J. Food and Dairy Sci., Mansoura Univ., Vol. 8 (3): 137- 143, 2017

Effect of *Eucalyptus* Leaves Powder on the Nutritional Value and Organoleptic Properties of Cookies

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ABSTRACT

Eucalyptus camaldulensis L. is a widely grown trees in Egypt and commonly used as medicinal plant. The present study aims at highlighting the nutritive potential of *Eucalyptus* leaves powder (ELP) and its possible utilization as supplementation for cookies. The chemical composition, minerals and the bioactivity of dried leaves powder as well as the cookies supplemented with variable ratios of ELP at 0 (control), 1.5, 3.0, 4.5, 6.0 and 7.5% were determined. Free fatty acids during 60 days' storage, peroxide value and the physical properties of cookies were also determined. ELP supplementation significantly improved phenolic and mineral composition as well as the antioxidant activities of the products using 2, 2-diphenyl-1-picrylhydrazyl (DPPH) and β-Carotene-linoleic acid assays. ELP supplementation enhanced the dietary fibers, minerals and ash compositions along with reduced fat values in some treatments compared to control in cookies. ELP supplementation (7.5% ELP) showed almost 45% higher stability in supplemented cookies compared to the control. ELP supplementation at 1.5-4.5% was acceptable in the overall acceptability sensory evaluation and was in the range from 8.14 to 7.66, which might be encouraging for future application in the cookies industry in Egypt. The present study suggests that cookies supplemented with ELP might enhance the mineral composition, antioxidant values, storage stability and physical properties of products.

Keywords: cookies, Eucalyptus, nutritional value, organoleptic properties, antioxidants

INTRODUCTION

Eucalyptus is one of the world's important and most widely planted genera belongs to Family Myrtaceae which includes 140 genera and about 3800 species grown in tropical and subtropical parts of the world Ali *et al*., (2011) and Akin *et al*., (2010). *Eucalyptus* is an evergreen tree, native to Australia and Tasmania, and successfully introduced and planted in worldwide countries Mubita *et al*., (2008). *Eucalyptus* species are well-known as medicinal plants because of their biological and pharmacological properties Bachheti *et al*., (2011), Elaissi *et al*., (2011), Nezhad *et al*., (2009), Song *et al*., (2009), Salari *et al*., (2006) and Oyedeji *et al*.,(1999). The extracts of *Eucalyptus* species are used to control several diseases derived from microbial infections Ghalem and Mohamed (2008). Leaf extracts of some *Eucalyptus* species have been approved as food additives, and the extracts are also currently used in cosmetic formulations Takahashi *et al*., (2004). The chemical composition of the essential oil from the genus *Eucalyptus* had been well characterized. Terpenes (isoprenoids) are produced in large amount in the essential oil of the *Eucalyptus* species which are accumulated in glands abundantly distributed throughout the leaf parenchyma and bark Rakotonirainy and Lavédrine (2005) & Moleyar and Narasimham (1986). Natural antioxidants are current important resources of medicinal and food industry, especially with the rising community awareness of the importance of these compounds in the reduction of free radicals, cancer infections and elder symptoms Elansary and Ashmawy (2013) and Elansary *et al*., (2012). *Eucalyptus* trees are common in Egypt, hence; represent a cheap resource of plant material such as leaves.

Bakery products such as cookies may contain several useful supplements Dhingra *et al*., (2012). In such industry, the flour is the base material of cookies and contain many useful compositions such as the carbohydrates. Supplements used with flour may contain fiber, minerals and antioxidants as recently found in several studies Youssef and Mousa, (2012) , Ismail *et al*., (2014), and Soma *et a*l., (2016). Supplementing flour in cookies industry may raises concerns regarding consumer's acceptability for color, taste, texture and other baking characteristics Kulkarni and Joshi (2013). From this point of view, any new supplementation need to be investigated thoroughly to evaluate nutritional and organoleptic of the product and therefore a novel approach to enhance the medicinal and nutritional values of cookies products using local plant materials was studied, and it was proposed that ELP supplemented cookies might have additive healthy values by means of enhanced phenolic and antioxidant activities. Further, the nutritional value as well as the organoleptic properties such as taste, color texture and other characteristics were also evaluated.

MATERIALS AND METHODS

Materials

Plant material

Leaf samples were collected in October 2016 from grown plants of *E. camaldulensis*, located at Antoniades Gardens, Alexandria, Egypt. Samples were identified by Prof. Ahmed A. El-Settawy (Department of Forestry and Wood Technology, Faculty of Agriculture, Alexandria University).

Cookies ingredients

Commercial wheat flour (72% extract), and baking ingredients were purchased from the local markets of Damietta city, Egypt.

Chemicals

All solvents and chemicals were analytical grade and purchased from Sigma Aldrich Company, Egypt.

Methods

Leaves dehydration

The fresh leaves of Eucalyptus (*Eucalyptus camaldulensis L.*) were air dried for 5 days at room temperature and ground twice into powder using a grinder (Moulinex, France). The *Eucalyptus* leaves powder (ELP) was sieved through a 60 mesh screen until fine powder was obtained and kept frozen at -18°C in polyethylene pages until used.

Cookies preparation

Cookies were prepared with little modification in the method No. 10-50D described in AACC (2000) as presented in Figure 1. Mixtures of wheat flour (72%)

and ELP were prepared by substituting the wheat flour with ELP at 0 (control), 1.5, 3.0, 4.5, 6.0 and 7.5%. The cookies were formulated and blended with the other ingredients as shown in Table 1:

Table 1. Ingredients of the chicken burger samples.

Ingredient %	Treatments					
	T0	T1	T2	T3	T4	T5
Wheat flour (72%)	41.70	40.20	38.70	37.20	35.70	34.2
Sugar powder	21.00	21.00	21.00	21.00	21.00	21.00
Shortening	21.00	21.00	21.00	21.00	21.00	21.00
Eggs	15.00	15.00	15.00	15.00	15.00	15.00
Baking powder	1.00	1.00	1.00	1.00	1.00	1.00
Salt	0.3	0.3	0.3	0.3	0.3	0.3
ELP %	-	1.5	3	4.5	6	7.5
Total	100	100	100	100	100	100

As shown in Figure (1), the dry ingredients were weighed accurately. Shortening and sugar were mixed in Kitchen Mixer (Moulinex, France) and eggs were added one by one. The wheat flour along with pre-weighed proportions of Eucalyptus dried powder were homogenously mixed and blended with baking powder and sifted. The flour and leaf powder composite were added to sugar- shortening -egg mass and mixed to get a homogeneous mass. The dough was rolled out to uniform thickness 3.5 mm with the help of the rolling pin. Cookies were cut out with the help of cookie cutter (51-mm diameter) and placed in trays. Baking was done in a conventional oven (universal, Egypt) at 170–180 °C for 15–20 min. Cookies were allowed to cool at room temperature for 8–10 min and stored in airtight glass jars at room temperature for further analysis.

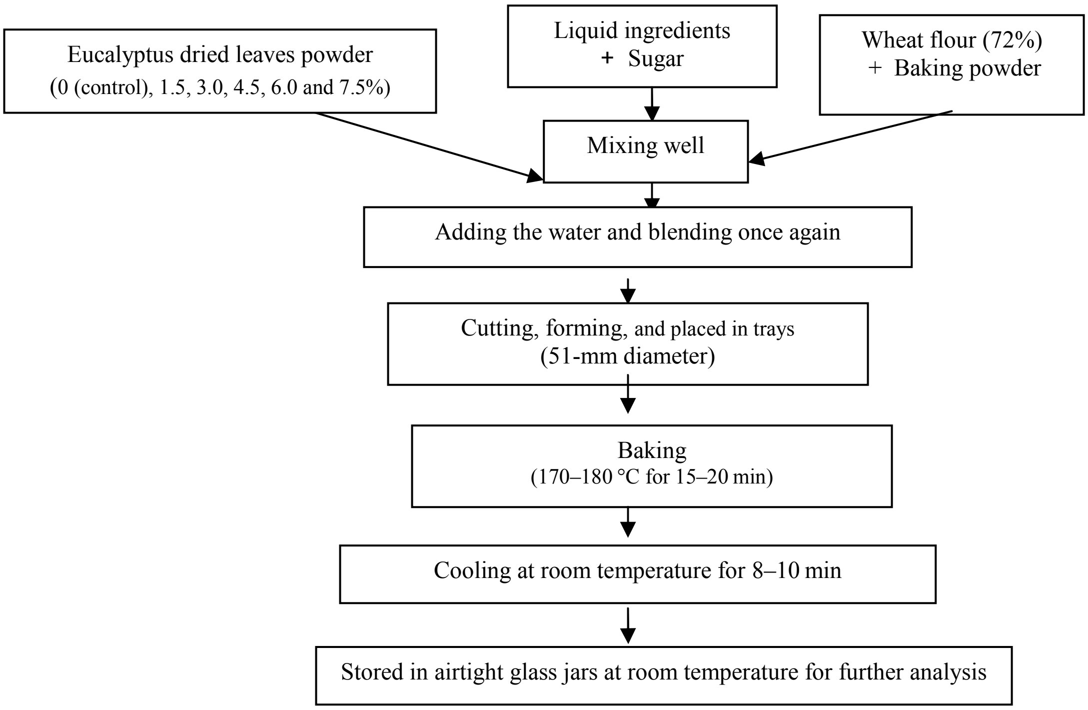

Figure 1. Flow chart of prepared cookies

Nutritional composition

Eucalyptus leaves powder as well as Eucalyptus powder supplemented cookies was subjected to nutritional profiling according to the methods outlined in A.O.A.C (2000). Moisture, ash, crude fiber and crude protein contents were determined according to the standard analytical methods as described above. Carbohydrate content was calculated using the following equation: %Carbohydrate = 100% _ (Moisture + Crude fat + Ash+ Crude protein) %. Moisture was determined in hot air oven at 105 °C up to constant weight and loss of weight was recorded as moisture percentage in dried powder. Eucalyptus leaves powder samples were ashed in muffle furnace at 550 °C for 5–6 h until constant weight. Crude protein was estimated by Kjeldhal method and crude fiber contents were measured by acid and alkali digestion followed by ashing.

Mineral composition

The ash was dissolved in 5 ml of concentrated hydrochloric acid and the volume was completed to 100 ml using distilled water. Sodium (Na), calcium (Ca) and potassium (K) were estimated using Gallen Kamp Flame Analyzer. Iron (Fe), magnesium (Mg), zinc (Zn) and copper (Cu) were estimated using Perkin Elmer Atomic Absorption Spectrophotometer, according to in A.O.A.C (2000).

Free fatty acids in cookies

Cookies stored for a period of two months in air tight glass jars at room temperature were periodically analyzed for free fatty acids contents at an interval of 30 days. n-Hexane was used to remove fat from the crushed cookies and the extracted lipids were analyzed for free fatty acid composition according to the method described in AOCS (1993).

Peroxide value of cookies

Peroxide value was determined based on A.O.A.C (2000). Analysis was conducted after baking on the same day (Initial Reading), day 30, and day 60.

Antioxidant capacity

Free radical scavenging activity of the samples was determined using the DPPH method Elansary and

Mahmoud (2015) with some modifications. The reaction mixture was mixed for 10 s and left to stand in fibber box at room temperature in the dark for 30 min. The absorbance was measured at 517 nm, using a UV scanning spectrophotometer (Unico® 1200). Total antioxidant activity (TAA) was expressed as the percentage inhibition of the DPPH radical and was determined by the following equation:

$$\% TAA = \frac{Abs_{control} - Abs_{sample}}{Abs_{control}} \times 100$$;

Where TAA = total antioxidant activity; Abs control = absorbance of control reaction, and Abs sample = absorbance of sample.Tests were carried out in triplicate. The concentration of sample required to scavenge 50% of DPPH (IC_{50}) was determined. Decreasing of the DPPH solution absorbance indicates an increase of the DPPH radical scavenging activity. The *β*-Carotene-linoleic acid assay was conducted using the method described by Elansary and Mahmoud (2015) and the absorbance was measured at 470 nm.

Total phenolic composition quantification

Determination of total phenolic content in aqueous extracts of air dried leaves and cookies was carried using Folin-Ciocalteau colorimetric method Amerine and Ough (1988) and Singleton and Rossi (1965). Gallic acid was used as the reference standard and the results were expressed as Gallic acid equivalents (GAE).

Physical properties of prepared cookies

All the physical characteristics of cookies were measured on the second day after preparation, and five cookies were used to evaluate each parameter. The cookies width (centimeters) was evaluated by laying cookies edge-to-edge with the help of a scale. The same set of cookies was rotated 90º and the diameters were re-measured. The thickness (centimeters) of cookies was measured by stacking cookies on top of one another. The spread ratio was calculated by dividing the width by thickness (Zoulias et al., 2000). The objective evaluation of texture expressed as breaking strength was measured using the triple beam snap (three-point break) technique of Gaines (1991) using a Texture Analyzer (TVT- 300XP). A crosshead speed of 10 mm/min with a load cell of 50 kg was used in these studies. The force required to break biscuits individually was noted and the average was calculated.

Sensory evaluation

Eucalyptus leaves powder supplemented cookies were evaluated for sensory characteristics i.e. taste, color, crispiness, texture and overall acceptability on 9-point Hedonic Scale Land and Shepherd (1988). Twelve sensory panelist members were selected based on their product discriminative ability for different sensory attributes. The objectives of study were briefed to the panelists. The judges were given questionnaires to record their observations. The information contained on the proforma was; 9 = like extremely; 8 = like very much; 7 = like moderately; 6 = like slightly; 5 = neither like nor dislike; 4 = dislike slightly; 3 = dislike moderately; 2 = dislike very much; 1 = dislike extremely. Sensory testing was made in the panel room completely free of food/chemical odor, unnecessary sound and mixing of daylight Akhtar et al., (2008).

Statistical analysis

The data were presented as means of triplicates ± SD (Standard Deviation). Analysis of variance (ANOVA) was used as implemented in SAS software (Ver. 9.2) at a level of significance of $P \leq 0.05$. Differences among means were determined by the least significant differences (LSD) test.

RESULTS AND DISCUSSION

Nutritional composition and mineral composition

The nutritional composition of the ELP as well as the wheat flour are presented in Table 2. The moisture, protein, carbohydrates, and fat compositions of the ELP were low compared to wheat flour. However, the fiber as well as ash composition were higher than wheat flour which may add digestive and nutritive values to the cookies produced with relatively higher compositions of ELP.

Table 2. Nutritional composition (g/100g) of Eucalyptus leaves powder (ELP) and wheat flour

Nutrients	Nutritional composition (g/100g) ELP	wheat flour
Moisture	1.11 ± 0.24	14.15 ± 0.24
Protein	3.18 ± 0.54	11.43 ± 0.04
Fat	0.25 ± 0.01	1.54 ± 0.09
Ash	5.56 ± 0.48	0.51 ± 0.11
Fiber	15.42 ± 0.62	0.28 ± 0.23
*Carbohydrates	75.59 ± 0.12	86.24 ± 0.23
Caloric value (Kcal/100g)	317.33 ± 0.22	404.54 ± 0.12

Mean ± SD (n= 3).
*** Calculated on dry weight = 100- (Protein+ Fat+ Ash+ Fiber)**
Caloric value (Kcal/100g) = Carbohydrate * 4 kcal/100g + Protein * 4 kcal/100g + Fat * 9 kcal/100g

The nutritional composition (g/100g) of eucalyptus leaves powder supplemented cookies are presented in Table3. Significantly the highest protein compositions were found in the T0 and T1 treatments followed by T2-T5. T5 treatment showed significantly the lowest protein composition. However, T5 treatment showed significantly the highest fiber and ash compositions. T0 and T1 treatments significantly were the highest in the carbohydrate compositions. The nutritional composition of cookies is related to the additive compositions added during manufacturing Dos-Passos et al., (2013). The high dietary fiber as well as the low fat composition of ELP supplemented cookies might be of interest of dieticians and might be recommended for losing weight. These results are in agreement with Soma et al., (2016).

The results presented in Table 4 revealed that the levels of potassium (K), iron (Fe), calcium (Ca), magnesium (Mg), zinc (Zn), and copper (Cu) significantly increased ($P \leq 0.05$) to 467.18, 20.42, 202.25, 258.82, 2.69, and 2.85 mg/kg, respectively in the cookies supplemented with 7.5% ELP. However, the levels of sodium (Na) were significantly decreased ($P \leq 0.05$) to 996.52 mg/kg in the prepared cookies with 7.5%ELP compared to control. With respect to the decrease in Na levels, supplementation of cookies with ELP is a rich source of minerals and fiber. Previous investigation reported that improved nutritional values of cookies might be achieved by the addition of plant materials such as fruit waste, fruit peel, and tea fibers as supplementation (Youssef and Mousa, 2012, Ismail et al., 2014, and Soma et al., 2016), which is in agreement with the current study.

Table 3. Nutritional composition (g/100g) of *Eucalyptus* leaves powder supplemented cookies.

Nutrients	Nutritional composition (g/100g)					
	T0 (Control)	T1 (1.5%ELP)	T2 (3%ELP)	T3 (4.5%ELP)	T4 (6%ELP)	T5 (7.5%ELP)
Moisture	5.28±0.14^{a}	5.24±0.03^{a}	5.18±0.02^{ab}	5.11±0.02^{ab}	5.01±0.01^{b}	5.00±0.03^{b}
Protein	11.1± 0.11^{a}	10.58±0.04^{b}	10.48±0.05^{b}	10.27±0.01^{cd}	9.99±0.06^{d}	9.79±0.05^{d}
Fat	22.24±0.06^{a}	22.11±0.02^{ab}	21.06±0.03^{b}	21.00±0.02^{bc}	20.88±0.02^{bc}	20.01±0.01^{c}
Ash	0.59±0.16^{e}	0.65±0.01^{d}	0.71±0.07^{c}	0.77±0.01^{b}	0.82±0.03^{a}	0.86±0.01^{a}
Fiber	0.26±0.27^{f}	0.61±0.04^{e}	1.05±0.01^{d}	1.35±0.03^{c}	1.55±0.02^{b}	1.79±0.02^{a}
*Carbohydrates	66.92±0.09^{a}	65.95±0.04^{ab}	65.70±0.07^{ab}	65.64±0.04^{ab}	64.76±0.05^{ab}	62.77±0.06^{b}
Caloric value (Kcal/100g)	507.8±0.23^{a}	505.51±0.29^{ab}	500.26±0.34^{ab}	595.37±0.36^{ab}	489.92±0.28^{ab}	470.35±0.13^{b}

Mean ± SD (n= 3).
Values sharing same superscript in row are not statistically significant at *p ≤0.05*
*** Calculated on dry weight = 100- (Protein+ Fat+ Ash+ Fiber)**
Caloric value (Kcal/100g) = Carbohydrate * 4 kcal/100g + Protein * 4 kcal/100g + Fat * 9 kcal/100g

Table 4. Mineral composition of eucalyptus leaves powder (ELP) and ELP supplemented cookies (mg/kg).

Mineral (mg kg^{-1})	Treatment						
	ELP	T_0 (Control)	T_1 (1.5%ELP)	T_2 (3%ELP)	T_3 (4.5%ELP)	T_4 (6%ELP)	T_5 (7.5%ELP)
Na	803.75± 2.15^{g}	1024.96±1.11^{a}	1019.47±0.87^{b}	1012.91±0.49^{c}	1007.98±1.18^{d}	1002.75±1.35^{e}	996.52±0.61^{f}
K	1813±1.07^{a}	195.83±0.08^{g}	250.82±2.07^{f}	312.61±0.86^{e}	364.33±1.47^{d}	414.2±1.52^{c}	467.18±1.04^{b}
Fe	53.49±1.45^{a}	20.32±0.10^{e}	20.34±0.41^{e}	20.36±0.18^{de}	20.37±1.13^{cd}	20.40±1.36^{bc}	20.42±0.44^{b}
Ca	2400.23±1.14^{a}	74.44±1.02^{g}	107.09±0.92^{f}	131.54±0.75^{e}	154.62±0.68^{d}	176.38±1.34^{c}	202.25±0.57^{b}
Mg	253.52±0.45^{e}	253.95±0.78^{e}	254.89±0.24^{e}	255.72±0.67^{d}	257.02±0.41^{c}	257.87±0.13^{b}	258.82±0.38^{a}
Zn	3.77± 0.21^{a}	2.57±0.87^{f}	2.59±0.11^{ef}	2.61±0.09^{de}	2.64±0.10^{cd}	2.67±0.03^{bc}	2.69±0.06^{b}
Cu	1.35± 0.03^{c}	1.34±0.08^{c}	1.45±0.51^{c}	1.57±0.26^{bc}	1.89±1.24^{b}	2.77±0.07^{ab}	2.85±1.12^{a}

Mean ± SD (n= 3).
Values sharing same superscript in row are not statistically significant at *p ≤0.05*

Phenolic composition and antioxidant activities

The phenolic composition as well as the antioxidant activities of leaf powder as well as Eucalyptus powder supplemented cookies are presented in Table 5. The highest phenolic composition was found in the leaf powder followed by T5 treatment containing 7.5% Eucalyptus leaf powder (ELP). The highest phenolic associated with increasing the percentage of ELP in cookies. The antioxidant activities using the DPPH and linoleic assay methods showed the highest significant antioxidant activities in the leaf powder followed by T5 treatment. The antioxidant activities as well as the phenolic compositions significantly decreased with reducing ELP ratio in the cookies. The reduction in the phenolic composition in T1 and T2 might be explained by the lower ratios of ELP in the cookies and that the addition of ELP in the cookies at higher levels might increase the phenolic composition and the antioxidant activities. Several investigations reported association between the phenolic composition and the antioxidant activities Chidambara et al., (2002), EI-Ghorab et al., (2003) and Zahin et al., (2010). The addition of ELP to cookies may suggest a complimentary effect of ELP in cookies by increasing the antioxidant activities of the product. In agreement with the current study, low phenolic composition as well as antioxidant activities had been reported before in white flour used for bread and cookies production Vaher et al., (2010) and Han and Koh (2011).

Table 5. Total phenolic composition and antioxidant activity of *Eucalyptus* leaves powder and *Eucalyptus* powder supplemented cookies.

Treatments	Phenolic composition (mg GAE/100 g)	DPPH (%)	*β*- Carotene - Linoleic acid (%)
Leaf powder	1523.00 ± 32.5^{a}	79.52 ± 1.30^{a}	86.41 ± 0.93^{a}
T0 (Control)	91.33 ± 2.11^{g}	21.53 ± 0.51^{g}	26.11 ± 0.83^{g}
T1 (1.5%ELP)	98.47 ± 1.35^{f}	25.11 ± 0.71^{f}	29.76 ± 0.42^{f}
T2 (3%ELP)	110.25 ± 1.51^{e}	29.32 ± 0.83^{e}	35.32 ± 0.65^{e}
T3 (4.5%ELP)	129.42 ± 3.12^{d}	34.64 ± 0.94^{d}	39.28 ± 0.87^{d}
T4 (6%ELP)	145.87 ± 3.11^{c}	38.53 ± 0.71^{c}	45.65 ± 0.63^{c}
T5 (7.5%ELP)	172.32 ± 2.97^{b}	45.54 ± 0.65^{b}	49.24 ± 0.97^{b}

Values with same letters in the same column are non-significant at *p ≤ 0.05*, Mean ± SD.

Physical attributes of prepared cookies

The results of physical attributes of prepared cookies were presented in Table 6. There was no significant difference (p ≤0.05) between the width values of baked cookies supplemented with ELP up to 7.5% and the control sample cookies. However, weight of the cookies with 7.5%ELP was 5.58 g and these was significantly lighter (p ≤0.05) than control cookies (6.48 g). The thickness of cookies significantly increased (p ≤0.05) from 3.18 to 4.42 cm. Also, the breaking strength of cookies significantly increased (p ≤0.05) from 5.61 to 8.96 N. This might be attributed to higher fiber composition of T5 cookies and that cookies became harder with increased fiber composition. On the other hand, the spread ratio of the cookies significantly decreased (p ≤0.05) with adding ELP up to 7.5% from 8.33 to 6.01, which might be attributed to increase in cookies thickness. Parallel findings were reported by Soma et al., (2016).

Sensory evaluation

The sensory evaluation of ELP supplemented cookies is presented in Table 7. Control (T0) treatment significantly showed the highest taste, texture, color, crispiness and overall acceptability compared to other treatments of T1-T5 that contain ELP. However, within ELP supplemented cookie treatment, there were significant variations in some parameters such as taste, crispiness and overall acceptability. The taste of T1 treatment was significantly higher than T5, also similar results were achieved in the crispiness and the overall acceptability. The treatments of T1-T3 were all still acceptable and were in the range of 8.14-7.66 which might be encouraging for future application in the cookies industry in Egypt. Taste and crispiness were the only parameters that was scored below acceptability range at 7.5% in the T4 and T5 treatments. In order to improve acceptability and consumption levels of astringent functional food preparations, bitter taste blockers possessing human taste receptors antagonistic properties have been identified as ideal solution to organoleptic concerns Bom et al., (2012) and Karanewsky et al., (2012). The addition of plants parts such as fruit peels or waste products remaining from fruit industry as well as the edible horticultural plants had been widely investigated in the processing of cookies and bakery. Consumer score declined with increasing supplementation levels of ELP, however, the product remained acceptable in almost all treatments. The color of the cookies supplemented with ELP was significantly reduced in all treatments compared to control, this may be attributed to the chlorophyll composition of leaves. Similar changes in the color of the manufactured products had been described by Turksoy and Ozkaya (2011). They reported reductions in color evaluations in treatments supplemented with carrot powder. Also, Ismail et al., (2014) reported reductions in specific sensory parameters of cookies supplemented with fruit peels such as color and crispiness.

Table 6. Physical characteristics of ELP supplemented cookies.

Treatment	Physical parameters				
	Weight (g)	**Width (cm)**	**Thickness (cm)**	**Spread ratio**	**Breaking Strength (N)**
T_0 (Control)	6.48 ± 0.14^{a}	26.49 ± 0.18^{a}	3.18 ± 0.05^{b}	8.33 ± 0.12^{a}	5.61 ± 0.18^{d}
T_1 (1.5%ELP)	6.50 ± 0.24^{a}	26.51 ± 0.08^{a}	3.29 ± 0.09^{b}	8.05 ± 0.07^{a}	6.83 ± 0.24^{c}
T_2 (3%ELP)	6.51 ± 0.09^{a}	26.53 ± 0.22^{a}	3.35 ± 0.23^{b}	7.92 ± 0.21^{a}	7.18 ± 0.32^{bc}
T_3 (4.5%ELP)	6.53 ± 0.39^{a}	26.55 ± 0.13^{a}	3.40 ± 0.35^{b}	7.81 ± 0.24^{a}	7.92 ± 0.14^{b}
T_4 (6%ELP)	6.55 ± 0.26^{a}	26.56 ± 0.09^{a}	3.81 ± 0.07^{b}	6.97 ± 0.08^{ab}	7.93 ± 0.35^{b}
T_5 (7.5%ELP)	5.58 ± 0.33^{b}	26.58 ± 0.03^{a}	4.42 ± 0.11^{a}	6.01 ± 0.09^{b}	8.96 ± 0.07^{a}

Mean ± SD (n= 4).
Values sharing same superscript in column are not statistically significant at *p ≤0.05*

Table 7. Sensory evaluation of ELP supplemented cookies

Treatment	Taste	Texture	Color	Crispiness	Overall acceptability
T0 (Control)	9.35 ± 0.13^{a}	9.24 ± 0.09^{a}	8.91 ± 0.08^{a}	8.92 ± 0.01^{a}	8.84 ± 0.05^{a}
T1 (1.5%ELP)	8.57 ± 0.09^{b}	8.46 ± 0.07^{b}	8.13 ± 0.01^{b}	8.22 ± 0.02^{b}	8.14 ± 0.02^{b}
T2 (3%ELP)	8.03 ± 0.03^{bc}	8.11 ± 0.03^{b}	8.07 ± 0.03^{b}	7.82 ± 0.03^{bc}	7.68 ± 0.06^{bc}
T3 (4.5%ELP)	7.39 ± 0.06^{bc}	8.28 ± 0.02^{b}	8.09 ± 0.07^{b}	7.70 ± 0.03^{bc}	7.66 ± 0.02^{bc}
T4 (6%ELP)	6.95 ± 0.14^{bc}	8.13 ± 0.02^{b}	7.97 ± 0.06^{b}	7.46 ± 0.03^{bc}	7.36 ± 0.03^{c}
T5 (7.5%ELP)	6.66 ± 0.11^{c}	8.08 ± 0.03^{b}	7.77 ± 0.09^{b}	7.24 ± 0.07^{c}	7.02 ± 0.02^{bc}

Mean ± SD (n= 20).
Values sharing same superscript in column are not statistically significant at *p ≤0.05*

Storage stability and packaging of cookies

The shelf-life of packed cookies with respect to moisture content, free fatty acids and peroxide value data were presented in Table 8. Moisture loss, textural alteration, oxidation, and spoilage are an important factors to evaluate quality degradation of cookies during prolonged storage (Adegoke et al., 1998). All cookies were stored up to 60 days in air tight glass jars. The initial moisture content of 5.28 and 5.00 g/100 g significantly increased ($p \leq 0.05$) to 7.48 and 6.68 g/100 g, respectively in control and T5 (7.5%ELP) cookies within 60 days. Also, the peroxide value and free fatty acids significantly increased ($p \leq 0.05$) during storage up to 60 days. Peroxide values and free fatty acids values are indicators of product oxidation during storage especially in higher fat contents cookies. The free fatty acids and peroxide value of prepared cookies were slightly increased during storage up to 30 days and the cookies were soft. Free fatty acids levels during storage study up to 60 days in control (0.38%) and T5 supplemented cookies with 7.5% ELP (0.16%) indicated that ELP supplementation showed almost 45% higher stability in supplemented cookies compared to the control cookies. This might be attributed to high antioxidants activity content of ELP. These results were in agreement with Maisuthisakul et al. 2007, and Umesha et al, 2014.

Table 8. Moisture, free fatty acids and peroxide value in ELP supplemented cookies stored up to 60 days in air tight glass jars at room temperature

Treatment	Period of storage (days)		
	Initial Reading	**30**	**60**
	Moisture (g/100g)		
T_0 (Control)	$5.28\pm0.14^{a\gamma}$	$5.88\pm0.21^{a\beta}$	$7.48\pm0.14^{a\alpha}$
T_1 (1.5%ELP)	$5.24\pm0.03^{a\gamma}$	$5.85\pm0.42^{ab\beta}$	$6.74\pm0.32^{bc\alpha}$
T_2 (3%ELP)	$5.18\pm0.02^{ab\gamma}$	$5.79\pm0.11^{bc\beta}$	$6.78\pm0.17^{b\alpha}$
T_3 (4.5%ELP)	$5.11\pm0.02^{ab\gamma}$	$5.72\pm0.08^{cd\beta}$	$6.41\pm0.03^{cd\alpha}$
T_4 (6%ELP)	$5.01\pm0.01^{b\gamma}$	$5.68\pm0.02^{e\beta}$	$6.67\pm0.27^{c\alpha}$
T_5 (7.5%ELP)	$5.00\pm0.03^{b\gamma}$	$5.64\pm0.37^{e\beta}$	$6.68\pm0.56^{c\alpha}$
	Free fatty acids (%)		
T_0 (Control)	$0.16\pm0.03^{a\gamma}$	$0.20\pm0.01^{a\beta}$	$0.38\pm0.02^{a\alpha}$
T_1 (1.5%ELP)	0.14 ± 0.02^{ab}	$0.18\pm0.01^{ab\beta}$	$0.33\pm0.02^{ab\alpha}$
T_2 (3%ELP)	0.12 ± 0.03^{c}	$0.16\pm0.01^{ab\beta}$	$0.25\pm0.02^{bc\alpha}$
T_3 (4.5%ELP)	0.10 ± 0.01^{c}	$0.12\pm0.03^{bc\beta}$	$0.19\pm0.02^{c\alpha}$
T_4 (6%ELP)	0.06 ± 0.01^{d}	$0.11\pm0.02^{bc\beta}$	$0.18\pm0.01^{c\alpha}$
T_5 (7.5%ELP)	0.05 ± 0.04^{d}	$0.08\pm0.02^{c\beta}$	$0.16\pm0.03^{c\alpha}$
	Peroxide value (meq of O2/kg of oil)		
T_0 (Control)	$3.27 \pm 0.15^{a\gamma}$	$8.11\pm1.4^{a\beta}$	$35.81\pm1.8^{a\alpha}$
T_1 (1.5%ELP)	$3.25\pm0.44^{ab\gamma}$	$7.37\pm0.09^{ab\beta}$	$31.29\pm0.11^{b\alpha}$
T_2 (3%ELP)	$3.23\pm0.20^{c\gamma}$	$6.43\pm0.94^{b\beta}$	$29.88\pm0.07^{c\alpha}$
T_3 (4.5%ELP)	$3.19\pm0.11^{d\gamma}$	$6.39\pm0.27^{b\beta}$	$29.62\pm0.22^{cd\alpha}$
T_4 (6%ELP)	$3.11\pm1.03^{e\gamma}$	$5.18\pm0.17^{c\beta}$	$28.49\pm0.51^{d\alpha}$
T_5 (7.5%ELP)	$3.08\pm0.61^{f\gamma}$	$5.07\pm0.03^{cd\beta}$	$28.13\pm0.34^{de\alpha}$

Mean ± SD (n= 3).
Values sharing same superscript (a-e) in column are not statistically significant at *p ≤0.05*, and in a row same Greek symbol (α- γ) are not statistically significant at *p ≤0.05*.

CONCLUSION

ELP supplementation in cookies enhanced the phenolic as well as the antioxidant activities of the product. Also, the nutritional value was enhanced by means of increased mineral composition, fiber, and decreased fat. The overall acceptability was in moderate range using 1.5-4% supplementation of ELP. During the storage period up to 30 days the cookies showed slight increase rate of peroxide value and free fatty acids and all cookies were rancidity free and quite crisp. ELP supplementation at 7.5% significantly increased product stability during 60 days' storage. The finding of the current study may open new lines in cookies and food industries using ELP from local trees. However, further studies might be performed to investigate the toxicological effects of ELP as well as the use as food preservative

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تاثير استخدام مسحوق أوراق الكافور على القيمة الغذائية والخصائص الحسية للكعك المحلى

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تزرع أشجار الكافور بمساحات كبيرة في مصر و تستخدم كنبات طبي. تهدف هذه الدراسة لتقييم تأثير إضافة مسحوق أوراق الكافور على القيمة الغذائية والخصائص الحسية للكعك المحلى من خلال اضافته بنسب صفر، ١,٥ ، ٣ ، ٤,٥ ، ٦ ، ٧,٥%. تم تقدير التركيب الكيماوي و المحتوى المعدني والنشاط المضاد للاكسدة والخصائص الحسية والفيزيائية لكلا من مسحوق الأوراق المجففة والكعك المحلى المضاف اليه نسب من مسحوق الأوراق. بالاضافة لتقدير الاحماض الدهنية الحرة ورقم البيروكسيد و المحتوى الرطوبى للكعك المحلى خلال التخزين لمدة ٦٠ يوم على درجة حرارة الغرفة. و لقد أوضحت النتائج ان استخدام مسحوق الأوراق المجففة للكافور كمكمل غذائي للكعك المحلى حسن بشكل معنوي من المحتوى الفينولي والمحتوى المعدني و النشاط المضاد للاكسدة بطريقتي دي بي اتش والبيتا كاروتين-حامض اللينوليك. و لقد ادى اضافة مسحوق أوراق الكافور للكعك المحلى ايضا الى زيادة محتواه من الالياف والرماد والمعادن وخفض نسبة الدهون في بعض المعاملات مقارنة بالكنترول. و اوضحت نتائج التقييم الحسي ان اضافة مسحوق أوراق الكافور للكعك المحلى كانت مقبولة بنسب تتراوح بين ١,٥ - ٤,٥%. فى حين اتضح ثبات تخزينى اعلى بنسبة ٤٥% تقريبا للكعك المضاف له اوراق الكافور بنسبة ٧,٥% مقارنة بالكنترول مما يشجع على امكانية تطبيقها فى مجال صناعة الكعك المحلى فى مصر. و خلصت الدراسة الى ان اضافة مسحوق أوراق الكافور كمكمل غذائي للكعك المحلى حتى نسبة ٧,٥% قد حسن معنويا من القيمة الغذائية و النشاط المضاد للاكسدة و والخواص الفيزيائية والثبات اثناء عملية التخزين.