# Utilization of Orange, Banana and Potato Peels Versus their Ethanolic Extracts as Antioxidants in Corn Oil

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## ABSTRACT

The present study was conducted on three different peels namely, orange, banana and potato along with their ethanolic extracts to reveal their antioxidant potency. Orange peels (OP), banana peels (BP) and potato peels (PP) had the following gross chemical composition: The range of moisture (71.98 – 87.16 %), crude protein (4.99 – 7.89%), total lipids (1.48 – 10.17%), ash (5.64 – 9.41%) and carbohydrates (77.72 – 82.38%). The OP exhibited the highest values of total phenolics (1715.91 mg gallic acid (GA) equivalent / 100g), ascorbic acid (130.82 mg / 100 g) and β- carotene (6.15 mg /100 g) on dry weight basis. Furthermore, the OP ethanolic extract had the highest DPPH$^{\cdot}$ % scavenging (55.00%), the highest $H_2O_2$ % scavenging (42.40%) and the lowest $IC_{50}$ (6.13 mg / mg DPPH$^{\cdot}$) as compared to BP and PP extracts. It was obvious that the peels under study along with their ethanolic extracts exhibited potent antioxidant activity for corn oil. However, OP and its extract were superior in terms of lowering peroxide value, *ρ*- anisidine value and totox value along with treatment with BHT for oils stored at 60°C for 25 days, as compared to the control oil. No significant differences could be traced in this respect between OP and its ethanolic extract.

***Keywords: Orange peels, banana peels, potato peels,ethanolic extracts, total phenolics,corn oil, antioxidant activity.***

## INTRODUCTION

Antioxidants are compounds or systems that are capable to interact with free radicals and terminate the autoxidation reactions and thereby avoid damage of the cell "DNA and protein" (Asimi *et al*., 2013, Oroian & Escriche, 2015). There are some serious problems regarding the safety and toxicity of many of synthetic antioxidants, consequently, the search for natural antioxidants is highly desirable (Linderschmidt *et al.*, 1986).

Nowadays, dietary fiber and bioactive compounds such as antioxidants are widely used as functional ingredients in processed foods. The market in this field is competitive and the development of the food field. In this regard, it is interesting to consider not only the nutritional quality of the ingredients, but also its distribution, cost and other additional benefits, sine the use of these ingredients would give added value to the production of these materials (Elleuch *et al*., 2011).

Food wastes are promising sources for natural bioactive compounds including antioxidants. One of the valorization objectives in food industry is to utilize food wastes for producing fine chemicals and bioactive compounds, (Federici *et al.,* 2009, Elleuch *et al.,* 2011). It was reported that food processing generates about 1.3 billion tons of waste per year which are estimated at more than US$ 400 billion per year according to the Waste Resources Action Programs "WRAP" (WRAP, 2008, FAO, 2013).

It is obvious that the potential benefits of decline food wastes are substantial, because less food wastes leads to more efficiency and more economic productivity (Parry *et al.*, 2015). Numerous research papers have been published regarding utilization of peels belonging to citrus, banana and potato as potent source of bioactive compounds (Nagarajaiah & Prakash, 2011, Barros *et al*., 2012, Khalifa *et al.,* 2015).

The present study was conducted to investigate the chemical composition and the antioxidant potency of orange, banana and potato peels.Moreover, the aforementioned peels versus their ethanolic extracts were compared in terms of their antioxidant potency in corn oil to extend its shelf life.

## MATERIALS AND METHODS

### Materials

About 15 kg each of fresh orange, banana and

potato peels were collected from local food and beverage stores of Alexandria market, Egypt.

Refined bleached and deodorized (RBD) corn oil, free from any additives obtained from Extracted Oil and Derivatives Company, Alexandria, Egypt was used in the present study. All chemicals used in the present study were of analytical grade.

## Samples preparation

The fresh orange peels (OP), banana peels (BP) and potato peels (PP) were collected individually and washed with distilled water. Peels were sun dried for three days, ground using laboratory grinder (Moulinex- AR1044), sieved through 60 mesh sieve, then packed in polyethylene bags and stored finally at – 18ºC until used.

## Chemical analysis

### Gross chemical composition

Moisture, crude protein and ash contents of the three different tested peels were determined according to the AOAC, (2005). Total lipid contents were determined by Folch *et al*. (1957) using a mixture of chloroform and methanol (2:1 v/v). Carbohydrate content was calculated by difference (AOAC, 2005).

### Total phenolics content

Phenolics were extracted from different tested peels using 80% ethanol solvent. Twenty five grams, of OP, BP and PP powders were individually blended with the solvent (1:10 w/v) at room temperature and the extraction was carried out twice, and the combined extracts were collected. The solvent was removed using rotary evaporator (IKA. Com BIMA RCD) at 50°C then, the extracts were lyophilized by using Vir Tis Scientific Lyophilizer. The lyophilized extracts were kept in tightly closed brown bottles and stored at -18°C until used. Yield was calculated as a percentage (g extract/100 g sample). Total phenolics were determined using Folin- Ciocalteu reagent (Singleton *et al.,* 1974).

### Ascorbic acid content

Ascorbic acid was determined using 2, 6 dichlorophenol indophenol dye (Ranganna, 1977), except that 4% oxalic acid in 8% glacial acetic acid was used for sample extraction (Plummer, 1978).

### The β- carotene content

The β- carotene in the tested peels was extracted according to the method described by Tee *et al.* (1996). The β- carotene was determined by RP- HPLC. A Hewlett packared HPLC series 1100, USA equipped with degasser, quaternary pump, auto sampler and diode array detector was used. The mobile phase was: acetone- methanol- ethyl acetate (88:10:2) and with the flow rate of 1.0 ml/ min.

## Antioxidant activity using the DPPH· method

Radical scavenging activity of peel extracts was measured using the stable radical DPPH (2, 2-diphenyl-1- picrylhydrazyl) according to Brand-Williams *et al.* (1995). The percentage of DPPH· scavenging for peel extracts along with ascorbic acid as a standard was calculated as follows:

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

The $IC_{50}$ was determined using different concentrations of peel extracts and ascorbic acid.

## Hydrogen peroxide method

The ability of peels extract under study to scavenge hydrogen peroxide was determined according to Rush *et al.* (1989). The percentage of $H_2O_2$ scavenging of peel extracts and ascorbic acid were calculated as follows.

$$\text{Scavenged \% } [H_2O_2] = [(\text{Abs}_{\text{control}} - \text{Abs}_{\text{sample}}) \times 100] / \text{Abs}_{\text{control}}$$

## Oxidative stability of corn oil

The RBD corn oil, free of additives, was used as the substrate for oxidative stability studies according to the method described by Khemakhem *et al*. (2015).

Oil samples containing 750 and 1500 ppm orange (OP), banana (BP) and potato peel (PP) ethanolic extracts were separately used. The aforementioned whole peels (OP, BP and PP) have been added in different quantities according to its extract yield percentage to obtain a final concentration equivalent to 1500 ppm of the extract for each peel separately. Furthermore, butylatedhydroxy toluene (BHT) as a reference antioxidant was used at a concentration of 200 ppm for comparison along with the control corn oil (neither peel nor extract were added). All the aforementioned materials at their different concentrations have individually blended with 100 ml of corn oil in dry brown tightly closed bottles, then flashed with nitrogen gas and stored for 10 days in cool, dark and dry place to avoid any oxidation. Thereafter, oil was filtered to remove any residue and used directly for oxidation stability test.

Modified Schaal oven test was used to estimate the oxidative stability of corn oil samples versus the control oil (AOCS, 2007). All samples were stored at 60 ± 3ºC for 25 days. Every 4 days, a sample was taken to evaluate its oxidative stability using the following parameters: Peroxide values (AOAC, 2005), *ρ*-anisidine value (IUPAC, 1979) and totox value (Moigradean *et al.,* 2012).

### Statistical analysis

All determinations were carried out in triplicates and data were expressed as mean values ± standard deviation (SD). Data were statistically analyzed and the treatments were subjected to analysis of variance (one way ANOVA) followed by Duncan's multiple comparison test at the 5% level of probability (Steel &Torrie, 1980).

## RESULTS AND DISCUSSION

### Gross chemical composition of peels

Table (1) shows the proximate chemical composition of peels belonging to each of: orange, banana and potato. The moisture content ranged between 71.98% in OP to 87.16% in BP, while the moisture content of PP lied in between and being 85.76 %. In accordance it was reported that the moisture content of OP ranged between 74.80% and 76.01%, (Kammoun *et al.,* 2011, M'hiri *et al.,* 2015) which shows a slight difference from this result. Nagarajaiah & Prakash, (2011) mentioned that the moisture content of BP among three different varieties ranged from 82.6% to 88.9% which was close to this result. Meanwhile, M'hiri *et al*. (2015) found that the moisture content of PP was 79.3% which is slightly lower than that obtained in the present study.

Crude protein content of OP, BP and PP ranged from 4.99 to 7.89%. The BP exhibited the least crude protein content (4.99%), on contrary to PP which possessed the highest content (7.89%) as shown in Table (1). Meanwhile, OP with crude protein content (6.46%) being in between the former results and slightly lower than that previously reported (M'hiri *et al*., 2015) being 8.12%. On the other hand, the result of the crude protein content belongs to BP is in agreement with that reported by Nagarajaiah & Prakash, (2011) being 4.60%, while, Dhingra *et al*. (2012) reported that the crude protein content of PP was 14.04% which was higher than that obtained in the present study.

The OP had obviously the highest total lipids content (10.17%), while the BP exhibited total lipid of 5.42% and the PP tailed behind, since it had 1.84% total lipid content (Table 1). It was reported that OP had total lipid of 13.12 % which was higher than that reported in the present study (Al-Saadi *et al.,* 2009), whereas, Dhingra *et al.* (2012) found that the total lipid content of PP was 1.17% which was close to that found in the present study.

Table (1) reveals that PP possessed the highest ash content (9.41%); on contrary to OP which had the least ash content (5.64%), as for BP, it had ash content being in between the aforementioned two peels (7.3%). It was found that the ash content of OP was 5.51% which was close to this result. In contrast ,Nagarajaiah & Prakash, 2011 found that ash content of BP belonging to three different varieties of banana ranged between 8.98% and 12.96% (Adewole *et al*., 2014).

As it is shown in Table (1), the total carbohydrate content of the three types of peels (OP, BP and PP) ranged from 77.7% to 82.38% which indicates that carbohydrate was the most abundant component for these three peels.

### Total phenolics, ascorbic acid and β-carotene contents

Total phenolics (TP) and ascorbic acid (AA)

**Table 1: Proximate chemical composition of orange, banana and potato peels on dry weight basis**

| Component % | Peels | | |
|---|---|---|---|
| | OP | BP | PP |
| Moisture content | 71.98 ± 0.15 | 87.16 ± 0.25 | 85.76 ± 0.45 |
| Crud protein (N × 6.25) | 6.46 ± 0.29 | 4.99 ± 0.34 | 7.89 ± 0.31 |
| Total lipids | 10.17 ± 0.65 | 5.42 ± 0.45 | 1.48 ± 0.25 |
| Ash | 5.64 ± 0.31 | 7.30 ± 0.2 | 9.41 ± 0.33 |
| Carbohydrate (Calculated by difference) | 77.72 ± 1.16 | 82.38 ± 0.25 | 80.21 ± 0.29 |

Results are expressed as mean of three values ± SD. OP: Orange peel. BP: Banana peel. PP: Potato peel.

contents are presented in Table (2). The TP of OP was relatively higher (1715.91 mg /100 g), while that of BP and PP were 994.26 and 541.97 mg /100 g, respectively. It was reported that TP in the ethanolic extract of OP *Baladi* variety was 169.5 mg /100 g on dry weight basis (DW) (Hegazy& Ibrahim, 2012) whereas, the TP of BP ranged from 850.0 mg tannic acid equivalent / 100 g for methanolic extract of *Nendranbale* variety's (Nagarajaiah & Prakash, 2011). In addition to that, TP in the ethanolic extracts varied from 430.0 mg tannic acid equivalent /100 g to 750.0 mg tannic acid equivalent /100 g in ethanolic extract of *Pachabale* variety. Also, TP in the ethanolic extract of PP, *Lady Claire*varietiys was found to be 431.0 mg GAE /100 g (DW) (Wijngaard *et al.,* 2012).

Table (2) shows a large diversity in AA content among the aforementioned peels. The OP exhibited much higher AA content (130.82 mg /100 g) on contrary to samples of BP and PP which had 14.75 and 7.25 mg /100 g, respectively. The AA content of sour OP was 117.6 mg /100 g (DW) (Ersus & Cam, 2007). The AA content of BP was 17.83 mg/100 g for *Yelakkibale* variety, while it was only 1.79 and 1.80 mg /100 g in *Pachabale* and *Nendranbale* varieties, respectively (Nagarajaiah & Prakash, 2011).

The data presented here indicate that the TP contents of peels under study were found to be significantly correlated with both DPPH$^{\cdot}$ scavenging % and $H_2O_2$ inhibition% ($r$ = 0.999$^{*}$ and 0.997$^{*}$, respectively,). Notwithstanding, none of the following interactions were significantly correlated to each other: Ascorbic acid content x DPPH$^{\cdot}$ scavenging %, ascorbic acid x $H_2O_2$ inhibition% and ascorbic acid x $IC_{50}$.

The point of interest is that the TP contents of peels under study were found to be highly significantly correlated ($r$ = 0.944) with their AA content. It is well known that both TP and AA act as potential antioxidants and may possess synergetic effect. Such finding confirms the significance of utilizing the peels under investigation as potential natural antioxidants. In accordance, Barros *et al.* (2012) found that the antioxidant capacity of four citrus species was correlated to both vitamin C and phenolic acids from citrus pulp, the peels were also good source of some bioactive compounds (minerals) and can be explored for their health promoting values in food products.

The β- carotene content for orange and banana peels were 6.15 and 1.15 mg / 100 g (DW), respectively, as shown in Table (2). Such findings are in agreement with the results reported by Nagarajaiah & Prakash, (2011) who found that β- carotene content of BP was 1.52 mg /100 g in *Yelakkibale* variety, while it was 1.86 and 0.49 mg /100 g in *Pachabale* and *Nendranbale* varieties, respectively.

## Antioxidant activity of ethanolic extract from orange, banana and potato peels

In the present study, two analytical methods (DPPH$^{\cdot}$ and $H_2O_2$ scavenging) were used to determine the antioxidant activity of the ethanolic extracts belonging to OP, BP and PP along with ascorbic acid (AA) as a reference antioxidant. The data given in Table (3) show that OP had the highest DPPH$^{\cdot}$ scavenging activity (55.00%) as compared to both BP (37.50%) and PP (24.21%), while AA exhibited DPPH$^{\cdot}$ scavenging activity of 93.25%.

The $IC_{50}$ value is defined as the concentration of sample that scavenges 50% of DPPH$^{\cdot}$. In this respect, OP was superior (6.13 mg extract / mg DPPH$^{\cdot}$) to both BP (9.42 mg extract / mg DPPH$^{\cdot}$) and PP (21.19 mg extract / mg DPPH$^{\cdot}$) as it is shown in Table (3). On the other hand, AA possessed only $IC_{50}$ of 20.02 mg extract / mg DPPH$^{\cdot}$.

It is worth to mention that the data of $H_2O_2$ scavenging activity were well correlated with their

**Table 2: Total phenolics, ascorbic acid and β- carotene contents of orange, banana and potato peels on dry weight basis**

| Component | Peels | | |
|---|---|---|---|
| | OP | BP | PP |
| Total phenolics (mg gallic acid equivalent / 100 g) | 1715.91 ± 4.02 | 994.26 ± 2.1 | 541.97 ± 2.21 |
| Ascorbic acid (mg / 100 g) | 130.82 ± 3.65 | 14.75 ± 0.86 | 7.25 ± 0.51 |
| β- carotene (mg / 100 g) | 6.15 | 1. 15 | N.D |

Results are expressed as mean of three values ± SD.

OP: Orange peel, BP: Banana peel,PP: Potato peel,N.D: Not detected.

counterparts of DPPH· scavenging activity. In other words, the aforementioned peel extracts can be ordered descendingly in terms of $H_2O_2$ scavenging activities as follows: OP (52.40%), BP (40.15%) and PP (30.11%). Meanwhile, AA exhibited $H_2O_2$ scavenging activity of 96.37% (Table 3).

The data indicated that OP and BP can be considered as potential antioxidants, with OP being superior in this regard. These data are in accordance with other authors, who found that the DPPH· scavenging activity of OP from two cultivars, ranged from 65.0% to 72.0%, (Abd El-aal & Halaweish, 2010) whereas, the DPPH· scavenging activity of BP ranged from 26.55% to 52.66% as found by other authors (Choo & Azis, 2010).

The potent antioxidant activity of such peels can be attributed to their high content of phenolics. Numerous researchers confirmed the role of these compounds as potential antioxidants (Huang *et al*., 2005, Moharram & Youssef, 2014, Alshikh *et al.,* 2015, Oroian & Escriche, 2015).

The point of interest is that up to date there is no universal and simple method to evaluate qualitatively and quantitatively the antioxidant activity (Huang *et al.,* 2005). Therefore, comparative assessment using different antioxidant evaluation methods strongly suggests that not all the adopted methods are highly related and thereby antioxidant capacity should be evaluated by more than one method (Moharram & Youssef, 2014).

## Oxidative stability of corn oil

Three parameters, peroxide value (PV) a very important parameter that monitors the oxidative process in its early stages, *ρ*-anisidine value (*ρ*-AV) another important parameter that determines the secondary oxidation products and totox value (TOV) were assessed during the storage period of corn oil at 60ºC for 25 days at regular intervals.

## Oil treated with orange peel (OP) and its extract

The results show that different additions of OP to corn oil exhibited the highest oxidative stability throughout the 25 days of storage where the PV at zero time was 1.21 mEq $O_2$ / kg followed by orange peel extract (OPE) at 1500 ppm with PV of 1.24 mEq $O_2$ / kg and was more stable than BHT treatment (as reference) with PV 1.31 mEq $O_2$ / kg at zero time (Table 4). The PV for oils treated with OP and OPE at 1500 ppm and BHT were always significantly lower (33.93, 35.59 and 38.17 mEq/$O_2$ / kg, respectively) during the entire storage period until the last day of storage compared to the control (101.2 mEq $O_2$ / kg) which usually exhibits the highest value.

Almost the *ρ*-AV and TOV followed the same trends as the PV (Table 4) where, the addition of OP or OPE at 1500 ppm and BHT to corn oil exhibited the lowest values of *ρ*-AV (2.05, 2.16 and 2.03, respectively) as well as for TOV (4.48, 4.64 and 4.66, respectively) followed by the oil treated with OPE at 750 ppm. In other study, Abd El-aal & Halaweish, (2010) mentioned that the PV of oil treated with OPE at 1200 and 1600 ppm had higher inhibition for soy bean oil peroxidation than that of synthetic antioxidants BHT and BHA at 200 ppm. Notwithstanding, the addition of methanolic extract of citrus peel exhibited considerable antioxidant potency during storage of refined corn oil. The level of citrus peel extract was 8–10 times higher than that of synthetic antioxidant to control the development of rancidity in corn oil. As expected, the control treatment possessed the highest values for *ρ*-AV (2.40) and TOV (6.09) as well as for PV (Rehman, 2006).

## Oil treated with banana peel (BP) and its extract

The results presented in Table (5) show that the oil treated with banana peel extract BPE at 1500

**Table 3: Antioxidant activity of orange, banana and potato peels**

| Test | Extract | | | AA |
|---|---|---|---|---|
| | OPE | BPE | PPE | |
| DPPH· % Scavenging | 55.00 ± 1.42 | 37.50 ± 1.26 | 24.21 ± 0.91 | 93.25 ± 1.93 |
| $IC_{50}$ ( mg/mg DPPH) | 6.13 ± 0.79 | 9.42 ± 0.48 | 21.19 ±1.41 | 20.02 ± 2.61* |
| Hydrogen peroxide % scavenging | 52.40 ± 1.15 | 40.15 ± 0.95 | 30.11 ± 1.21 | 96.37 ± 1.47 |

Results are expressed as mean values ± SD.
*Microgram /mg DPPH
OPE: Orange peel ethanolic extract.
BPE: Banana peel ethanolic extract.
PPE: Potato peel ethanolic extract.
AA: Ascorbic acid.

**Table 4: Changes in peroxide, *ρ*-anisidine and totox values of corn oil treated with orange peel, orange peel extract and BHT during storage at 60ºC for 25 days**

| Test | Oxidation periods (day) | Control | Orange peel extract | | Orange peel | Reference |
|---|---|---|---|---|---|---|
| | | | 750 ppm | 1500 ppm | Equivalent 1500 ppm | BHT |
| Peroxide value | 0 | 1.84$^{a}$ | 1.56$^{b}$ | 1.24$^{c}$ | 1.21$^{c}$ | 1.31$^{c}$ |
| | 4 | 6.29$^{a}$ | 4.09$^{b}$ | 2.73$^{cd}$ | 2.44$^{d}$ | 3.04$^{c}$ |
| | 7 | 15.53$^{a}$ | 7.07$^{b}$ | 4.70$^{d}$ | 4.13$^{e}$ | 5.15$^{c}$ |
| | 11 | 28.17$^{a}$ | 16.2$^{b}$ | 8.21$^{d}$ | 7.31$^{e}$ | 9.61$^{c}$ |
| | 14 | 37.75$^{a}$ | 25.18$^{b}$ | 16.22$^{d}$ | 15.22$^{d}$ | 17.27$^{c}$ |
| | 18 | 58.65$^{a}$ | 41.78$^{b}$ | 22.83$^{d}$ | 21.78$^{d}$ | 26.80$^{c}$ |
| | 21 | 88.27$^{a}$ | 50.23$^{b}$ | 32.19$^{d}$ | 30.71$^{e}$ | 34.31$^{c}$ |
| | 25 | 101.20$^{a}$ | 58.43$^{b}$ | 35.59$^{cd}$ | 33.93$^{d}$ | 38.17$^{c}$ |
| *ρ*-anisidine value | 0 | 2.40$^{a}$ | 2.31$^{ab}$ | 2.16$^{bc}$ | 2.05$^{c}$ | 2.03$^{c}$ |
| | 4 | 3.01$^{a}$ | 2.88$^{ab}$ | 2.74$^{abc}$ | 2.59$^{bc}$ | 2.47$^{c}$ |
| | 7 | 3.95$^{a}$ | 3.72$^{ab}$ | 3.49$^{bc}$ | 3.32$^{cd}$ | 3.11$^{d}$ |
| | 11 | 6.44$^{a}$ | 5.41$^{b}$ | 4.56$^{cd}$ | 4.15$^{d}$ | 4.87$^{c}$ |
| | 14 | 9.97$^{a}$ | 7.39$^{b}$ | 6.72$^{c}$ | 5.42$^{d}$ | 6.87$^{c}$ |
| | 18 | 15.85$^{a}$ | 12.14$^{b}$ | 9.03$^{cd}$ | 8.75$^{d}$ | 9.41$^{c}$ |
| | 21 | 19.71$^{a}$ | 15.44$^{b}$ | 13.02$^{c}$ | 11.69$^{e}$ | 12.37$^{d}$ |
| | 25 | 26.64$^{a}$ | 19.95$^{b}$ | 16.81$^{c}$ | 15.96$^{d}$ | 16.15$^{d}$ |
| Totox value | 0 | 6.09$^{a}$ | 5.43$^{b}$ | 4.64$^{c}$ | 4.48$^{c}$ | 4.66$^{c}$ |
| | 4 | 15.59$^{a}$ | 11.06$^{b}$ | 8.20$^{cd}$ | 7.48$^{d}$ | 8.55$^{c}$ |
| | 7 | 35.00$^{a}$ | 17.87$^{b}$ | 12.90$^{c}$ | 11.59$^{d}$ | 13.41$^{c}$ |
| | 11 | 62.79$^{a}$ | 37.82$^{b}$ | 20.98$^{e}$ | 18.78$^{d}$ | 24.09$^{c}$ |
| | 14 | 85.48$^{a}$ | 57.76$^{b}$ | 39.16$^{d}$ | 35.87$^{e}$ | 41.41$^{c}$ |
| | 18 | 132.89$^{a}$ | 95.71$^{b}$ | 54.7$^{d}$ | 52.31$^{e}$ | 63.14$^{c}$ |
| | 21 | 196.26$^{a}$ | 115.91$^{b}$ | 77.41$^{d}$ | 73.12$^{e}$ | 80.99$^{c}$ |
| | 25 | 229.06$^{a}$ | 136.81$^{b}$ | 88.00$^{cd}$ | 83.82$^{d}$ | 92.51$^{c}$ |

Results are mean of three values.
Values with the same superscript within the same row are not significantly different ($P \leq 0.05$).

ppm had high antioxidant potency (with always lower PV) at zero time (1.28 mEq $O_2$ /kg) as well as over the storage period till the last day of storage (37.80 mEq $O_2$ /kg) followed by the oil treated with BP where the PV was 1.30 mEq $O_2$ / kg and being very close to the BHT treatment with PV of 1.31 mEq $O_2$ / kg at zero time. No significant differences could be observed among the three treatments at zero time as well as over the storage period. On the other hand, a significant difference existed with oil treated with BHT and BPE at 1500 ppm (38.17 and 37.80 mEq $O_2$ /kg) compared to oil treated with 750 ppm and the control (58.66 and 101.20 mEq $O_2$ / kg) after 25 days of storage at 60°C.

The oil treated with BP showed higher PV (lower oxidative stability) as compared to oil treated with BPE at 1500 ppm and BHT. Also, oil treated with BP represented higher PV (lower antioxidant potency) all over the entire storage period as shown in Table (5) compared to oil treated with OP as shown in Table (4). This may be due to the hydrophobic nature of the bioactive components responsible for the antioxidant activity such as β-carotene in OP which can be easily extracted in the oil and increase the antioxidant potency of the treated oil.

Almost the *ρ*-AV and TOV of the treated oil followed the same trend as for the PV where, the addition of BHT, BPE (1500 ppm) and BP to corn oil exhibited the highest oxidative stability and the lowest values of *ρ*-AV (2.03, 2.28 and 2.33, respectively) as compared with the other treatments (BPE at 750 ppm and the control) which showed *ρ*-AV of 2.57 and 2.40, respectively. This trend was almost

**Table 5: Changes in peroxide, *ρ*-anisidine and totox values of corn oil treated with banana peel, banana peel extract and BHT during storage at 60ºC for 25 days**

| Test | Oxidation periods (day) | Control | Banana peel extract | | Banana peel | Reference |
|---|---|---|---|---|---|---|
| | | | 750 ppm | 1500 ppm | equivalent 1500 ppm | BHT |
| Peroxide value | 0 | 1.84$^{a}$ | 1.56$^{b}$ | 1.28$^{c}$ | 1.30$^{c}$ | 1.31$^{c}$ |
| | 4 | 6.29$^{a}$ | 4.04$^{b}$ | 3.26$^{b}$ | 3.94$^{b}$ | 2.04$^{c}$ |
| | 7 | 15.53$^{a}$ | 7.02$^{b}$ | 5.22$^{c}$ | 5.57$^{c}$ | 5.15$^{c}$ |
| | 11 | 28.17$^{a}$ | 16.6$^{b}$ | 10.05$^{cd}$ | 11.01$^{c}$ | 9.61$^{d}$ |
| | 14 | 37.75$^{a}$ | 25.34$^{b}$ | 17.14$^{c}$ | 18.12$^{c}$ | 17.27$^{c}$ |
| | 18 | 58.65$^{a}$ | 41.52$^{b}$ | 27.23$^{d}$ | 29.22$^{c}$ | 26.80$^{d}$ |
| | 21 | 88.27$^{a}$ | 50.45$^{b}$ | 37.42$^{d}$ | 39.13$^{c}$ | 34.31$^{e}$ |
| | 25 | 101.20$^{a}$ | 58.66$^{b}$ | 37.80$^{d}$ | 44.35$^{c}$ | 38.17$^{d}$ |
| *ρ*-anisidine value | 0 | 2.40$^{ab}$ | 2.57$^{a}$ | 2.28$^{b}$ | 2.33$^{ab}$ | 2.03$^{c}$ |
| | 4 | 3.01$^{a}$ | 2.95$^{ab}$ | 2.51$^{c}$ | 2.66$^{bc}$ | 2.47$^{c}$ |
| | 7 | 3.95$^{a}$ | 3.89$^{ab}$ | 3.61$^{b}$ | 3.74$^{ab}$ | 3.11$^{c}$ |
| | 11 | 6.44$^{a}$ | 6.05$^{a}$ | 4.91$^{c}$ | 5.39$^{b}$ | 4.87$^{c}$ |
| | 14 | 9.97$^{a}$ | 8.29$^{b}$ | 6.86$^{c}$ | 7.12$^{c}$ | 6.87$^{c}$ |
| | 18 | 15.58$^{a}$ | 13.15$^{b}$ | 10.21$^{d}$ | 11.49$^{c}$ | 9.41$^{e}$ |
| | 21 | 19.71$^{a}$ | 16.64$^{b}$ | 13.70$^{d}$ | 14.53$^{c}$ | 12.37$^{e}$ |
| | 25 | 26.64$^{a}$ | 20.74$^{b}$ | 17.31$^{d}$ | 18.26$^{c}$ | 16.15$^{e}$ |
| Totox value | 0 | 6.09$^{a}$ | 5.75$^{b}$ | 4.85$^{c}$ | 4.94$^{c}$ | 4.66$^{c}$ |
| | 4 | 15.59$^{a}$ | 11.03$^{b}$ | 9.70$^{c}$ | 10.56$^{bc}$ | 8.55$^{d}$ |
| | 7 | 35.00$^{a}$ | 17.93$^{b}$ | 14.06$^{cd}$ | 14.89$^{c}$ | 13.41$^{d}$ |
| | 11 | 62.79$^{a}$ | 39.26$^{b}$ | 25.01$^{d}$ | 27.43$^{c}$ | 24.09$^{d}$ |
| | 14 | 85.48$^{a}$ | 58.99$^{b}$ | 41.15$^{c}$ | 43.37$^{c}$ | 41.41$^{c}$ |
| | 18 | 132.90$^{a}$ | 96.20$^{b}$ | 64.67$^{d}$ | 69.93$^{c}$ | 63.14$^{d}$ |
| | 21 | 196.26$^{a}$ | 117.56$^{b}$ | 88.54$^{d}$ | 92.98$^{c}$ | 80.99$^{e}$ |
| | 25 | 229.06$^{a}$ | 138.20$^{b}$ | 92.91$^{d}$ | 106.96$^{c}$ | 92.51$^{d}$ |

Results are mean of three values.
Values with the same superscript within the same row are not significantly different ($P \leq 0.05$).

the same throughout the storage period for 25 days at 60ºC for the different treatments under study.

## Oil treated with potato peel (PP) and its extracts

The results show that the oil treated with BHT had the highest antioxidant potency (lowest PV) at zero time (1.31 mEq $O_2$/kg) as well as after storage for 25 days at 60°C (38.17 mEq $O_2$ /kg) compared to the other four treatments, The BHT (200 ppm) exhibited the highest inhibition of thermal deterioration of corn oil compared with potato peel extract (PPE) (1500 – 750 ppm) and PP.

On the other hand, the oil treated with PPE at 1500 ppm exhibited lower values of PV, *ρ*-AV and TOV compared with the control, PP and PPE at 750 ppm during the entire storage period for 25 days at 60ºC. The PV, *ρ*-AV and TOV of the oil treated with PPE (1500 ppm) were 62.30 mEq $O_2$ /kg, 20.40 and 145.00, respectively, while, for the control oil the PV, *p*-AV and TOV values reached the highest levels (101.2 mEq $O_2$ /kg, 26.64 and 229.6, respectively). In other study, El- Shorbagy *et al.* (2014) reported that the PV was in the range from 64.21–147.34 mEq $O_2$ / kg for sunflower oil treated with potato peel methanolic extract at 250, 500 and 1000 ppm after 24 days of storage at 65ºC.

The data in Table (6) show the low antioxidant potency for PP and its extracts at different levels (750 and 1500 ppm) compared to both OP and BP and their extract at the same levels (750-1500 ppm) as shown in Table (4) and (5).

The *ρ*-AV and TOV of corn oil followed the same trend as for PV of corn oil treated with PP and its extracts at zero time and also during storage at 60ºC for 25 days; which convince the very low antioxidant potency for PP as well as for its extract (Table 6).

Corn oil treated with PPE at both levels (750 and 1500 ppm) exhibited lower values regarding PV, *ρ*- AV and TOV as compared to corn oil treated with PP at the end of the storage period , indicating the higher antioxidant potency for PPE against PP (Table 6) . This may be also due to the hydrophilic nature of the antioxidant components in PP such as phenolic compounds which can be extracted easily with ethanol as a solvent before adding it to corn oil and thereby elevatets oxidative stability.

## CONCLUSION

The present study obviously explored the significance of utilizing orange and banana peels as potent antioxidants to extend the shelf- life of corn oil as monitored by PV, *p*-AV and Totox values. Peels were comparable to their ethanolic extracts in terms of elongation the shelf life of corn oil. However, orange peels and their ethanolic extracts were superior in extending the shelf life of corn oil as

**Table 6: Changes in peroxide, *ρ*-anisidine and totox values of corn oil treated with potato peel, potato peel extract and BHT during storage at 60ºC for 25 days**

| Test | Oxidation periods (day) | Control | Potato peel extract | | Potato peel | Reference |
|---|---|---|---|---|---|---|
| | | | 750 ppm | 1500 ppm | Equivalent 1500 ppm | BHT |
| Peroxide value | 0 | 1.84$^{a}$ | 1.60$^{b}$ | 1.69$^{ab}$ | 1.56$^{b}$ | 1.31$^{c}$ |
| | 4 | 6.29$^{a}$ | 5.25$^{ab}$ | 4.05$^{c}$ | 5.82$^{b}$ | 2.04$^{d}$ |
| | 7 | 15.53$^{a}$ | 9.89$^{b}$ | 8.14$^{c}$ | 9.52$^{b}$ | 5.15$^{d}$ |
| | 11 | 28.17$^{a}$ | 20.23$^{b}$ | 18.27$^{c}$ | 21.28$^{b}$ | 9.61$^{d}$ |
| | 14 | 37.75$^{a}$ | 31.01$^{b}$ | 28.11$^{c}$ | 29.4$^{bc}$ | 17.27$^{d}$ |
| | 18 | 58.65$^{a}$ | 47.51$^{b}$ | 44.93$^{c}$ | 46.53$^{b}$ | 26.8$^{d}$ |
| | 21 | 88.27$^{a}$ | 58.55$^{b}$ | 54.55$^{c}$ | 57.28$^{b}$ | 34.31$^{d}$ |
| | 25 | 101.20$^{a}$ | 65.32$^{b}$ | 62.30$^{c}$ | 67.58$^{b}$ | 38.17$^{d}$ |
| *ρ*-anisidine | 0 | 2.40$^{ab}$ | 2.59$^{ab}$ | 2.42$^{b}$ | 2.78$^{a}$ | 2.03$^{c}$ |
| value | 4 | 3.01$^{a}$ | 3.03$^{a}$ | 3.09$^{a}$ | 3.08$^{a}$ | 2.47$^{b}$ |
| | 7 | 3.95$^{a}$ | 3.88$^{a}$ | 3.42$^{b}$ | 4.02$^{a}$ | 3.11$^{b}$ |
| | 11 | 6.44$^{a}$ | 6.34$^{a}$ | 5.89$^{b}$ | 6.29$^{ab}$ | 4.87$^{c}$ |
| | 14 | 9.97$^{a}$ | 8.74$^{c}$ | 7.90$^{d}$ | 9.05$^{b}$ | 6.87$^{e}$ |
| | 18 | 15.58$^{a}$ | 14.32$^{b}$ | 12.71$^{c}$ | 14.34$^{b}$ | 9.41$^{d}$ |
| | 21 | 19.71$^{a}$ | 17.74$^{b}$ | 16.33$^{c}$ | 18.17$^{b}$ | 12.37$^{d}$ |
| | 25 | 26.64$^{a}$ | 21.61$^{c}$ | 20.40$^{c}$ | 23.53$^{b}$ | 16.15$^{d}$ |
| Totox value | 0 | 6.09$^{a}$ | 5.82$^{b}$ | 5.80$^{b}$ | 5.88$^{b}$ | 4.66$^{c}$ |
| | 4 | 15.59$^{a}$ | 13.54$^{b}$ | 11.02$^{c}$ | 14.73$^{ab}$ | 8.55$^{d}$ |
| | 7 | 35.00$^{a}$ | 23.66$^{b}$ | 19.71$^{c}$ | 23.07$^{b}$ | 13.41$^{d}$ |
| | 11 | 62.79$^{a}$ | 46.81$^{b}$ | 42.43$^{c}$ | 48.85$^{b}$ | 24.09$^{d}$ |
| | 14 | 85.48$^{a}$ | 70.77$^{b}$ | 64.13$^{c}$ | 67.86$^{b}$ | 41.41$^{d}$ |
| | 18 | 132.89$^{a}$ | 109.35$^{b}$ | 102.58$^{c}$ | 107.41$^{b}$ | 63.14$^{d}$ |
| | 21 | 196.26$^{a}$ | 134.75$^{b}$ | 125.44$^{c}$ | 132.84$^{b}$ | 80.99$^{d}$ |
| | 25 | 229.06$^{a}$ | 152.27$^{b}$ | 145.00$^{c}$ | 158.7.00$^{b}$ | 92.51$^{d}$ |

Results are mean of three values.
Values with the same superscript within the same row are not significantly different (P≤ 0.05).

compared to banana and potato peels. Consequently, orange peels can be used as a natural potent antioxidant for different oils.

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# استخدام قشورالبرتقال والموز والبطاطس مقابل مستخلصاتها الكحولية كمضادات أكسدة في زيت الذرة

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أجريت هذه الدراسة على ثلاثة أنواع مختلفة من القشور هى قشور البرتقال ، الموز والبطاطس ومستخلصاتها الكحولية ، للكشف عن فعاليتها المضادة للأكسدة. وكان التركيب الكيماوي الإجمالي لهذه القشور كما يلي : تراوحت نسبة الرطوبة مابين (٧١,٩٨- ٨٧,١٦٪)، البروتين الخام (٤,٩٩-٧,٨٩٪) ، الليبيدات الكلية (١,٤٨ - ١٠,١٧٪) والرماد (٥,٦٤-٩,٤١٪) والكربوهيدرات (٧٧,٧٢ - ٨٢,٣٨٪). كما أظهرت قشور البرتقال أعلى القيم للفينولات الكلية (١٧١٥,٩١ ملجم مكافئات حمض الجاليك / ١٠٠جم)، وحمض الأسكوربيك (١٣٠,٨٢ ملجم / ١٠٠جم) والبيتا- كاروتين (٦,١٥ ملجم / ١٠٠جم) على أساس الوزن الجاف. بالإضافة إلي ذلك ، كان للمستخلص الإيثانولي لقشور البرتقال القيمة الأعلى لكسح شوارد DPPH الحرة (٥٥,٠٠٪) والأعلى لكسح شوارد $H_2O_2$ الحرة (٤٢,٤٠٪) والأقل لقيمة $IC_{50}$ ( ٦,١٣ملجم / ملجمDPPH ) مقارنة بمستخلصات قشور الموز والبطاطس. وكان واضحاً أن القشور قيد الدراسة أظهرت نشاطاً قوياً مضاداَ للأكسدة لزيت الذرة جنباً إلى جنب مع مستخلصاتها الكحولية. ومع ذلك ، كانت قشور البرتقال ومستخلصها الكحولي متفوقة من حيث خفض قيم كل من رقم البيروكسيد ، البارا- أنسيدين والتوتوكس مقارنة بالمعاملة بمضاد الأكسدة الصناعي BHT لزيت الذرة المخزن على درجة حرارة ٦٠°م لمدة ٢٥ يوماً أيضاً مقارنة بالكونترول. كما لم يلاحظ وجود أي اختلاف معنوي في هذا الصدد بين قشور البرتقال ومستخلصها الكحولي.