko *et al.*, 1994). In addition to the sweet diterpenoid glycoside several other diterpenes have been isolated from stevia. Since these compounds may be part of the waste stream produced during processing, their availability in large quantities could make them into valuable Co-products (Pasquel *et al.*, 2000) Jerusalem artichoke and chicory tubers are a potential source of fructose for use as a sweetener in foods (Femenia *et al.*, 1998) and are vegetatively agriculture plant with nutritional, medicinal and energetic potential (Piet, 1996). Jerusalem artichoke store carbon predominately in the form of inulin, a functional food of increasing interest due to its dietary health benefits for humans and caloric replacement potential in processed foods. Also, chicory root processed for the extraction of inulin and its leaves are used as salad greens (Somda *et al.*, 1999). Utilization of this wastes in production of phenolic compounds, which are the major plant compounds with antioxidant activity and other biological properties such as anticarcinogenicity, antimutagenicity, antiallergenicity and antiaging activity have been reported for natural and synthetic antioxidants (Moure *et al.*, 2001). In the same time, public concern about environmental issues and natural products rather than synthetic products and safety of foods (Meijer and Mathijssen, 1996). Therefore, the objective of this study was to determine and identify the phenolic components in sugar cane farm, sugar cane bagasse, sugar beet farm, sugar beet pulp, stevia leaves, Jerusalem artichoke tubers, chicory leaves, and chicory pulp wastes. Evaluate the antioxidant activity of phenolic extracted from each studied of waste materials.

MATERIALS AND METHODS

Sugar cane (*Scchanum officinarum* variety pH 80-13, sugar beet (*Beta vulgaris*, Baraca), *Stevia rebaudiana* Bertoni and Jerusalem artichoke tubers (*Helianthus tuberosus* L..) were harvested from Sabahia Agricultural Research Station Farm at Alex. Governorate. As well as chicory (*Chichorum inhybus* L.) was harvested from Agric. Research Center Farm at Al-Giza Cairo. Agro-industrial wastes were collected as the following:

1- **Sugar cane farm wastes (ScF):** Farm sugar cane wastes as arrows which represents about 13.76% of total crops yields was collected from the field.
2- **Sugar cane bagasse (ScB):** A waste product of the sugar factory after milling which represents about 43.62% of total crop was obtained from Technological Lab. at Sabahia Agric. Research Station, Alex.
3- **Sugar beet farm wastes (SbF):** Leaves of sugar beet which considered as a farm wastes and represents about 14.84% of total crop weight, was collected at the field.
4- **Sugar beet pulp (SbP):** *The pulp of sugar beet which is to be* considered as a waste of beet sugar manufacture represent about 21.9% of total crop obtained at the factory (Delta beet sugar Company, Kafr El-Sheikh Governorate, Egypt).

5- **Stevia wastes (SW):** Stevia was harvested after 4 months and leaves were left to dry then subjected to extraction process to obtain most of sweeteners in the leaves according to Hassan *et al.* (2002). Residue after sweeteners extraction was used in this study.
6- **Jerusalem artichoke waste (JAW):** The tubers of plant were harvested in March 2003 (spring harvest) and then inulin was extracted according to Zeitoun *et al.* (2003). The residue after extraction and filtration was studied as Jerusalem artichoke wastes.
7- **Chicory farm wastes (CF):** The plant was grown under normal recommended practices and harvested after six months age, then leaves was used as a chicory farm wastes.
8- **Chicory pulp waste (CP):** Chicory pulp after milling and extraction of inulin as described by Zeitoun *et al.* (2003). Then the residue after extraction and filtration was studies as a chicory pulp wastes.

Samples preparation: Samples of all plant wastes were dried at 40°C ± 2°C in electric oven (E. Schulg & Co. Inh. Franz. KG) until the moisture content reached 10% or less. Then they were ground and sieved through 60 mesh sieve.

Proximate composition: The following determinations were carried out as described in AOAC (1990): moisture, ash, crude, protein, crude fat and crude fiber. Total carbohydrate (%) was calculated by difference.

Extraction of total phenolic: The powder of each dried samples (5 g) were macerated in absolute methanol (50 ml) for 24 hours at room temperature according to Ziada (2002). The extract were filtered, the filtrate was evaporated under vacuum in rotary evaporator at 45°C and weighed to determine the extracted yield of each plant material.

Determination of total phenolic content in the methanolic extract.

Total phenolic content in extract were assayed spectrophotometrically using the Folin-Ciocalteu method (Gamez-Meza *et al.*, 1999): A 1 ml of the extract was delivered to a 15 ml test tube and mixed with 1 ml ethanol amine (2%) and 0.5 ml of folin reagent was added and the total volume was brought to 10 ml with water. Absorbance was read on a spectrophotometer at 760 nm. The content of phenolics was expressed as gallic acid equivalents in mg/g of extract.

Phenolic compounds identification in each methanolic extracts by HPLC:

High-performance liquid chromatography (HPLC) was used for analysis of methanolic extracts, according to Torres *et al.* (1987) where different extracts of samples (20 µl) were injected. Acetic acid 5% (A) and acelonitrile (B) HPLC grade (Fisons Co. England) was used as mobile phase. A C_{18}-CLC-ODS Hypersil reversed phase column, 4.6 x 250 mm, particle size 5, COL No. 0923002 N was used. A variable wave length UV detector was used to detect phenolic compounds constituents at 300 nm. For the gradient elution, the solvent systems that were used: 100% A and 0% B over 30 min. then 90% A and 10% B over 10 min, 40% A and 60% B over the next 10 min and finally 0% A and 100% B over the final 10 min to purge column. The flow rate was 10 ml/min and identification of the phenolic compounds was based on the comparison of the retention times of peaks which obtained by Torres et *al.* (1987).

Antioxidant activity evaluation:

Antioxidant activity was determined by mixing 400 ppm of each methanolic extract according to Ziada (2002) in sunflower oil to compare with 200 ppm of TBHQ as a synthetic antioxidant. Then sunflower oils with natural or synthetic antioxidant were stored in drying oven set at 60°C for 7 days during this period. The peroxide values were determined at zero, 3, 5 and 7 days of storage according to AOCS (1989).

RESULTS AND DISCUSSION

1. Proximate composition:

Table (1) shows a proximate composition of agro-industrial wastes sugar and sweeteners crops (on dry weight basis). The obtained results indicated that the percentage of total carbohydrate content of waste materials varied from 32.05% in dried sugar cane farm to 65.53% in chicory pulp. The results also indicated that the crude fiber content of sugar cane bagasse, beet pulp, Jerusalem artichoke tubers and chicory pulp were even lower than agriculture wastes of this crops and the highest amount was obtained in sugar cane bagasse (37.94%) while lowest amount was obtained in sugar beet farm (13.79%). The highest amount of protein content was obtained in sugar beet farm waste (18.83%) while the lowest amount was obtained in chicory pulp (5.83%). At the same time, study revealed that sugar beet farm waste contained a considerable amount of protein (18.83%) followed by chicory farm (14.95%). The obtained results are in agreement with Shalaby (1991), who reported that dried sugar beet leaves contain 5.5% fats, 27.9% crude proteins, 13.6% crude fiber, 20.7% ash and 32.3% carbohydrates. Youssef (1996) also found that the beet pulp contained 9.86% protein on the opposite beet pulp and sugar cane bagasse recorded the lowest content of fat being 0.42 and 0.88% while Beshay (2001) reported that the bagasse contained 0.65 and 1.15% fat. The crude fiber content was amounted to range of 20.6-30.7% in beet pulp and from 34.49 to 45.4% in bagasse. Hassan *et al.* (2002) found that dry stevia leaves contained 12.29% protein, 4.28% crude fat, 14.02% ash, 11.99% crude fiber and carbohydrate 57.42%, which drying in an electric oven at 50°C. Dried tubers of Jerusalem artichoke contained mean ash content of 3.06%. Total carbohydrate content (47.28%) varied with genotype Joshi *et al.* (1994). Also Praznik *et al.* (2002) reported that the lipid content in dry matter of powders was 0.9 ± 0.2%, ash content 4.3 ± 0.3, content of protein 6.6% (autumn harvest) and 8.5 ± 3% (Spring harvest). Average chicory root nitrogen content did not differ among varieties ranging from 0.78 to 0.62%, total sugar 21.48 to 17.79% and inulin 17.91 to 14.77% on fresh materials (Piccaglia *et al.*, 2002).

Table (1): Proximate composition of agro-industrial wastes of sugar and sweeteners crops (on dry basis)*.

Agro-industrial waste / Constituents %	Sugar cane farm	Sugar cane bagasse	Sugar beet farm	Sugar beet pulp	Stevia wastes	Jerusalem artichoke tubers	Chicory leaves	Chicory pulp
Moisture	9.01 ± 0.05	7.24± 0.02	8.22 ± 0.01	9.08 ± 0.07	9.12 ± 0.14	9.24 ± 0.07	8.07 ± 0.05	9.56 ± 0.08
Protein	11.99 ± 0.57	3.61 ± 0.09	18.83 ± 0.27	8.39 ± 0.15	12.19 ± 0.17	10.09 ± 0.33	14.95 ± 0.26	5.83 ± 0.51
Crude fat	3.86 ± 0.08	0.97 ± 0.05	3.09 ± 0.13	0.78 ± 0.11	4.18 ± 0.07	1.78 ± 0.05	3.87 ± 0.03	1.95 ± 0.12
Ash	16.97 ± 0.03	3.16 ± 0.01	15.83 ± 0.01	5.21 ± 0.03	13.94 ± 0.01	8.29 ± 0.02	15.04 ± 0.07	5.67 ± 0.01
Crude fiber	35.13 ± 0.13	37.94 ± 0.23	13.79 ± 0.12	21.58 ± 0.15	16.82 ± 0.29	15.33 ± 0.11	17.47 ± 0.12	21.02 ± 0.14
** Total carbohydrate	32.05 ± 0.08	45.30 ± 0.4	48.46 ± 0.54	63.96 ± 0.51	52.87 ± 0.68	64.51 ± 0.52	48.67 ± 0.53	65.53 ± 0.86

* Values are means ± standard deviations

** Total carbohydrates were calculated by difference.

2. Methanolic extracted yield and total phenolic content:

Methanolic extracted yield and its total phenolic content in different studied wastes are presented in (Table 2). It is clear that the farm sugar cane contained the highest amount of methanolic extracted yield (22.92%) followed by stevia waste (20.77%). At the same time sugar beet farm and chicory farm produced almost the same percentage of extracted yield (14.34 and 13.07% respectively), while the lowest amount obtained were in sugar cane bagasse, beet pulp and chicory pulp wastes (3.89, 4.23 and 6.10%, respectively). The data clearly showed that stevia wastes produced the highest content of phenolic in all studied waste materials (Table 2). These variations in total phenolic content could be due to the nature of plant type. In the same time the phenolic content in sugar cane farm waste, sugar beet farm waste and chicory farm waste are within the range of 3.85% to 4.12% which is quit similar, on the other side the phenolic content in industrial waste of the same material are represented almost the half (1.68-2.56%) of the phenolic content in farm waste as well as the phenolic content in Jerusalem artichoke tubers waste.

Table (2): Methanolic extracted yield and total phenolic content of different agro-industrial wastes of sugar and sweetener crops samples (on dry weight basis)*.

Samples of Materials wastes	Methanolic extracted yield (%)	Total phenolic (%)	Total phenolic content g/kg material
1. Sugarcane farm	22.92 ± 0.5	4.12 ± 0.2	41.15
2. Sugarcane bagasse	3.89 ± 0.3	2.01 ± 0.6	20.06
3. Sugar beet farm	14.34 ± 0.7	3.85 ± 0.3	38.45
4. Sugar beet pulp	4.23 ± 1.1	2.56 ± 0.5	25.57
5. Stevia wastes	20.77 ± 0.5	16.13 ± 1.2	161.28
6. Jerusalem artichoke tubers	8.93 ± 0.7	2.30 ± 0.3	22.97
7. Chicory farm	13.07 ± 1.3	3.89 ± 0.7	38.86
8. Chicory pulp	6.10 ± 0.2	1.68 ± 0.6	16.82-

* values are means ± standard deviations

3. Identification of phenolic compounds:

The obtaining more information about the separation and identification of phenolic compounds of each methanolic extract (natural sources of antioxidant), the methanolic extracts were separated and identified with HPLC. The results obtained are represented in Figure (1) and Table (3) which showed clearly the phenolic compounds and their percentage of each methanolic extract of studied waste materials. Seven of phenolic compounds were identified in sugar cane farm extract (Table, 3) where chlorogenic, *p*-hydroxybenzoic; syringic and caffeic acid had the highest percent (25.86, 20.94, 12.59 and 10.86% respectively). At the same time, eight compounds of phenolic were identified in sugar cane bagasse where syringic, *p*-phydroxybenzoic, chlorogenic and caffeic acid had the highest percent (13.71, 13.02, 10.87 and 7.92% respectively). On the other hand their compounds had lower percent comparing with the same compounds in sugar cane farm extract.

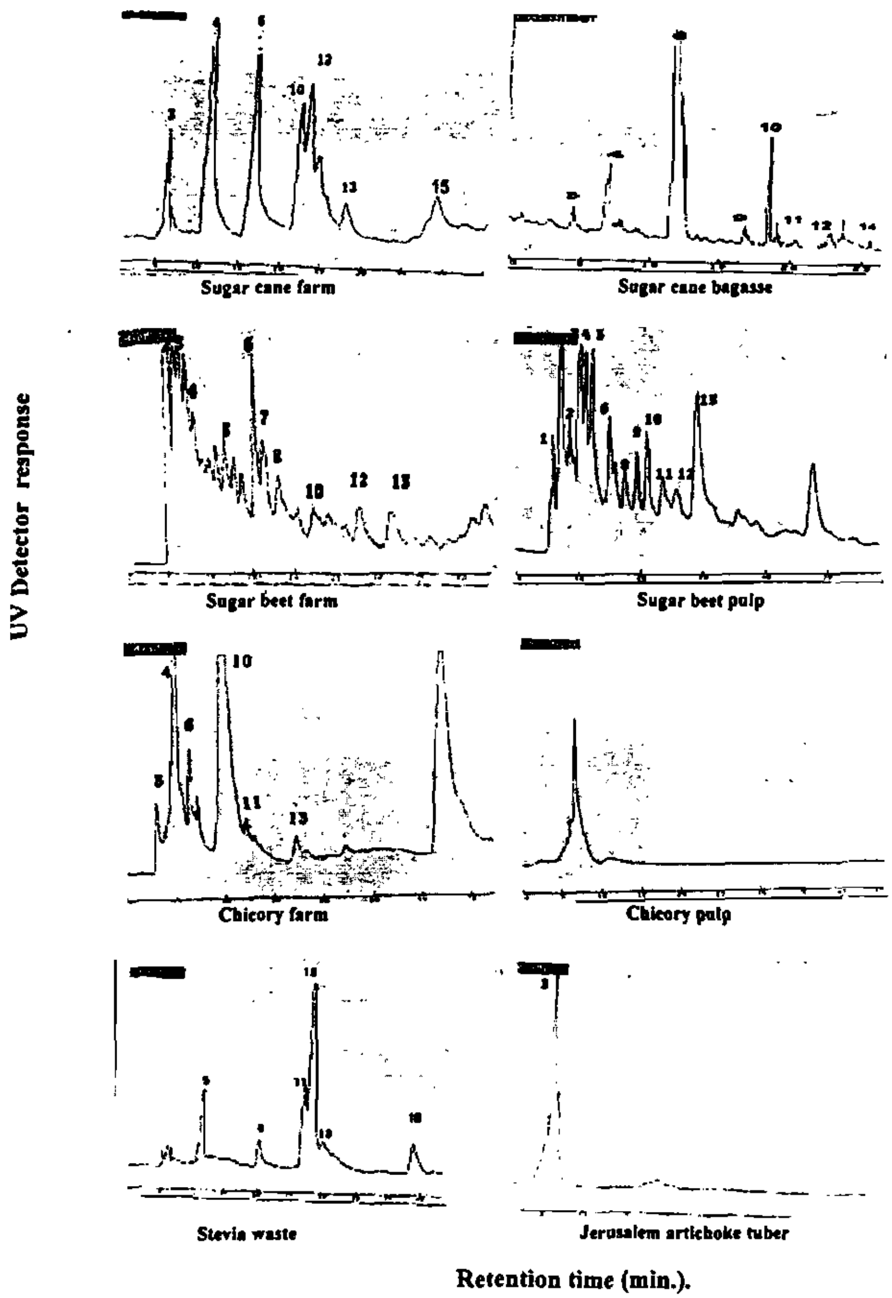

Figure (1) HPLC chromatogram of methanolic extract for some agro industrial wastes of sugar and sweetener crops. peak number: 1,gallic; 2,α resorcylic; 3,protocatechuic; 4,chlorogenic; 5,γ resorcylic; 6, ρ-hydroxybenzoic; 7, β resorcylic; 8, o-pyrocatechuic; 9,vanillic; 10,caffeic; 11,iso vanillic; 12, syrinic; 13, ρ - coumaric; 14,m-coumaric; 15,ferulic; 16,cinnamic acid.

Table (3): Phenolic compounds (%) in methanolic extracts of sugar crops and sweeteners wastes as identified with HPLC.

Samples	Compound name	Phenolic compound (%)
Sugar cane farm (ScF)	- Protocatechuic (3,4 dihydroxybenzoic) acid.	5.96
	- Clorogenic acid	25.86
	- ρ-hydroxybenzoic (4-hydroxybenzoic) acid.	20.94
	- Caffeic (3,4, dihydroxycinnamic) acid.	10.86
	- Syringic (4-hydroxy-3,5-dimethoxy benzoic) acid.	12.59
	- ρ-coumaric (4-hydroxycinnamic)	9.15
	- Ferulic (4-hydroxy-methoxycinnamic)	6.97
	- Unknown two compound	7.67
Sugar cane bagasse (ScB)	- Protocatechuic acid.	4.15
	- Chlorogenic acid	10.87
	- ρ-hydroxybenzoic acid.	13.02
	- Vanillic (4-hydroxy-3 methoxybenzoic) acid.	4.30
	- Caffeic acid.	7.92
	- Isovanillic (3-hydroxy-4 methoxybenzoic) acid.	4.23
	- Syrinic acid.	13.71
	- m-Coumaric (3-hydroxycinnamic) acid.	6.96
	- Unknown two compound	34.84
Sugar beet farm (SbF)	- α-resorcylic acid	6.22
	- Protocatechuic acid	4.69
	- Chlorogenic acid	2.90
	- Y resorcylic acid	4.61
	- ρ-hydroxybenzoic acid	6.78
	- β- resorcylic acid	5.70
	- O. procatechuic acid	2.84
	- Caffeic acid	4.04
	- Syringic acid	2.59
	- ρ-coumaric acid	3.80
	- Unknown five compound	55.83
Sugar beet pulp (SbP)	- Gallic acid	7.98
	- α - resorcylic acid	3.42
	- Protocatechuric acid	5.81
	- Chlorogenic acid	6.82
	- Y resorcylic acid	6.21
	- ρ-hydroxybenzoic acid	5.70
	- O. pyrocatechuic	6.72
	- Vanillic acid	4.04
	- Caffeic acid	6.22
	- Iso vanillic acid	4.04
	- Syringic acid	0.23
	- Ferulic acid	12.83
	- Unknown four compound	27.43
Stevia leaves (SW)	- Y resorcylic acid	8.82
	- Pyrocatechuic acid	4.44
	- Isovanillic acid	27.92
	- Syringic acid	36.42
	- P-Coumeric acid	10.83
	- Cinnamic acid	6.92
	- Unknown two compound	4.65
Jerusalem artichoke tubers (JA)	- Protocabhuic acid	57.61
Chicory Farm (CF)	- Protocabhuic acid	2.27
	- Chlorogenic acid	19.32
	- ρ-hydroxybenzoic acid.	10.72
	- Caffeic acid	39.50
	- Iso vanillic acid.	2.27
	- ρ-coumaric acid	3.50
	- Unknown two compound	22.42
Chicory pulp (CP)	One compound (unknown)	59.08

Paton *et al.* (1992) found that the colour of cane extracts was related to the concentration of flavonoids and chlorogenic acid. These results are similar with results obtained by Armas *et al.* (1999) who studied the phenolic compounds and polyamines in both raw and clarified sugar cane juice. They found that centrifuged juice contained three phenolic compounds from the benzoic acid series and three cinnamic acid derivatives. Chlorogenic acid and caffeic acid ester occurred only as soluble, unconjugated component of the centrifuged juice and low molecular mass carbohydrates preparation contained only ρ-hydroxybenzoic and sysingic acids as components of the first series of phenols, cinnamic acid traces and small amounts of both P-coumaric and caffeic acid associated with the preparation containing SH-PAS polyamines. Rodrigues *et al.* (2001) reported that the highest concentration of phenolic compounds were detected from sugar cane bagasse for syringic acid (0.05%), followed by vanillic acid (0.0421%) and phydroxybenzoic acid (0.02 %).

Ten and twelve phenolic compound were detected in sugar beet farm waste and sugar beet pulp waste respectively which are shown in Table (3) and Figure (1). α-resorcylic acid, ρ-hydroxybenzoic, β resorcylic and protocatechuic acid were shown to be the major phenolic compounds in sugar beet farm amounted to 6.22, 6.78, 5.70 and 4.69%, respectively. But ferulic, gallic, chlorogenic, O. pyrocatechuic and caffeic acid were amounted to 12.83, 7.98, 6.82, 6.72 and 6.22%, respectively which were the represented the highest amount in sugar beet pulp. Luc and Jean-Francois (1999) found that phenolic acid represent approximately 1% in sugar beet pulp and ferulic acid being the major one. Also, Ferreira *et al.* (1999) reported that sugar beet pulp, a by-product of the sugar industry, is relatively rich in ferulic acid (1%).

Six phenolic compounds were identified and two unknown compounds were observed in the stevia waste extract as shown in Figure (1) and Table (3). Syringic, isovanillic acid were amounted to the highest percent of 36.42% and 27.92% respectively, followed by ρ-coumaric acid (10.831) than o-pyrocatechuic acid (4.44%), γ resoraylic (8.82%) and cinnamic acid (6.92%).

Leaves of *Stevia rebaudiana* Bertomi contain a sweet diterpenoid glycosides and several other diterpenes. Since these compounds may be a part of the waste stream produced during processing. Their availability in large quantities could make them into valuable co-products (Sholichin *et al.* 1980 and Pasquel *et al.*, 2000).

In Jerusalem artichoke tubers methanolic extract, has only one phenolic compound (protecatehuic acid) as identified by HPLC.

Also, six compounds of phenolic acids were identified in chicory farm waste (Table 3 and Figure 1) where caffeic, chlorogenic and ρ-hydroxybenzoic acid were amounted to be the highest percent of 39.5, 19.32 and 10.72% respectively when compared with chicory pulp which contained only one compound (unidentified). These results are similar with the results obtained by Mulinacci *et al.* (2001) who reported that chicory (*Chichorium intybus* L. Silvestre) leaves extracts contained chicoric acid, monocaffeoyl ρ-

hydroxcinnamoyl tartaric acid, caffeic acid, chlorogenic acid, quercetin-3-0-*glucuronide, Luteolin-7-0-glucuronide* and quercetin-3-0-glucoside.

4. Antioxidant activity evaluation

Antioxidant activity of the methanolic extracts. *Ziada (2002) found that* the addition of 400 ppm of methanolic extract of sage inhibited the hydroperoxide formation in sunflower oil and had the same effect of 200 ppm of TBHQ added in sunflower oil. Therefore in present study 400 ppm of each methanolic extract were added in sunflower oil to compare its individual antioxidative activity with antioxidative activity of 200 ppm of TBHQ.

The data illustrated in Figure (2) showed a different inhibition effect on peroxide value of sunflower oil with 400 ppm of each methanolic extract of studied samples. The *highest inhibition effect of peroxide formation* was obtained in case of using the methanolic extract of sugar cane farm followed by stevia methanolic extract. In the same time the inhibition effect of stevia extract of 400 ppm on hydroperoxide formation was similar to the *inhibition* effect of 200 ppm TBHQ. All the methanolic extract of samples had an inhibition affect on the hÿdroperoxide formation.

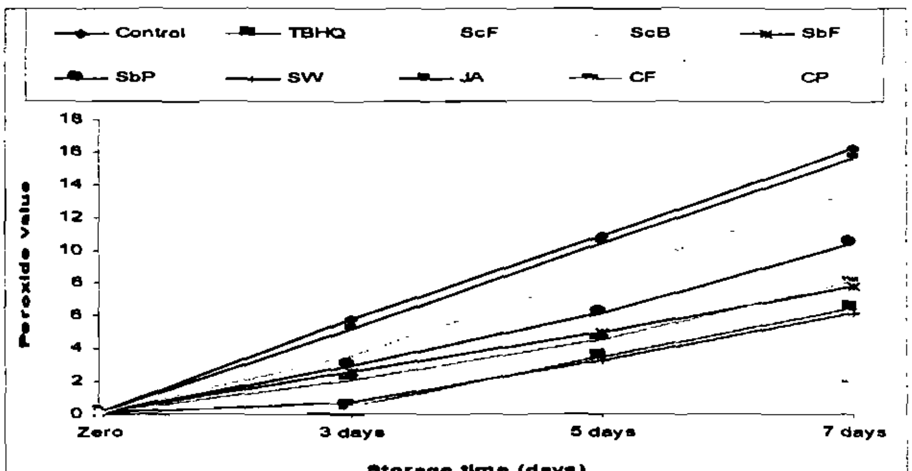

Figure (2). Peroxide value of sunflower oil with added methanol extracts of some agro-industrial wastes of sugar and sweeteners crops during storage time at 60±1°C

The results also revealed that the higher phenolic content had the higher inhibition effect. This finding was in agreement with the conclusion obtained by Hee-Pyo *et al.* (2004) who stated that there is a positive Linear *Correlation (R = 0.943) was demonstrated* between *radical scavenging* activity and total phenolic content of each methanolic extract. Therefore, application such material as antioxidant may provide health promoting advantages to the consumer as a natural antioxidant *and maximize the* utilization of such crops.

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مدخل لاستخدام المخلفات المزرعية والصناعية لمحاصيل السكر والمحليات لإنتاج مضادات الأكسدة الطبيعية

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تم تقدير التركيب التقريبي لبعض المخلفات المزرعية والصناعية للمحاصيل السكرية والمحليات وهي المخلفات المزرعية لقصب ومصاصة لصب السكر وأوراق البنجر ولب البنجر ومخلفات نبات الاستيفيا والطرطوفة وأوراق الشيكوريا ولب الشيكوريا، وتم استخلاص المركبات الفينولية من تلك المخلفات بواسطة الميثانول ثم تم التقدير الكلي لتلك المركبات الفينولية في المستخلصات والتعرف على مجموعة المركبات الفينولية المختلفة في جميع المستخلصات باستخدام HPLC . كذلك تم قياس فاعلية هذه المستخلصات الفينولية كمثبطات ضد الأكسدة وذلك على زيت عباد الشمس عند تخزينه على درجة حرارة ٦٠ ± ١°م لمدة سبعة أيام . وأوضحت النتائج المتحصل عليها أن نسبة المركبات الفينولية في مستخلصات المخلفات التي تمت دراستها تتراوح بين ١,٦٨ إلى ١٦,١٣% من الوزن الجاف وأن مستخلص الاستيفيا هو الأعلى في محتواه من المركبات الفينولية المختلفة يليها مستخلص المخلفات الحقلية للقصب . وأظهرت نتائج التعرف على المركبات الفينولية في المستخلصات باستخدام HPLC سبع مركبات فينولية مختلفة بتركيزات مختلفة في جميع المستخلصات ما عدا مستخلص لب الطرطوفة وكذلك مستخلص لب الشيكوريا التي تحتوي على مركب واحد. وأوضحت نتائج دراسة قياس نشاط المواد المضادة للأكسدة لتلك المستخلصات على زيت عباد الشمس المخزن على درجة ٦٠°م عن طريق تقدير رقم البيروكسيد أن جميع المستخلصات تساعد على خفض رقم البيروكسيد . واتضح أن نشاط مستخلص المخلفات الحقلية لقصب السكر وكذلك مخلفات نبات الاستيفيا هما الأكثر تثبيطا للأكسدة من باقي المستخلصات . مما يعطي إمكانية تطبيق هذه المواد كمضادات للأكسدة حيث أن لها ميزات صحية للمستهلك كمادة طبيعية وفي نفس الوقت تعظيم الاستفادة من هذه المحاصيل .