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Frying Quality of Virgin Coconut Oil as Affected by Zea *mays* Extract

(Kualiti Menggoreng Minyak Kelapa Dara Disebabkan oleh Ekstrak Zea *mays)*

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ABSTRACT

The effect of corn silk or Zea mays *extract on the physicochemical changes of virgin coconut oil was studied during three consecutive days of deep frying. There were three types of oil blend systems used: virgin coconut oil without antioxidant as control system; virgin coconut oil with butylated hydroxytoluene (BHT) as synthetic antioxidant and virgin coconut oil with* Zea mays *extract as natural antioxidant. The oil quality was assessed by measuring the colour, viscosity, peroxide, p-anisidine, free fatty acids, totox and iodine value. The results show that* Zea mays *extract delayed the oil deterioration. The* Zea mays *extract significantly (*p*<0.05) lowered the rate of oxidation in virgin coconut oil compared to control oil and was comparable to BHT.* Zea mays *extract did not change the sensory profiles of French fries which was shown by insignificant difference (*p*<0.05) between* Zea mays *and control fries for all sensory attributes (colour, taste, aroma, crispiness, oiliness and overall quality). In general, the* Zea may *extract was capable of extending the stability and quality of virgin coconut oil and therefore has potential as new source of natural antioxidant for use in deep frying.*

Keywords: Fats; frying; oils; virgin coconut oil; Zea mays

ABSTRAK

*Kesan ekstrak sutera jagung (*Zea mays*) ke atas perubahan fizikokimia minyak kelapa dara semasa penggorengan telah dikaji selama tiga hari berturut-turut. Terdapat tiga jenis campuran minyak yang digunakan: minyak kelapa dara tanpa antioksidan sebagai kawalan, minyak kelapa dara bersama butylated hydroxytoluene (BHT) sebagai antioksidan sintetik dan minyak kelapa dara bersama ekstrak* Zea mays *sebagai antioksidan semula jadi. Kualiti minyak dinilai dengan mengukur warna, kelikatan, nilai peroksida, nilai asid lemak bebas, nilai totox dan nilai iodin. Keputusan kajian menunjukkan bahawa ekstrak* Zea mays *telah melewatkan kadar kerosakan minyak. Ekstrak* Zea mays *telah menurunkan kadar pengoksidaan minyak secara signifikan (*p*<0.05) berbanding dengan minyak kawalan dan setara dengan minyak bercampur BHT. Ekstrak* Zea mays *tidak mengubah profil sensori kentang jejari sebagaimana ditunjukkan dalam keputusan kajian bahawa tidak ada perbezaan yang signifikan (*p*<0.05) berbanding kawalan pada semua attribut sensori (warna, rasa, aroma, keranggupan, rasa berminyak dan kualiti keseluruhan). Secara keseluruhan, ekstrak* Zea mays *mampu memanjangkan kestabilan dan kualiti minyak kelapa dara dan dengan itu mempunyai potensi sebagai sumber baru antioksidan semula jadi untuk digunakan dalam penggorengan.*

Kata kunci: Lemak; menggoreng; minyak kelapa dara; Zea mays

INTRODUCTION

Deep fat frying remains as one of the top choices of cooking preparation despite concerns over adverse health effects due to its pleasant taste and aroma. Since this method of cooking has been around for some time, it is difficult and almost impossible to remove it totally from our diet. Thus, efforts to improve the quality of deep frying oil are continue to evolve to ensure that people can enjoy their favourite foods without having to worry about the consequences.

Lipid oxidation is one of the major deteriorative reactions in frying oils (Che Man & Tan 1999). Oxidation of unsaturated fatty acids is the major cause of off-flavor compound formation and in the reduction of nutritional value of food products (Hemalatha 2007). Lipid oxidation not only produces rancid flavour, but can also lower the nutritional value of food by the formation of oxidation products, which may play a role in the development of disease and can be harmful to humans (McClement & Decker 2000). The oxidative deterioration of edible oils can be retarded by antioxidants, the main additives used to protect the quality of oil. However, synthetic antioxidants such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) are believed to exhibit toxic and carcinogenic effects (Nor et al. 2008). Thus, natural antioxidants are the preferred choice due to its safety.

Plant extracts have been reported to have some degree of antioxidant activity. In recent years, considerable attention has been focused on exploring their potential antioxidant. Corn silk or *Zea mays* (dried cut stigmata of maize female flowers, *Zea mays* ssp. *mays,* Poaceae) is one of the plant extracts being studied for its antioxidant properties. It consists of various chemicals such as proteins, vitamins, alkaloids, tannins and mineral salts, carbohydrates, steroids, flavonoids and volatile chemicals (El-Ghorab et al. 2007). It is also rich in phenolic compounds such as anthocyanins, p-coumaric acid, vanillic acid, protocatechuic acid, derivatives of hesperidin and quercetin (Ebrahimzadeh et al. 2008). There have been numerous reports on the biological activities of *Zea mays* constituents. *Zea mays* extract exhibited anti inflammation effect (Wang et al. 2012), reduced hyperglycemia (Guo et al. 2009) and have been found to prevent overproduction of free radicals (Liu et al. 2011). *Zea mays* extract activity may be related to the high amount of flavonoid and phenolic compounds which have antioxidant activity (Ebrahimzadeh et al. 2008; Maksimovic & Kovacevic 2003). The objective of the present study was to evaluate the effect of *Zea mays* extract in increasing the oxidative stability of virgin coconut oil during deep fat frying.

MATERIALS AND METHODS

MATERIALS

Virgin coconut oil was obtained from Kelantan Biotech Corporation. *Zea mays* extract was donated by Nutrition Lab, School of Health Sciences, Universiti Sains Malaysia (The *Zea mays* hairs was dried in a hot oven at 40°C for 24 h, grounded into powder and extracted with ethanol at 1:10 ratio of powder to ethanol). French fries were purchased from local grocery store. All chemicals and reagents used were of analytical grade.

FRYING EXPERIMENT

Deep frying were carried out in a stainless steel electrical open fryer (Takada, model ISB-306,) with a 3 L maximum capacity pot of oil equipped with a stainless steel basket and portable filter system. There were 3 types of frying systems used: VCO without antioxidant as control system, VCO with 200 ppm of BHT and VCO with 200 ppm of *Zea mays* extract. The frying for all systems was done simultaneously. Approximately 120 g oil samples were collected from each fryer to represent the sample for day 0 before frying. The remaining oil was heated at 180±5°C and was allowed to equilibrate at this temperature for 30 min. Fifteen batches of 100 g of French fries were fried for 3 min for each batch at 20 min intervals daily. The fryers were left uncovered during the frying experiment. The fryers were turned off at the end of the frying experiment each day and the oil was cooled to 60°C before being collected. Frying oil (120 g) from each fryer was sampled into amber bottles at the end of each day. All oil samples were flushed with slow bubbles of nitrogen gas and stored at -20°C prior to chemical analysis. The lids of the fryers were put on and fryers were left overnight for the following's day of frying. The fryers were topped up to initial level to replenish the used oil before the frying process of the next day. The whole procedure for each oil blend system was repeated consecutively for three days.

ANALYSIS OF OIL QUALITY

Changes in the quality of the oil was monitored using AOCS standard procedure (AOCS 1996) to determine the peroxide value (PV) (Method Cd 8-53), *p*-anisidine value (*p*-AV) (Method Cd-18-90), free fatty acids (Method Ca 5a-40) and iodine value (Method Cd 1d-92). Total oxidation value (TOTOX) were calculated using formula 2PV + *p*-AV) (Shahidi & Wanasundara 2002). Oil colour was measured using CM-3500d Spectrophotometer (Minolta, Osaka, Japan). The L*a*b* colour system consists of a luminance or lightness component (L*) and two chromatic components: the a* component for green (-a) to red (+a) and the b* component from blue (-b) to yellow (+b) colours. Viscosity of the oil was measured using Rheolyst AR1000 Rheometer (TA Instruments, DE, USA) with a 2 degree cone and plate geometry of 40 mm diameter. The equilibration time was 5 min and shear rate range was 10-50 s-1. All measurements were carried out in triplicate (*n*=3).

SENSORY EVALUATION

Sensory evaluation was conducted on the first day of each oil blend system of French fries and evaluated using a 7-point hedonic scale (1 = very poor; 7 = very good) by 60 untrained panelists which were students and staffs of School of Health Sciences, Universiti Sains Malaysia. Sensory attributes tested were colour, flavour, taste, oiliness, crispiness and overall acceptability.

STATISTICAL ANALYSIS

Statistical analyses were carried out using analysis of variance (ANOVA) and significant differences were determined by Duncan multiple range test with a 95% significant level (p=0.05) using SPSS Predictive Analytics Software Statistics, version 18 software (SPSS Inc. Chicago 2009).

RESULTS AND DISCUSSION

Table 1 shows the changes in chemical characteristics during the deep frying study. The formation of peroxides increased rapidly after the first day of frying for all frying systems. Peroxide value represents primary reaction products of lipid oxidation, which can be measured by their ability to liberate iodine from potassium iodide (Nor et al. 2008). The number of peroxides present in vegetable oils reflects its oxidative level and thus it tendency to become rancid (Marina et al. 2009). Theoretically, compared to other unsaturated oils, VCO exhibit a low rate of oxidation due to its low content of unsaturated fatty acids. The present study shows that after three days of frying, the peroxide values not exceeding 6, which can be considered quite low for oils that have been frying for three days. Compared with the control sample, oils with antioxidants showed lowest level of peroxides. It was observed that the *Zea mays* extract significantly reduced the peroxide value ($p<0.05$) compared to control oil and comparable to BHT extract oil. On the third day of frying, the *Zea mays* extract was capable of reducing the peroxide value by 39% compared with the control oil.

Peroxides under deep fat frying conditions are unstable and can break down to carbonyl and aldehydic compounds in the presence of high heat, air and light as occurs in deep fat frying operations (Che Man & Tan 1999). Since high heat (180±5°C) was used on these systems, peroxides formed during oxidation may be decomposed to secondary oxidation products. In the second phase of oxidation, peroxides decompose and form alcohols, carboxylic acids, ketones and aldehydes, which are responsible for the rancid smell and taste. *p*-anisidine value test was used to measure this secondary oxidation. Table 1 shows the anisidine value increased from 0.38 to 15.15, 0.32 to 12.3 and 0.43 to 12.58 for control, BHT and *Zea mays* extract, respectively, as the days of frying increased. The *Zea mays* extract significantly lowered the anisidine value compared with the control sample. There was no significant difference between *Zea mays* extract and BHT, meaning that *Zea mays* extract performance was equal to BHT.

A totox or total oxidation value is a measure of total oxidation, which includes primary and secondary oxidation (Serjouie et al. 2010). An increase by one peroxide value unit corresponds to an increase in about two anisidine value units (Ghazali et al. 2009). Table 1 shows that the totox value increased significantly ($p<0.05$) faster in control compared with BHT and *Zea mays* extract. On the last day of frying, totox value of control sample was 26.35, compared to 19.50 and 19.65 for BHT and *Zea mays* extract, respectively. This indicates that *Zea mays* extract was comparable to BHT in preventing oils from deterioration during frying.

Free fatty acids values during the three days of frying were shown in Table 1. Free fatty acids are formed by hydrolytic rancidity and responsible for the undesirable flavours in fats (Marina et al. 2009). *Zea mays* extract and BHT significantly ($p<0.05$) lowered the free fatty acids formation during the three days of frying compared to the control sample. The lower content of free fatty acids in *Zea mays* extract however is not attributed to the antioxidant in the extract as antioxidant can only prevent oxidative stability and have no direct effect on hydrolytic rancidity (Che Man & Tan 1999).

Iodine value measures the degree of unsaturation in fats and oils. Hypothetically, compared to other vegetable oils, virgin coconut oil is relatively stable oil due to a low degree of unsaturation. It was observed that the iodine values of all treatments decreases significantly ($p<0.05$) from day 1 to day 3 (Table 1). The decrease in iodine value is associated with the decrease in number of double bond as it becomes oxidizes (Che Man & Tan 1999).

TABLE 1. Changes in chemical characteristics of virgin coconut oil during deep frying

Chemical properties	Day of frying	Control	BHT	*Zea mays* extract
Peroxide value (meq. O_2/kg)	0	0.24 ± 0.01^{Cd}	0.27 ± 0.01^{Bc}	0.29 ± 0.01^{Ad}
	1	3.55 ± 0.13^{Ac}	2.73 ± 0.10^{Bb}	2.66 ± 0.12^{Bc}
	2	4.02 ± 0.14^{Ab}	3.42 ± 0.16^{Ba}	3.23 ± 0.11^{Bb}
	3	5.60 ± 0.29^{Aa}	3.59 ± 0.11^{Ba}	3.40 ± 0.03^{Ba}
Anisidine value	0	0.38 ± 0.03^{Bd}	0.32 ± 0.01^{Cd}	0.43 ± 0.02^{Ad}
	1	6.19 ± 0.29^{Ac}	3.85 ± 0.14^{Bc}	3.95 ± 0.19^{Bc}
	2	8.58 ± 0.24^{Ab}	6.73 ± 0.25^{Bb}	6.94 ± 0.28^{Bb}
	3	15.15 ± 0.45^{Aa}	12.30 ± 0.29^{Ba}	12.58 ± 0.28^{Ba}
Totox value	0	0.86 ± 0.03^{Bd}	0.86 ± 0.02^{Bd}	1.01 ± 0.02^{Ad}
	1	13.28 ± 0.53^{Ac}	9.32 ± 0.36^{Bc}	9.28 ± 0.44^{Bc}
	2	16.62 ± 0.53^{Ab}	13.26 ± 0.46^{Bb}	13.41 ± 0.49^{Bb}
	3	26.35 ± 1.03^{Aa}	19.50 ± 0.47^{Ba}	19.65 ± 0.34^{Ba}
Free fatty acids (%)	0	0.44 ± 0.01^{Ad}	0.41 ± 0.02^{Ac}	0.44 ± 0.02^{Ac}
	1	0.55 ± 0.03^{Ac}	0.44 ± 0.01^{Bc}	0.46 ± 0.01^{Bbc}
	2	0.64 ± 0.02^{Ab}	0.48 ± 0.01^{Bb}	0.47 ± 0.01^{Bab}
	3	0.75 ± 0.02^{Aa}	0.54 ± 0.02^{Ba}	0.50 ± 0.01^{Ca}
Iodine value (g of I_2/100g oil)	0	9.79 ± 0.16^{Aa}	9.74 ± 0.18^{Aa}	9.79 ± 0.16^{ab}
	1	9.61 ± 0.35^{Aa}	9.55 ± 0.17^{Aa}	10.12 ± 0.26^{Aa}
	2	7.36 ± 0.21^{Cb}	9.08 ± 0.18^{Bab}	9.63 ± 0.18^{Ab}
	3	5.53 ± 0.16^{Bc}	8.71 ± 0.75^{Ab}	8.64 ± 0.27^{Ac}

-Means with different lowercase letters within each column are significantly different at ($p<0.05$)
-Means with different capital letters within each row are significantly different at ($p<0.05$)

The frying system with *Zea mays* extract had the least losses of unsaturation. This could be due to the presence of natural antioxidant in the *Zea mays* extract.

As the frying days increased, the colours of the oil continue to change over time. Table 2 summarizes the changes of colour in control, BHT and *Zea mays* extract during the frying operation. The values for 'a', 'b' and 'L' of oil systems increased throughout the three days of frying for all oil blend systems. The colour of frying oil darkens during frying, as a result of oxidation and formation of browning pigments from the French fries. Colour rise generally indicates an increase in oxidation. A more intense red colour indicates a more oxidized and less stable oil. The values for 'L' were higher in BHT and *Zea mays* extract compared with the control sample. This could be due to the presence of pigments and phenolic compounds and their breakdown products during heating and frying (Nor et al. 2008). There was a noteworthy significant ($p<0.05$) increase in viscosity with increase in days of frying for *Zea mays* extract and BHT compared to the control sample (Table 2). The observed increases in viscosity were due to polymerization, which resulted in formation of higher molecular weight compounds. The oil viscosity is also directly related to the coating kinetics and amount of oil adsorbed (Yaghmur et al. 2001).

Table 3 shows the sensory evaluation of French fries from all frying systems. Sensory evaluation was conducted to determine if adding the *Zea mays* extract would change the organoleptic properties of French fries. There results showed that there were no significant differences ($p<0.05$) in scores of colour, crispiness, aroma, taste, after-taste (oiliness), and overall quality among the three frying systems. This indicated the presence of *Zea mays* extract was undetected by panellists, meaning that *Zea mays* extract did not change the sensory profiles of French fries. Thus, *Zea mays* extract should be considered as a potential antioxidant in frying oils because it does not contribute to off flavour in sensory profile of French fries.

CONCLUSION

The present study shows that addition of *Zea mays* extract in virgin coconut oil greatly improved the peroxide, *p*-anisidine, totox and frees fatty acids values compared to virgin coconut oil frying alone. These findings indicate

TABLE 2. Changes in physical characteristics of virgin coconut oil during deep fat frying

Physical properties		Day of frying	Control	BHT	*Zea mays* extract
Colour	Lightness (L*)	0	38.52 ± 0.02[b]	39.67 ± 0.10[a]	38.57 ± 0.14[b]
		1	38.92 ± 0.03[a]	38.75 ± 0.04[b]	38.81 ± 0.07[b]
		2	38.95 ± 0.02[a]	38.84 ± 0.04[b]	38.91 ± 0.04[a]
		3	38.51 ± 0.45[c]	48.75 ± 0.14[a]	46.67 ± 0.33[b]
	Redness (a*)	0	-1.31 ± 0.02[c]	-1.36 ± 0.03[b]	-1.42 ± 0.01[a]
		1	-1.46 ± 0.02[b]	-1.51 ± 0.01[b]	-1.47 ± 0.02[b]
		2	-1.57 ± 0.02[c]	-1.65 ± 0.02[b]	-1.92 ± 0.01[a]
		3	-1.65 ± 0.04[c]	-2.53 ± 0.02[b]	-2.97 ± 0.02[a]
	Yellowness (b*)	0	3.27 ± 0.06[b]	2.93 ± 0.03[c]	3.82 ± 0.02[a]
		1	3.46 ± 0.02[c]	4.55 ± 0.03[a]	4.24 ± 0.03[b]
		2	4.32 ± 0.02[c]	4.76 ± 0.03[b]	5.67 ± 0.01[a]
		3	4.67 ± 0.03[b]	4.70 ± 0.14[b]	5.94 ± 0.02[a]
Viscosity (mPa.s)		0	35.54 ± 0.03[b]	35.32 ± 0.01[b]	37.15 ± 0.64[a]
		1	35.65 ± 0.04[b]	37.37 ± 0.28[a]	37.64 ± 0.51[a]
		2	36.30 ± 0.13[c]	37.45 ± 0.04[b]	38.72 ± 0.06[a]
		3	38.68 ± 0.70[c]	59.55 ± 0.69[b]	65.08 ± 0.03[a]

Means with different lowercase letters within each row are significantly different at ($p<0.05$)

TABLE 3. Sensory evaluation of French fries fried in virgin coconut oil with different treatments

Attribute	Control	BHT	*Zea mays* extract
Colour	4.97 ± 1.21	5.03 ± 1.00	4.98 ± 1.13
Crispiness	5.08 ± 1.17	5.00 ± 1.11	5.09 ± 1.08
Aroma	4.61 ± 1.44	4.63 ± 1.29	4.64 ± 1.31
Taste	5.02 ± 1.34	4.94 ± 1.13	4.95 ± 1.21
After taste	4.77 ±1.38	4.84 ± 1.39	4.84 ± 1.29
Overall acceptance	5.09 ± 1.21	5.00 ± 1.22	5.10 ± 1.13

that the virgin coconut oil stability can be increased further by incorporating natural antioxidant such as *Zea mays* extract.

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