Improving the frying performance of RBD palm olein oil using NaturFORT™ TRLG 101 liquid as on-top of TBHQ in deep-fat frying of potato chips

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Abstract Improvement in the frying performance of palm olein oil with NaturFORT™ TRLG 101 (TRLG 101) liquid in addition to tert-butyl hydroquinone (TBHQ) has been evaluated. Four treatment groups (Negative control, 200 ppm TBHQ, 200 ppm TBHQ + 400 ppm TRLG 101 liquid and 200 ppm TBHQ + 750 ppm TRLG 101 liquid) were added to RBD (Refined, Bleached and Deodorized) palm olein oil which was used to produce potato chips. Frying trials were conducted for 120th frying cycles. The oil samples were analyzed for peroxide value, free fatty acid, *p*-anisidine value, oxidative stability index, %total polar compounds and Chroma (C*) values after every 20 frying cycles. Potato chips were analyzed for Chroma (C*) values after every 20 frying cycles. The results of oxidative stability index, total polar compounds and *p*-anisidine value showed that the addition of NaturFORT™ TRLG 101 liquid at 750 ppm had showed significantly better performance followed by the addition of NaturFORT™ TRLG 101 liquid at 400 ppm. Thus, the addition of NaturFORT™ TRLG 101 liquid as on top of TBHQ contributes to the improvement in the frying performance of palm olein oil with subject to their dosage and this could be a better solution for frying industries which would like to get extra frying cycles for their products without encountering the regulatory hurdles posed by the limitations of using such additives.

Keywords NaturFORT™ TRLG 101 liquid · TBHQ · Frying cycle · Palm olein oil and deep fat frying

Introduction

Tertiary Butyl Hydroquinone (TBHQ) is a synthetic food grade antioxidant that was developed for use in stabilizing various oils, fats and foods against oxidative deterioration, thus retarding the development of rancidity in these products and extending the shelf life. Compared to other synthetic antioxidants, TBHQ has shown to be an effective antioxidant in highly unsaturated vegetable oils and many edible animal fats (Telingai and Augustine 2006; Choe and Min 2007) but there is strict restriction on its' use. In many major countries organisations like FDA (Food and Drug Administration, USFDA 1980), FSIS (Food Safety and Inspection Service) and others only permit the use of TBHQ or combinations with BHA (Butylated Hydroxy Anisole) or BHT (Butylated Hydroxy Toluene) at concentrations up to 0.02% by weight of the fat or oil content of the food. Although there are many studies that report on the use of synthetic antioxidants for various applications, there is limited information on the effectiveness of combinations of antioxidants in retarding the deterioration of oils during frying. To meet the increasing demand in improving the performance and to overcome the restriction of using higher TBHQ's dosage, natural antioxidants can be used in addition.

Green tea, rosemary and tocopherols are rich source of catechins, terpenoids and polyphenols with potential antioxidant properties. Plant extract antioxidants are natural and safe when used in small amounts from their natural source, but when use in larger amounts to prevent oxidation of food systems, the safety effects are unknown. When some compounds with antioxidant properties are combined, different interactions may occur showing various effects that may be synergistic, antagonistic or additive. These effects are not definite properties for plant extracts,

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but they are widespread properties related to the way they are explained and their ratios. There are some studies about antioxidant properties of green tea (Frankel et al. 1997; Gramza et al. 2006; Ziaedini et al. 2010), rosemary (Lalas and Dourtoglou 2003; Nasiri 2012) and tocopherols (Kamal-Eldin and Appelqvist 1996) that show the antioxidant activity of their extracts. Also, possible interactions for combined extracts of these natural antioxidants that show the ability of using very low doses of each individual extract in preventing oxidation in food systems which is the main purpose of present study has still not been evaluated even though some other studies has evaluated interactions between some antioxidants compounds. It is understood from our in-house study that Kemin's proprietary and plant derived antioxidant blend—NaturFORT™ TRLG 101 liquid (combination of tocopherol, rosemary and green tea extracts at ~6.0/2.5/0.5 (w/w/w)) can extent the shelf life of frying foods while offer a more label friendly option to TBHQ. In this study, we focus on the synergistic improvement in frying performance of RBD (Refined, Bleached and Deodorized) palm olein oil using Kemin's proprietary plant derived antioxidant blend—NaturFORT™ TRLG 101 liquid as on top of TBHQ during deep fat frying of potato chips. RBD (Refined, Bleached and Deodorized) palm olein oil was chosen for this lab study to mimic the industrial frying condition as it is the most commonly used vegetable oil in major frying industries in Asia Pacific and India.

Materials and methods

Materials

Raw potatoes were obtained from local supermarket. Antioxidant-free RBD palm olein oil and Tertiary Butyl Hydroquinone (TBHQ, min 99% purity) were obtained from Kemin Industries South Asia (KISA) Pvt Ltd stores, Gummidipundi. NaturFORT™ TRLG101 liquid (consisted of min ~6.0/2.5/0.5 (w/w/w) tocopherol, rosemary and green tea extracts) was produced and obtained from Kemin Food Technologies, Singapore. Briefly, lipid soluble green tea, mixed tocopherol and rosemary extract were first added into a mixer and mixed for 30 min at 60 ± 5 °C to ensure that it was homogenously mixed. The ingredients used in NaturFORT™ TRLG101 liquid were of food grade and all other chemicals were of analytical reagent AR grade.

Potato slice preparation

10 kg of fresh potatoes were selected manually based on size, visual defects, blemishes and washed with tap water. The washed potatoes were peeled using a hand-

peeler and sliced manually into pieces of uniform thickness of 2.0 ± 0.5 mm using a hand slicer. The sliced potatoes were soaked in clean water for 30 min in dark condition after which the excess water was drained and the potato slices were kept in an incubator at 65 ± 5 °C for 10 min. Finally, the potato slices were spread on muslin cloth and any surface water was removed using an air dryer. This procedure was repeated daily for 6 consecutive days.

Treatment Preparation

The different treatments used in the study consisted of RBD palm olein oil (5 kg) treated with respective antioxidants (namely four treatment groups: Negative control, 200 ppm TBHQ, 200 ppm TBHQ + 400 ppm TRLG 101 liquid and 200 ppm TBHQ + 750 ppm TRLG 101 liquid) which was used for the frying of potato chips. Briefly, the bulk palm olein oil (15 kg) treated with 200 ppm of TBHQ was prepared using the following step: exactly 500 g of oil was first weighed from the 15 kg bulk palm olein oil and heated to 110 °C. The calculated amount of TBHQ was weighed in a beaker and 500 g of the pre-heated oil was added. The mixture was maintained at 110 °C with continuous stirring at 1440 rpm using stirrer (Remi Laboratory Direct Drive Stirrers, RQ-124A/D) for 1 h and finally added to remaining bulk palm olein oil (after TBHQ is completely dissolved in premix). The bulk palm olein oil treated with the TBHQ was stirred with laboratory stirrer at 1440 rpm for 10 min to obtain a uniform mixture. Next, the bulk oil was divided into three portions (5 kg each) for the remaining treatments. NaturFORT™ TRLG 101 liquid at their respective inclusion rates was added on top to this TBHQ-treated palm olein oil at room temperature of 25 °C and stirred for 10 min with stirrer at 1440 rpm to obtain a uniform mixture before frying study.

Frying experiment

The frying trial was conducted using batch fryer (Karma Global, Model GF – 4TE, Taiwan). Oil (5 kg) of different treatments was first heated to 60 °C and the %Total Polar Compounds (TPC) was measured, followed by collection of 100 g of oil for further analysis. The remaining oil was then heated to 180 ± 5 °C whereby the %Total Polar Compounds (TPC) was measured again, followed by another collection of 100 g of oil for further analysis. Frying was started once the temperature reached 180 ± 5 °C. Potato slices of 100 ± 2 g were added into the fryer and fried for 160 ± 5 s. After which, the oil temperature was allowed to reach 180 ± 5 °C again before the next batch of potato slices were added. Twenty frying

cycles were conducted daily for 6 consecutive days. In total, there was a total of 120 frying cycles for each treatment and the fryer was kept open during the frying operation. At the end of each day, the %Total Polar Compounds (TPC) at 60 °C was measured, followed by collection of 100 g oil sample from the fryer for further analysis. The potato chips were collected after the 1st and every 20th frying cycles and stored in zip-lock polythene pouch for colour measurement. After the frying, the oil in the fryer was left overnight at room temperature (25 ± 5 °C).

Chemical analysis of oil

Free fatty acid (FFA), peroxide value (PV), *p*-anisidine value (*p*-AV) and oxidative stability index (OSI) were analysed following AOCS official method Ca 5a-40, Cd 8-53, Cd 18-90 and Cd 12b-92 respectively (AOCS 1990). There are no modifications made to the steps in all the AOCS methods for peroxide value (PV), free fatty acid (FFA) and *p*-anisidine (*p*-AV). But for the oxidative stability index (OSI), there is a slight modification where a temperature of 100 °C was used instead of 120 °C for 60th to 120th frying cycles to demonstrate statistical significance in OSI at these frying cycles. Oxidative stability index (OSI) was measured at 120 °C up to 40th frying cycles and at 100 °C for 60th to 120th frying cycles in order to show the difference between the treatments clearly. %Total Polar Compounds (TPC) was measured using VITO 270 cooking oil tester. The sensor of VITO oil tester was submerged into the oil sample and the was moved gently for 30 s. This rapid method detects the dielectric constant of oil. This constant was converted to the content of total polar compounds (%) based on the formula set up by the manufacturer. All the analysis was carried out in duplicate.

Colour analysis of potato chips and oil

The colour measurement of the collected potato chips was conducted by crushing the fried potato chips using a mortar and pestle and the crushed chips were filled in sample cell of Hunter Lab colorimeter (Model: Colorflex EZ) before measurement. Similarly for the oil sample, 15 g of the collected oil sample was used for measurement. All readings were taken as L^* , a^* , b^* colour space values at D65/10° (Daylight 65 and at an observer angle of 10°). Chroma C^* was calculated as $\sqrt{(a^*)^2 + (b^*)^2}$. Calibration of the instrument was performed using a standard white ceramic tile ($L^* = 98.06$, $a^* = -0.23$ and $b^* = 1.87$) and standard black ceramic tile provided along with instrument before measuring each new set of duplicate samples.

Statistical analysis

Analysis of variance (One-way ANOVA) and Duncan's multiple range tests were conducted using Statgraphics Plus version 5.0 software package at $p < 0.05$.

Results and discussion

Oxidative stability index

The results of oxidative stability index (OSI) for 0th to 40th frying cycles at 120 °C and for 60th to 120th frying cycles at 100 °C are shown in Table 1. In all treatments, oxidative stability index decreased significantly with increasing frying cycles. From the results, TRLG 101 at 750 ppm on top showed significantly ($p < 0.05$) higher OSI values among other treatments as follows: TRLG 101 at 750 ppm on top > TRLG 101 at 400 ppm on top > TBHQ at 200 ppm > Negative control. The OSI results of TRLG 101 at 750 ppm showed that the enhanced protection of more than 2.5 times was achieved from 20th to 60th frying cycle and more than three times was achieved from 80th to 120th frying cycle when compared to dry TBHQ.

Total polar compounds

Total polar compounds (TPC) for all treatments is shown in Fig. 1. All treatments showed a significant ($p < 0.05$) increase in the total polar compounds with increasing frying cycles. From the 20th frying cycle onwards, TRLG 101 at 750 ppm on top showed significantly ($p < 0.05$) lower values of total polar compounds compared to all other treatments. The frying cycles at which the treatment groups do not exceed TPC limit of 24% can be obtained from the black horizontal line drawn parallel to x -axis as shown in Fig. 1. It clearly indicated for negative control, it reached the limit earlier at 60th frying cycle and at 80th frying cycle for TBHQ at 200 ppm. Compared to these two treatments, both TRLG 101 at 400 ppm and TRLG 101 at 750 ppm on top can further extend the frying cycle by 1.5–2 time longer before it reached this saturation limit. In addition, it can be seen that from the 40th frying cycle onwards, the order of TPC formation is as follows: TRLG 101 at 750 ppm on top < TRLG 101 at 400 ppm on top < TBHQ at 200 ppm < Negative control.

Peroxide (PV) and *p*-anisidine (*p*-AV)

The results of the change in peroxide values (PV) and *p*-anisidine values (*p*-AV) for all the treatments with frying cycle are shown in shown in Tables 2 and 3 respectively. It was found that only *p*-anisidine value increased

Table 1 Changes in oxidative stability index (OSI) of RBD palm olein oil during frying ($n = 2$)

Characteristic	Frying cycles	Treatments			
		Control	TBHQ	TRLG 101 at 400 ppm on top	TRLG 101 at 750 ppm on top
OSI at 120 °C	Initial at 60 °C	9.81 ± 0.01 ^{aD}	16.33 ± 0.02 ^{bD}	20.44 ± 0.45 ^{cD}	22.91 ± 0.01 ^{dD}
	Initial at 180 °C	9.19 ± 0.03 ^{aC}	16.19 ± 0.01 ^{bC}	16.80 ± 0.10 ^{cC}	22.11 ± 0.30 ^{dC}
	20	5.17 ± 0.03 ^{aB}	6.30 ± 0.07 ^{bB}	13.03 ± 0.01 ^{cB}	18.11 ± 0.18 ^{dB}
	40	2.73 ± 0.05 ^{aA}	5.26 ± 0.04 ^{bA}	8.53 ± 0.03 ^{cA}	14.09 ± 0.09 ^{dA}
OSI at 100 °C	60	6.72 ± 0.04 ^{aD}	14.60 ± 0.11 ^{bD}	34.16 ± 0.01 ^{cD}	37.14 ± 0.04 ^{dD}
	80	3.90 ± 0.05 ^{aC}	8.90 ± 0.11 ^{bC}	25.78 ± 0.15 ^{cC}	29.80 ± 0.49 ^{dC}
	100	2.31 ± 0.04 ^{aB}	6.08 ± 0.06 ^{bB}	19.24 ± 0.04 ^{cB}	23.75 ± 0.06 ^{dB}
	120	1.92 ± 0.04 ^{aA}	4.77 ± 0.04 ^{bA}	11.35 ± 0.06 ^{cA}	17.18 ± 0.08 ^{dA}

^{a-d} Means within a row (between treatments) with different letters are significantly different ($p < 0.05$)

^{A-D} Means within a column (between frying cycles) with different letters are significantly different ($p < 0.05$)

Fig. 1 Changes in average %total polar compounds (TPC) of RBD palm olein oil during frying ($n = 2$)

proportionally as the frying cycle increased whereas for the peroxide value rose and fell during frying, which is the same pattern observed for peroxides in most deep-fat frying studies. Significant ($p < 0.05$) difference between treatments was observed from the 20th frying cycle onwards and TRLG 101 at 750 ppm showed significantly lower *p*-anisidine value among all treatments and the order is as follows: TRLG 101 at 750 ppm on top < TRLG 101 at 400 ppm on top < TBHQ at 200 ppm < Negative control.

Free fatty acids (FFA)

The results of free fatty acids (FFA) of the oil for different frying cycles and all treatments are shown in Fig. 2. The

trend showed that the free fatty acids gradually increased with increasing frying cycle. Generally, the increase in FFA content could be caused by an increase in rate of hydrolysis when moisture in the substrate is introduced into frying system during frying. As shown, antioxidant will have no significant role in controlling the hydrolytic rancidity to prevent formation of free fatty acids.

Chroma of frying oil and potato chips

The results of Chroma values for collected oils and potato chips are shown in Tables 4 and 5 respectively. Chroma analysis indicated that frying time had a significant ($p < 0.05$) effect on Chroma of the frying oil. From 60th frying cycle onwards, the negative control oil became

Table 2 Changes in peroxide value (PV) of RBD palm olein oil during frying (n = 2)

Characteristic	Frying cycles	Treatments			
		Control	TBHQ	TRLG 101 at 400 ppm on top	TRLG 101 at 750 ppm on top
Peroxide value (meq oxygen/Kg)	Initial at 60 °C	3.14 ± 0.05 ^{abC}	3.04 ± 0.17 ^{abAB}	3.34 ± 0.20 ^{bC}	2.79 ± 0.02 ^{aA}
	Initial at 180 °C	3.69 ± 0.15 ^{bD}	2.94 ± 0.07 ^{aAB}	3.70 ± 0.01 ^{bD}	2.83 ± 0.08 ^{aAB}
	20	2.32 ± 0.18 ^{aB}	4.00 ± 0.24 ^{bCD}	2.11 ± 0.11 ^{aA}	3.60 ± 0.07 ^{bD}
	40	1.58 ± 0.14 ^{aA}	2.66 ± 0.04 ^{cA}	2.05 ± 0.12 ^{bA}	3.04 ± 0.11 ^{dBC}
	60	2.33 ± 0.04 ^{bB}	3.33 ± 0.07 ^{dABC}	2.20 ± 0.00 ^{aAB}	3.15 ± 0.01 ^{cC}
	80	2.48 ± 0.12 ^{aB}	3.76 ± 0.02 ^{cBCD}	2.37 ± 0.05 ^{aAB}	3.26 ± 0.20 ^{bC}
	100	2.96 ± 0.22 ^{abC}	4.06 ± 1.03 ^{bCD}	2.54 ± 0.27 ^{aB}	3.98 ± 0.09 ^{abE}
	120	5.11 ± 0.03 ^{dE}	4.62 ± 0.06 ^{cD}	2.19 ± 0.19 ^{aA}	3.74 ± 0.04 ^{bD}

^{a-d} Means within a row (between treatments) with different letters are significantly different ($p < 0.05$)

^{A-E} Means within a column (between frying cycles) with different letters are significantly different ($p < 0.05$)

Table 3 Changes in *p*-anisidine value (*p*-AV) of RBD palm olein oil during frying (n = 2)

Characteristic	Frying cycles	Treatments			
		Control	TBHQ	TRLG 101 at 400 ppm on top	TRLG 101 at 750 ppm on top
<i>p</i> -anisidine value	Initial at 60 °C	7.05 ± 1.03 ^{aA}	8.62 ± 0.50 ^{aA}	7.74 ± 0.27 ^{aA}	7.68 ± 0.21 ^{aA}
	Initial at 180 °C	12.54 ± 0.57 ^{aB}	14.21 ± 1.69 ^{aB}	12.13 ± 0.86 ^{aB}	12.53 ± 0.09 ^{aB}
	20	40.24 ± 0.07 ^{dC}	32.52 ± 0.26 ^{cC}	26.70 ± 0.19 ^{bC}	22.58 ± 0.00 ^{aC}
	40	69.41 ± 0.19 ^{dD}	54.33 ± 0.18 ^{cD}	47.67 ± 0.30 ^{bD}	42.49 ± 0.26 ^{aD}
	60	87.93 ± 0.07 ^{dE}	74.34 ± 0.24 ^{cE}	59.61 ± 0.64 ^{bE}	57.11 ± 0.35 ^{aE}
	80	99.25 ± 0.81 ^{dF}	90.54 ± 0.29 ^{cF}	70.29 ± 0.59 ^{bF}	68.04 ± 0.14 ^{aF}
	100	115.96 ± 0.43 ^{dG}	100.38 ± 0.15 ^{cG}	79.76 ± 1.09 ^{bG}	76.18 ± 0.14 ^{aG}
	120	149.54 ± 0.48 ^{dH}	110.29 ± 0.05 ^{cH}	89.65 ± 1.02 ^{bH}	79.34 ± 0.63 ^{aH}

^{a-d} Means within a row (between treatments) with different letters are significantly different ($p < 0.05$)

^{A-H} Means within a column (between frying cycles) with different letters are significantly different ($p < 0.05$)

much darker compared to the other treatments. It was observed that throughout the frying, oil treated with TBHQ at 200 ppm showed significantly ($p < 0.05$) lower Chroma values than other treatments. On increasing the inclusion of TRLG 101 liquid, there is an increase in the Chroma of oil. The results of Chroma (C^*) values for potato chips are shown in Table 5, it is clear that significantly ($p < 0.05$) no difference was observed in Chroma of chips for all treatments except at 100th frying cycle where chips fried in TBHQ treated oil showed significantly ($p < 0.05$) lower Chroma value when compared to other treatments.

Rosemary, green tea and tocopherols are effective protectors against oxidation due to their antioxidant capacity. The ability to inhibit oxidation is associated with the chemical structure of phenolic compounds that are

similar to chemical antioxidants. Efficiency of natural extracts in food systems depends on factors such as the chemical reactivity of their constituents, extraction procedure, and interaction with food components. In general, plants and herbs extracts are known to contain a wide variety of phytochemicals, such as polyphenols, flavonoids, and catechins. These products could be natural antioxidants because the compounds could scavenge free radicals and provide oxidative stability to many food items. The mechanism involved in the antioxidant activity of either natural or synthetic antioxidants is dependent on molecular structure. In the present study, combining extracts can lead to various interactions and different effects. The amount of antioxidant components do not necessarily reflect the total

Fig. 2 Changes in average free fatty acid (FFA) content of RBD palm olein oil during frying (n = 2)

Table 4 Changes in average Chroma values of RBD palm olein oil during frying (n = 2)

Characteristic	Frying cycles	Treatments			
		Control	TBHQ	TRLG 101 at 400 ppm on top	TRLG 101 at 750 ppm on top
Chroma of oil	Initial at 60 °C	27.78 ± 0.48 ^{aA}	26.76 ± 0.36 ^{aA}	28.94 ± 0.23 ^{cA}	29.45 ± 0.01 ^{cA}
	Initial at 180 °C	29.41 ± 1.62 ^{aAB}	30.28 ± 0.19 ^{aB}	29.53 ± 0.16 ^{aAB}	32.79 ± 0.10 ^{bB}
	20	32.66 ± 0.60 ^{bB}	34.48 ± 0.04 ^{cC}	29.83 ± 0.28 ^{aB}	35.86 ± 0.05 ^{dC}
	40	37.40 ± 0.06 ^{aC}	36.91 ± 0.27 ^{aD}	42.33 ± 0.45 ^{bC}	47.93 ± 0.37 ^{cD}
	60	39.03 ± 0.65 ^{aC}	38.63 ± 0.57 ^{aE}	46.68 ± 0.48 ^{bD}	48.55 ± 0.72 ^{cD}
	80	53.48 ± 0.49 ^{dD}	44.71 ± 0.16 ^{aF}	48.42 ± 0.02 ^{bE}	52.04 ± 0.30 ^{cE}
	100	64.31 ± 0.23 ^{dE}	45.40 ± 1.13 ^{aF}	53.95 ± 0.34 ^{bF}	58.82 ± 1.54 ^{cF}
	120	75.37 ± 4.13 ^{cF}	53.16 ± 1.31 ^{aG}	62.33 ± 0.39 ^{bG}	65.18 ± 1.06 ^{bG}

^{a-d} Means within a row (between treatments) with different letters are significantly different ($p < 0.05$)

^{A-G} Means within a column (between frying cycles) with different letters are significantly different ($p < 0.05$)

Table 5 Changes in average Chroma values for potato chips during frying during frying (n = 2)

Characteristic	Frying cycles	Treatments			
		Control	TBHQ	TRLG 101 at 400 ppm on top	TRLG 101 at 750 ppm on top
Chroma of chips	0	31.72 ± 0.25 ^{aA}	31.30 ± 0.25 ^{aA}	31.43 ± 0.19 ^{aA}	31.85 ± 0.10 ^{aAB}
	20	31.86 ± 0.13 ^{aAB}	31.49 ± 0.23 ^{aA}	31.45 ± 0.38 ^{aA}	31.89 ± 0.03 ^{aAB}
	40	32.50 ± 0.09 ^{aB}	32.28 ± 0.58 ^{aB}	31.73 ± 0.13 ^{aAB}	31.68 ± 0.07 ^{aA}
	60	32.25 ± 0.47 ^{aAB}	31.76 ± 0.20 ^{aAB}	32.16 ± 0.50 ^{aBC}	32.54 ± 0.46 ^{aBC}
	80	32.43 ± 0.28 ^{aB}	32.24 ± 0.17 ^{aB}	32.47 ± 0.17 ^{aC}	32.62 ± 0.24 ^{aC}
	100	33.79 ± 0.33 ^{bC}	33.04 ± 0.11 ^{aC}	34.02 ± 0.19 ^{bD}	33.76 ± 0.28 ^{bD}
	120	35.28 ± 0.21 ^{aD}	34.61 ± 0.35 ^{aD}	34.68 ± 0.08 ^{aE}	35.27 ± 0.50 ^{aE}

^{a-b} Means within a row (between treatments) with different letters are significantly different ($p < 0.05$)

^{A-E} Means within a column (between frying cycles) with different letters are significantly different ($p < 0.05$)

antioxidant content of extracts because a synergistic effect in the extract is possible.

The results of oxidative stability index (OSI), %Total polar compounds (TPC) and *p*-anisidine value (*p*-AV) clearly showed that on top addition of TRLG 101 at 750 ppm was most effective in controlling the lipid oxidation of palm olein oil which is followed by TRLG 101 at 400 ppm.

The non-volatile oxidation byproducts are categorized as total polar compounds and its constituents include dimeric fatty acids, triglyceride monohydroperoxides, polymerized triglycerides (PTG), cyclic fatty acid monomers and aldehydic triglycerides. The percentage (%) of TPC in the cooking oil has been shown to be almost identical to the one present in the oil absorbed by the food. Thus, by measuring TPC % in frying oil, the direct content of TPC in the fried food could be reflected (Mlcek et al. 2015). It is known that total polar compounds of frying oil reaching above 24% is the indication that the product fried in that oil is too dark, unappealing flavor transfer is occurring and it is definitely time to change the oil. From Fig. 1, it is clearly shown that TPC is within the limit of 24% with the addition of TRLG 101 on top throughout the frying and with increasing the inclusion rates of TRLG 101 a better effect in controlling the oxidation of oil is observed.

Peroxides in oxidized oils are unstable intermediates, which decompose into various carbonyls and other secondary oxidation byproducts readily, principally 2-alkenals and 2, 4-dienals. Typically, when used on oils during frying, PV can be very misleading as peroxides are destroyed under frying conditions at 180 °C (Stavros 2008). From the results of free fatty acids (FFA), it is clear that either TBHQ or TRLG 101 liquid has any significant ($p > 0.05$) role in controlling hydrolytic rancidity. Chroma reflects the colour intensity or the saturation of the oil and it could be used as a indicator of consumer acceptance. Significantly ($p > 0.05$) no difference was found in the Chroma values of potato chips between the treatments except at 100th frying cycle which may be due to variation in thickness of potato chips fried in dry TBHQ treated oil. This contributed to its lower Chroma value and is almost uniform and stable for all other treatments indicating that addition of antioxidants has no negative impact in the Chroma values of potato chips.

Conclusion

On top addition of NaturFORT™ TRLG 101 liquid showed significant improvement in frying performance of palm olein oil and this could be a better solution for those frying industries which would like to get extra frying cycles for their products without encountering the regulatory hurdles posed by the limitations of using such additives.

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