



The Effect of Syrup Prepared from *Elaeis guineensis* jacq. (African Oil Palm) Sap and Honey on the Oxidation of Cooked Ground Beef during Short Term Storage

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Abstract

This study examined the performance of an oil palm syrup preparation and honey as antioxidant ingredients for the prevention of oxidation in cooked ground beef during storage at 4°C for 13 days. Antioxidant capacity of the oil palm syrup and honey was assessed by determination of their total phenolic content (TPC), 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity, reducing power, and β-carotene bleaching activity. Their performance as antioxidant preservatives in cooked ground beef was evaluated by determination of the thiobaburic acid reactive substances (TBARS) content of the beef. Both syrup and honey exhibited high oxidation inhibitory activity by the final day of the storage period (64.85±1.06 and 67.07±3.63 respectively), with higher activity than α-tocopherol (45.62±2.84) or butylated hydroxytoluene (59.37±3.45). The results of this study indicated that oil palm syrup and honey (each at a concentration of 7.5 g/kg) were suitable for use as antioxidant preservatives for cooked ground beef during short term storage in the refrigerator.

Key words: Honey, oil palm sugar, chemical characteristics, antioxidant activity, cooked ground beef.

Introduction

Lipid oxidation is a major cause of muscle food quality deterioration. It is a rather complex process whereby unsaturated fatty acids react with molecular oxygen via a free radical chain mechanism, to form fatty acyl hydroperoxides, the primary products of the oxidation (Gray, 1978; Ladikos and Lougovois, 1990). The primary auto-oxidation is followed by a series of secondary reactions which lead to the degradation of the lipid and the development of oxidative rancidity. Besides producing unpleasant odours, oxidation is responsible for the loss of flavour and affects the texture, consistency, appearance, nutritional value and safety of the meat (Ladikos and Lougovois, 1990, Gray *et al.*, 1996; Valenzuela and Nieto, 1996).

Catalysts of lipid oxidation that are found in muscle foods are of both enzymic and non-enzymic types. The non-enzymic type consists

of low molecular weight transition metal ions and sensitizers for the generation of singlet oxygen, such as metmyoglobin-H₂O₂, and other porphyrin compounds. Enzymes that catalyse the process are lipoxxygenase, myeloperoxidase and membrane enzyme systems that reduce iron (Erickson, 2002). Transition metals that can undergo electron redox cycling are major food pro-oxidants (Decker and McClements, 2001).

Honey is an edible sweet substance made by bees using nectar from flowers. Apart from its use as a sweetener, several applications of the material indicate that it also functions as a food preservative. It has been demonstrated that honey serves as a source of natural antioxidants, which are effective in preventing deteriorative oxidative reactions in foods, such as cooked ground poultry (Antony *et al.*, 2000; McKibben and Engeseth, 2002; Antony *et al.*, 2002). In Nigeria, beekeeping has increased

over the years, and locally produced honey has become readily available (Buba et al., 2013).

Palm sap is the white, semi-translucent, sugary sap obtained by tapping the stalk of the immature inflorescence or the upper stem of palm trees, or by tapping the felled trees. In Nigeria, palm sap is obtained mainly from the African oil palm (*Elaeis guineensis* Jacq.) and the raffia (*Raphia* spp) palms (Francisco-Ortega and Zona, 2013) and is usually left to ferment, and drunk as such (palm wine, fresh or pasteurised and bottled), or distilled to yield a strong liquor. In 1969, palm wine production from both sources was estimated at roughly two million metric tonnes (Okereke, 1982). The trade in palm wine provides a source of income, not only for the tappers, but also to a wide range of market intermediaries (Okereke, 1982). In Nigeria, it was found that an oil palm estate may be better off devoting all its resources to the production of 9, 770 L /ha/ annum of oil palm sap than 10 tons of fresh fruit bunches (FFB) /ha/annum, with bright prospects for the sap and the possibility of higher yields through selection and breeding of varieties capable of yielding 100 L of sap per palm (14,800 L per ha) per annum (Udom, 1987). This indicates that in Nigeria, oil palm sap production could in some cases be preferred to FFB production in plantations thereby becoming a readily available raw material for non-traditional products, such as palm sugar (as syrup, granulated sugar, and moulded solid sugar, palm sugar based products, such as confectionery, non-alcoholic beverages, and vinegar (Fellows and Hampton, 1992), non-beverage alcohol (for use as an industrial solvent and biofuel), and lactic acid for the food, cosmetics, pharmaceutical and chemical industries (Chooklin *et al.*, 2011). Production of these value-added products would increase the income of palm sap producers, which in turn would improve the rural economies where they are located.

A recent study showed that raffia and oil palm syrups produced under certain conditions were similar to honey in physico-chemical characteristics, and like the latter, had high total phenolic content and exhibited considerable antimicrobial activity against several pathogenic clinical microorganisms (Oboh *et al.*, 2016). Also, beverages prepared from oil palm syrup alone, or flavoured with *Aframomium melegueta* extract and/or citric acid exhibited good sensory characteristics and antioxidant capacity (Oboh and Imafidon, 2018).

This study was undertaken to evaluate the effect of locally produced oil palm sugar and honey on the oxidation of cooked ground beef during short-term storage at 4°C.

Materials and Methods

Materials

Reagents

2, 2-Diphenyl-1-picrylhydrazyl, hydroxymethylfurfural (5-HMF), and β -carotene were from Sigma-Aldrich Co. St. Louis, MO, USA. Thiobabituric acid, Folin-Ciocalteu reagent, gallic acid, methanol, absolute ethanol, BHT (butylated hydroxytoluene), α -tocopherol, trichloroacetic acid, linoleic acid, Tween 20, phenolphthalein, potassium ferricyanide, sodium chloride, disodium hydrogen phosphate, and sodium dihydrogen phosphate were from Merck, Darmstadt, Germany. All reagents were analytical grade.

Honey

Natural brown honey was obtained from the Benedictine Monastery, Ewu, Edo State, Nigeria.

Beef

Fatty (torso) beef, fresh from the abattoir was purchased at Oba Market, Kings Square, Benin City, Nigeria.

Preparation of syrup

The syrup was prepared as follows: The oil palm sap was filtered through cheese cloth. The filtrate was then boiled in an open pan until it turned brown and viscous; the syrup was cooled and its volume was measured. One and a half litres (1.5 l) of the sap gave 150 ml of syrup.

Preparation of the beef

Preparation of the beef was according to the method of Tang *et al.* (2002). The beef was cut into small pieces and homogenized in a blender. Ground beef was thoroughly mixed with oil palm sugar, honey, α -tocopherol or BHT to give a final concentration of 7.5 g of each material per kg of beef. Minced beef without additive was run as control. The beef samples (60 g each) were packed in polythene bags and cooked for 30 min in a water bath at $75\pm 1^\circ\text{C}$ and an internal temperature of 75°C . Following cooking, the beef was cooled and stored at 4°C in a refrigerator until required for analysis.

Analytical Procedure

Browning intensity

Browning intensity of palm syrup was measured as the absorbance of a 1% solution at 420 nm (Ajandouz *et al.*, 2001; Yusuf and Romeo, 2005).

pH

The pH values of palm sap, honey and palm syrup were measured using a pH meter (Jenway 3505, Germany). The values for the palm sap were determined using the raw (unfiltered) sap. Oil palm syrup or honey (0.5 g) was dissolved in 10 ml of distilled and deionised water. The pH was read in triplicate.

5-hydroxymethylfurfural (5-HMF) content

Hydroxymethylfurfural (5-HMF) concentration was determined spectrophotometrically according to Rattanathanalerk *et al.* (2005). Palm

syrup and honey (10 g samples) were each taken up in 50 ml deionized water and centrifuged at 5,000 rpm for 15 min. Aliquots of the supernatant (2 ml in triplicate) were each placed in a test tube and 2 ml of 12% trichloroacetic acid (TCA) and 2 ml of 0.025M thiobabituric acid (TBA) were added and mixed thoroughly. The test tubes were placed in a water bath at 40°C for 50 min and their contents cooled to ambient temperature under water. The absorbance of the solutions was measured at 443 nm, using a UV-visible spectrophotometer (GENESYS 10S, Thermo Fisher Scientific, Madison WI, USA). A calibration graph was plotted using different concentrations of 5-HMF. Determinations were in triplicate.

Antioxidant capacity

The antioxidant capacity of palm syrup was evaluated by determination of its total phenolic content, β -carotene bleaching antioxidant activity, 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity, and reducing power.

Total phenolic content

Total phenolic content (TPC) was determined spectrophotometrically by a modification of the procedure described by Azizah *et al.* (2007). Palm syrup or honey (10 g) was taken up in 50 ml deionized water and centrifuged at 5,000 rpm for 15 min. Aliquots (0.1ml, in triplicate) of the supernatant and gallic acid standards (50, 100, 150 to 500 mg/l) were each mixed with 0.5ml of 0.2N Folin-Ciocalteu reagent and after 8 min, 1.5 ml of 7.5% (w/v) sodium carbonate was added. The mixture was kept in the dark for 1 hour and its absorbance measured at 765 nm. TPC was calculated from the standard graph and expressed as mg gallic acid equivalent (GAE)/100 g of sample. The determination was carried out in triplicate.

2, 2 -Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity

DPPH radical scavenging activity was evaluated according to the method of Tang *et al.* (2002). Palm syrup and honey (10 g) were each taken up in 50 ml deionized water and centrifuged at 5,000 rpm for 15 min. One ml aliquots of 0.2 mM 2, 2-diphenyl-1-picrylhydrazyl in absolute ethanol were placed Percentage free radical scavenging activity was

$$\text{DPPH radical scavenging activity (\%)} = 1 - \frac{\text{Absorbance of sample at 517nm}}{\text{Absorbance of control at 517nm}}$$

Reducing power

The reducing power was determined according to the method of Oyaizu (1986). Aliquots (100 µl) of the palm sugar and honey (prepared as stated above) were mixed with 250 µl, 200 mM sodium phosphate buffer (pH 6.6), and 250 µl of 1% potassium ferricyanide. The mixtures were incubated at 50°C for 20 min. Trichloroacetic acid (250 µl of a 10% solution) was added to each mixture and 250 µl of this was mixed with 250 µl distilled water and 0.5 ml, 0.1% FeCl₃. Absorbance was measured at 700 nm. Ascorbic acid was used as standard and results were expressed as mg % ascorbic acid equivalent (%AAA) (Kamtekar *et al.*, 2014). The determination was carried out in triplicate.

β-carotene bleaching antioxidant activity

Antioxidant activity of the oil palm sugar, honey, BHT and α-tocopherol solutions were determined using the β-carotene bleaching method (Jayaprakasha *et al.*, 2001) as follows: One ml aliquots of a β-carotene solution (0.2 mg /ml of chloroform) were transferred into round-bottom flasks, each containing 0.02 ml of linoleic acid and 0.2 ml of Tween 20. The chloroform was removed at 40°C in a rotary evaporator. The resulting mixture was immediately diluted with 100 ml of distilled water and mixed for 2 min to form an emulsion. A mixture prepared similarly, but without β-carotene was used as blank. A control containing 0.2 ml, 70% ethanol instead of the sample was also prepared. Aliquots of

in test tubes containing 4 ml portions of the sample supernatant. A control was prepared by adding 1ml of DPPH solution to 4 ml of 70% ethanol. Following storage in the dark for 30 min, the absorbance was read at 517 nm. The determination was carried out in triplicate.

calculated as follows:

the emulsion (5 ml) were transferred into test tubes, each containing 0.2 ml aliquots of the samples (0.75% aqueous solution of the oil palm sugar, 0.75% aqueous solution of the honey, 0.75% solution of BHT or α-tocopherol in absolute ethanol). The tubes were incubated at 50°C in a water bath for 2 hr and the absorbance read at 470 nm. The determinations were carried out in triplicate. The percentage antioxidant activity was calculated as follows:

$$\text{Antioxidant activity (\%)} = 1 - \frac{(A_{0s} - A_{ts})}{(A_{0c} - A_{tc})} \times 100$$

Where A_{0s} and A_{ts} are the absorbance values for sample measured at time t =0 and t =120 min, and A_{0c} and A_{tc} are the absorbance values for the control at t =0 and t=2 hr.

Determination of the extent of lipid oxidation

The extent of cooked beef lipid oxidation was monitored in triplicate on days 1, 3, 7, 10 and 13 using the thiobabaturic acid (TBA) assay according to the extraction method of Mielnik *et al.* (2006) with modification. Cooked ground beef, with or without additive (10.0 g) was homogenized with 34 ml of a 7.5% aqueous solution of trichloroacetic acid (TCA). The homogenate was filtered under vacuum through Whatman No. 4 filter paper into a 50 ml measuring cylinder and the filtrate was made up to the 50.0 ml mark with 7.5%

aqueous TCA. A 5.0 ml aliquot was transferred into a glass-stoppered tube and 5.0ml of 0.02M aqueous TBA was added. The mixture was incubated at 80°C for 20.0 min in a water bath and then cooled for 20 min. Absorbance was measured at 532 nm against a blank containing

5 ml 7.5% TCA and 5.0 ml TBA solution. The determination was carried out in triplicate. The extent of lipid oxidation was expressed as thiobabaturic acid reactive substances (TBARS) value according to Pikul *et al.* (1989):

$$\text{TBARS value} = \text{Absorbance} \times 5.5 \text{ mg malonaldehyde (MDA)/kg beef}$$

Qualitative analysis of phytochemicals

The palm sugar and honey were screened for the presence of alkaloids, flavonoids, glycosides, saponins, terpenoids and tannins according to Malec and Pamilio (2003).

replicated three times with comparable results. Results with $p < 0.05$ were regarded as statistically significant. Pearson’s correlation coefficients were computed using Microsoft Excel 2007.

Statistical Analysis

Experimental replicates within individual experiments were averaged and expressed as mean \pm SD. Comparisons between means were determined by an unpaired Student’s t test with two-tailed p-values reported, employing Microsoft Excel 2007. Each experiment was

Results and Discussion

The honey was viscous, but could be poured. The palm sugar on the other hand was sticky, and had to be warmed for it to melt sufficiently to be poured. Some of their chemical characteristics are shown in Table 1.

Table 1. Chemical characteristics of oil palm syrup and honey^a

Characteristics	Oil palm syrup	Honey
Consistency at ambient temperature	Sticky	Viscous
pH	3.90 \pm 0.01	4.31 \pm 0.01
Colour	Dark brown	Dark brown
Browning intensity (Absorbance of a 1% aqueous solution at 420 nm).	0.131 \pm 0.001	0.071 \pm 0.00
5-hydroxymethylfurfural (mmol/kg) ^b	1.009 \pm 0.002	1.073 \pm .005

^aValues are expressed as mean \pm standard deviation (n=3).

^bValues for 20% palm syrup or honey in distilled water.

Both had pH in the acid range, in agreement with previous findings (Oboh *et al.*, 2016; Bogdanov, 2009); they had a dark brown colouration, but the palm sugar was darker, in keeping with its higher browning intensity. Browning intensity is a measure of the extent of non-enzymatic browning and caramelisation. During evaporation of sap to sugar, amino acids and sugars present in oil palm sap (Oboh *et al.*, 2016; Eze and Ogan,

1988) undergo the Maillard reaction to produce brown coloured compounds (non-enzymatic browning). Further evaporation results in some caramelisation of the sugars, thereby contributing to the browning. Honey also becomes darker during storage and on heat treatment during processing (Anon., 2008). Maillard reaction products (MRP) exhibit antioxidant activity by scavenging

oxygen radicals and by chelating pro-oxidant transition metals (Amin *et al.*, 2010).

Hydroxymethyl furfural (5- HMF), a decomposition product of fructose was present in the palm syrup and honey. It is formed during storage or heat treatment of foods and is an indicator of the extent of these; it also contributes to the flavour of foods and may function as an antioxidant (Bogdanov, 2009). The oil palm sugar and honey contained moderate amounts of this substance. The browning intensity and 5-HMF values of oil palm sugar were in keeping with the long period of heat treatment required for the evaporation of palm sap to yield palm syrup. The honey was a commercial preparation and its processing history was not known.

The palm sugar and honey had high total phenolic content. The total phenolic content assay by the Folin-Ciocalteu reagent is also a measure of the reducing capacity of a substance, and would include, in addition to phenolic compounds, non-phenolic compounds, including vitamin C, 5-HMF and Milliard reaction products (Huang *et al.*, 2005). Phenolic compounds in foods have been reported to possess many useful

properties. They act as antioxidants, metal chelators, antimutagens, anticarcinogens and antimicrobial agents (Cheynier *et al.*, 2005). Although there are numerous phytochemicals consumed in the diet, polyphenols constitute the largest group, and have attracted much attention due to their antioxidant properties. The antioxidant activity of regularly consumed fruits and vegetables reflects their phenolic and vitamin C content (Proteggente *et al.*, 2002, Anhe *et al.*, 2013). Wild yeasts present in palm sap contribute to the synthesis of its phenolic compounds, which in turn contribute to its sensory profile (Ayanru, 1989). It has been demonstrated that phenolic content has a strong positive correlation with the antioxidant activity of honeys (Gheldof *et al.*, 2002).

The antioxidant activity of the oil palm syrup and honey are shown in Table 2. Included for comparison are values for butylated hydroxytoluene (BHT), a synthetic phenolic antioxidant and food ingredient that is generally regarded as safe (GRAS). Using BHT as the standard, oil palm syrup had high DPPH scavenging activity and reducing power; honey had a high reducing power but a low DPPH radical scavenging activity.

Table 2. Antioxidant capacity of oil palm sugar and honey^a

Characteristics	Oil palm sugar	Honey	BHT ^b
Total Phenolic Content (mg GAE^c/100 g of extract)	168.65±0.65	125.15±1.36	-
DPPH Radical Scavenging Activity (%)^d	73.94±0.70	12.01±2.98	84.07±2.55
Reducing Power (mg % AAE^e)^d	39.71±1.00	47.44±0.05	5.12±0.02

^aValues are expressed as mean ±SEM (n=3).

^bValues for 0.02% BHT (butylated hydroxytoluene) in 70% ethanol

^cGAE: Gallic Acid Equivalent.

^dValues for 20% palm sugar or honey in distilled water

^eAAE: Ascorbic Acid Equivalent

The β-carotene bleaching antioxidant activity of the oil palm syrup, honey, BHT and α-tocopherol preparations used in the study are shown in Table 3.

Table 3. β -carotene bleaching antioxidant activity of the test preparations.

Product	Oil palm syrup ^a	Honey ^a	BHT ^b	α -Tocopherol ^b
β -Carotene bleaching antioxidant activity (%)	61.60±2.41*	68.80±1.70*	72.00±3.62*	43.50±2.56**

^a0.75% aqueous solution

^b0.75% solution in absolute ethanol

*, **Values are means ± standard deviation of three determinations. Values with different superscripts are significantly different at the level of p<0.05

There was no significant difference between the values for the oil palm syrup, honey, and BHT; the value for α -tocopherol, however, was significantly lower.

The effects of oil palm syrup, honey, BHT, and α -tocopherol treatment on lipid oxidation in ground beef cooked at 75°C after 1, 3, 7, 10 and 13 days storage at 4°C are shown in Table 4.

Table 4. The effect of oil palm syrup, honey, BHT and α -tocopherol on lipid oxidation in cooked ground beef

Treatment	TBARS (mg malonaldehyde /kg of cooked beef), days					% inhibition ^a on day 13
	1	3	7	10	13	
Control (no treatment)	0.158±0.04*	0.325±0.06*	0.833±0.02*	0.933±0.07*	1.843±0.16*	-
Oil palm syrup	0.206±0.03*	0.446±0.05**	0.796±0.02*	0.543±0.02**	0.649±0.07**	64.85±1.06
Honey	0.165±0.03*	0.444±0.02**	0.796±0.03*	0.383±0.05***	0.611±0.10**	67.07±3.63
BHT	0.042±0.02**	0.009±0.02***	0.151±0.01**	0.185±0.02****	0.745±0.02**	59.37±3.45
α -Tocopherol	0.352±0.08***	0.627±0.03****	0.812±0.06*	0.935±0.06*	0.999±0.05***	45.62±2.84

*, **, ***, **** Values are means ± standard deviation of three determinations. Values with different superscripts within the same column were significantly different at the level of p<0.05.

^a% Inhibition: (TBARS value of the control on day 13 – TBARS value of treated sample on day 13)/ TBARS value of control on day 13

TBARS values for beef that did not undergo any treatment increased continuously, from day 1 to day 13, as were those for the α -tocopherol-treated beef. For the BHT-treated beef there was a decrease up to day 3, followed by an increase up to day 13. Oil palm syrup- and honey-treated beef followed a different pattern, with TBARS values rising up to day 7, falling by day 10, followed by a modest rise by day 13 for the oil palm syrup, and a steep rise for the honey-treated beef. A comparison of TBARS values of the treated samples with that of the control on day 13 indicates that all the

treatments exhibited antioxidant effect. Oil palm sugar and honey gave similar inhibition (64.85 and 67.07%, respectively), followed by BHT (59.37%), with α -tocopherol exhibiting the lowest (45.62%).

These inhibition values exhibit a high positive correlation ($r^*=0.8260$) with β -carotene bleaching antioxidant values for oil palm syrup, honey, BHT, and α -tocopherol (Table 5); for the natural antioxidants (oil palm syrup, honey and α -tocopherol) the correlation was even higher ($r^{**}=0.9828$).

Table 5. Correlations between β -carotene bleaching antioxidant activity and % inhibition values

	β -Carotene bleaching antioxidant activity (%)	% Inhibition
Oil palm syrup	61.60	64.85
Honey	68.80	67.07
BHT	72.00	59.37
α -Tocopherol	43.50	45.62
Pearson's coefficients		
r*		0.8260
r**		0.9828

***r (0.8261)** = correlation between the β -carotene bleaching antioxidant activities of oil palm syrup, honey, BHT, and α -tocopherol, and their corresponding % inhibition values.

****r (0.9828)** = correlation between the β -carotene bleaching antioxidant activities of oil palm syrup, honey, and α -tocopherol, and their corresponding % inhibition values.

These correlations indicate a strong linear relationship between β -carotene bleaching antioxidant activity and inhibition of the oxidation of cooked ground beef. The amount and type of lipids found in muscle foods, and their relative reactivity and accessibility to catalysts and inhibitors determine their susceptibility to oxidation (Erickson, 2002). In this study, time dependent degradation of the structure of the beef probably allowed deeper penetration of the test substances towards the end of the study, thereby increasing access to the lipids, not only of the hydrolytic and oxidizing enzymes and other pro-oxidants in the beef, but also to the antioxidants naturally present and those added post mortem. Under these circumstances, the resistance of meat to the development of rancidity would then depended on the balance between the antioxidants and pro-oxidants present in the animal tissue, their mode of action and the ability of the antioxidants to inhibit the activity of the pro-oxidants (Enser, 1987).

Iron heme protein, including myoglobin and haemoglobin, are abundant in muscle tissue (Livingstone and Brown, 1981). The ability of heme to promote oxidation has been

demonstrated by several workers (Tapel, 1953). Non-heme iron participates in the production of the hydroxyl radical, a reactive oxygen species, via the Fenton reaction, which is effective when Fe^{3+} can be recycled to Fe^{2+} by various reducing agents, for example, ascorbate. Levels of low molecular weight non-heme iron are initially low, being only 2.4 to 3.9% of the total muscle iron in beef. However, in muscle that has been processed and stored (such as in this study), increases in the catalytic low molecular weight iron fraction have been observed (Decker and Hultin, 1990; Kanner *et al.*, 1988). Potential sources of non-heme iron are dislodgement of iron from the heme pocket by cooking (Igene *et al.*, 1979; Schricker and Miller, 1983) and release of iron from the iron storage protein ferritin, by the reducing agents cysteine and ascorbate (Decker and Welch, 1990). Cooked ground beef may contain cysteine due to hydrolysis by enzymes released during grinding. Oil palm syrup and honey have considerable iron (Oboh *et al.*, 2016) and ascorbate content (Oboh and Imafidon, 2018; Buba *et al.*, 2013). Thus, in this study, the presence of heme and non-heme iron (released by grinding and cooking) in the beef, and the

presence of sufficient lipid substrate (membrane and storage fat, and fatty acid peroxides) set the stage for the increase in the oxidation observed in the beef (from 0.158 on day 1 to 1.843 mg malonaldehyde/kg on day 13). This oxidation was then inhibited to various degrees by the different treatments employed, which in all cases decreased the extent of the process.

Although there are many nutritional and medicinal benefits of honey, it may also have toxic constituents. It has been reported that honey can be contaminated with heavy metals such as lead, arsenic, mercury and cadmium, depending on its region of origin (Islam *et al.*, 2014). Also, honey produced by bees from the nectar of various species, such as the rhododendrons, and other plants of the family

Ericaceae, contain a group of closely related toxins, the polyhydroxylated cyclic diterpenes known as grayanotoxins. These toxins are harmful, and cause a very rare poisonous reaction called grayanotoxin poisoning or honey intoxication (Mayor, 1995; Demircan, 2012; Jensen *et al.*, 2012), which may be lethal at high enough concentration (Mizrahi and Lensky, 1997; US FDA, 2012; Islam *et al.*, 2014). There are no reports of these toxic principles in oil palm sap, and syrup produced from it may be considered safe. Also, although screening of the palm syrup and honey samples used in this study showed the presence of flavonoids, glycosides and saponins, terpenoids and tannins were absent (Table 6). Thus, the honey used in this study did not contain the toxin.

Table 6. Phytochemicals of oil palm syrup and honey.

	Oil palm syrup	Honey
Alkaloids	-	-
Flavonoids	+	+
Glycosides	+	+
Saponins	+	+
Terpenoids	-	-
Tannins	-	-

Key: +: Present. - : Absent.

Conclusion

The results of this study indicated that oil palm syrup and honey (each at a concentration of 7.5 g/kg) exhibited high inhibition of oxidation in cooked ground beef during storage for 13 days at 4°C. They are therefore suitable (at this concentration) for use as antioxidant preservatives for cooked ground beef during short term storage in the refrigerator.

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