Effects of Additives on Quality and Frying Performance of Palm Superolein During Frying

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INTRODUCTION

Some 20 million tonnes of oils and fats are used for various frying activities around the world (Gertz, 2000; 2001). In the United States, it was estimated that the fast food restaurants used several million tonnes of frying oils and fats annually (Warner and Neff, 2001). During frying operations, usually carried out between 160°C-190°C, complex reactions including dehydration, oxidation, hydrolysis, polymerization, cyclization, *etc*. take place which affects the economic use of the oils and fats and the shelf-life stability of the fried foods. A restaurant operator or industrial fryer is concerned about the cost and stability of the oil/fat during frying and its effect on the fried food quality. The stability of the oil/fat and its effect on the quality of fried foods depends among other things on the presence of unsaturated fatty acids, natural and/or added antioxidants, anti-foaming agent, fryer design, frying conditions, and the nature of the foods, *etc*.

Synthetic antioxidants when added to oils at ambient temperature retard the oxidation process, but are less effective at frying temperatures, due to their volatility. It was reported that daily addition of tertiary butyl hydroquinone (TBHQ) improved the stability of palm olein during batch frying and prolonged the shelf-life of potato crisps (Asap and Augustine, 1986). The use of naturally occurring antioxidants such as tocopherols to improve the quality of frying oils has been studied also. However, conflicting results were reported in the literature concerning the stability of tocopherols at frying temperatures. Some researchers (Gordon and Margos, 1995) reported that tocopherols were rendered inactive by the high temperatures of frying. It was reported (Sakata *et al*., 1985) that the stability of palm oil during intermittent frying was increased when tocopherols were added. In the same report, it was mentioned that addition of silicone to palm oil prevented foaming and oxidation during intermittent frying. However, under continuous plant frying conditions (Sebedio *et al.,* 1996; Razali *et al.*, 2001), silicone alone or synthetic antioxidant(s) alone were found to be ineffective in preventing the deterioration of oils and fats.

A study was carried out to investigate the combined effects of TBHQ and silicone on the quality and frying performance of palm superolein with an iodine value (IV) of 62, during intermittent batch frying of chicken nuggets for five consecutive days. In addition, the organoleptic acceptability of the fried food was also evaluated.

EXPERIMENTAL

The two oils under test (*i.e*. one with and one without the additives) were heated to 177 ± 2°C in electrically heated open fryers (Frymaster, Split Pot USA) of 11.5 litres capacity. About 500 g of frozen pre-beaded chicken nuggets were defrosted and brought to room temperature and fried at 117 ± 2°C for 3.5 min at intervals of 30 min. Each oil was subjected to a total of 40 hr of frying and heating, *i.e*. 8 hr per day for five consecutive days. The level of the frying oil in the fryer was topped up with about 20% of fresh oil at the end of each day after filtration and then covered. For the analyses of physio-chemical changes, oil samples of about 400 ml (in duplicate) were taken after filtration at the end of each day's frying. The samples were cooled, sparged with nitrogen and kept at -18°C before analyses. The analyses were done according to the MPOB, IUPAC-AOAC and/or AOCS Official Test Methods.

Sufficient samples of freshly fried chicken nuggets were taken twice daily (in the morning and the afternoon) and served to a 25-member panel within 10 min

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after being taken out of the fryers. A nine-point hedonic scale was used by the panel members to judge their perception, where 9 = extremely crispy, 8 = very crispy and 1= very soggy. Two sensory sessions - one in the morning and one in the afternoon - were conducted daily over the five days of frying. Each panel member was provided with a score sheet and two pieces of freshly cooked chicken nugget coded with a three-digit number. The codes were randomized between the sessions to minimize bias. Chicken nuggets fried in palm superolein without additives were used as the reference.

RESULTS AND DISCUSSION

The initial characteristics of the fresh oils are shown in *Table 1.* As can be seen, the oxidative stability of the palm superolein (measured by OSI) with additives increased by some 2.3-fold when compared to the control. This can be attributed to the combined synergistic effect of TBHQ and silicone. The other initial quality parameters like free fatty acid (FFA), peroxide value (PV), anisidine value (AV), totox, smoke point and tocopherols + tocotrienols of these oils were not affected by the additives. The values indicate the two oils were of good quality. As expected, the two oils contained relatively high amounts of oleic and palmitic acid and only trace amounts of linolenic acid (*Table 2*).

Key changes in the characteristics of these two oils during five days of intermittent frying of chicken nuggets are shown in *Tables 3a* to *3d.* Palm superolein fortified with the additives performed significantly better than the control as reflected by, among others, a slower formation of PV, AV, FFA, polar and polymer compounds and slower drop in smoke point, OSI and a higher retention of tocopherols and tocotrienols during the five days of frying. In addition, no smoking and foaming were observed during this study in the presence of the additives.

During five days of intermittent frying of chicken nuggets, the palm superolein fortified with the additives showed better frying performance compared to the control without additives. After day five, from an initial FFA content of 0.04%, the FFA increased to 0.76% in the control compared to 0.48% in palm superolein spiked with the additives. The polar compounds increased from 6.7% to 20.8% and 11.6% while the polymer compounds increased from 0.45% to 3.8% and 2.4%. After day five, from an initial smoke point of 228°C, the smoke point dropped to 182ºC in the control compared to 190ºC in palm superolein spiked with additives. The tocopherols and tocotrienols decreased from 745 ppm to 214 ppm and 450 ppm while the OSI fell from 21 and 49 hr to 12 and 32 hr respectively. However, there was no significant difference in the mean sensory score and overall acceptability of the chicken nuggets over the five days of intermittent frying.

Synthetic antioxidants such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) and TBHQ when added to oils and fats at ambient temperatures retard the oxidation process (Weiss, 1983) but at high frying temperatures they are less effective because of their volatility (Peled *et al.*, 1975; Augustin and Berry, 1983). Silicone is commonly used to improve the quality and stability of frying oils. It acts as an oxygen barrier for the

TABLE 1. CHARACTERISTICS OF FRESH PALM SUPEROLEIN USED FOR FRYING OF CHICKEN NUGGETS

Parameter	Palm superolein (control)	Palm superolein (with additives)
Colour (Lovibond 1/4" cell)	2.3R, 50Y	2.3R, 50Y
FFA (%)	0.04	0.04
PV (meq kg^{-1})	0.99	0.90
AV	1.87	1.80
Totox (2PV+AV)	3.85	3.60
Iodine value (Wijs)	62.3	62.1
Tocopherol + tocotrienol (ppm)	745	745
TBHQ (ppm)	-	194
Silicone (ppm)	-	2.0
OSI (110ºC, hr)	21	49.0
Smoke point (ºC)	229	228
Flavour (smell)	Bland	Bland

TABLE 2. FATTY ACID COMPOSITION (%) OF PALM SUPEROLEIN USED FOR FRYING OF CHICKEN NUGGETS

Fatty acid	Palm superolein (control)	Palm superolein (with additives)
C12:0	0.3	0.4
C14:0	1.1	1.0
C16:0	34.5	34.6
C16:1	0.2	0.3
C18:0	3.4	3.6
C18:1 *(trans)*	-	-
C18:1 *(cis)*	46.3	46.2
C18:2 *(trans)*	-	-
C18:2 *(cis)*	12.5	12.4
C18:3	0.4	0.3
C20:0	0.3	0.2
C20:1	0.3	0.3
C22:0	-	-
Others	1.0	0.7

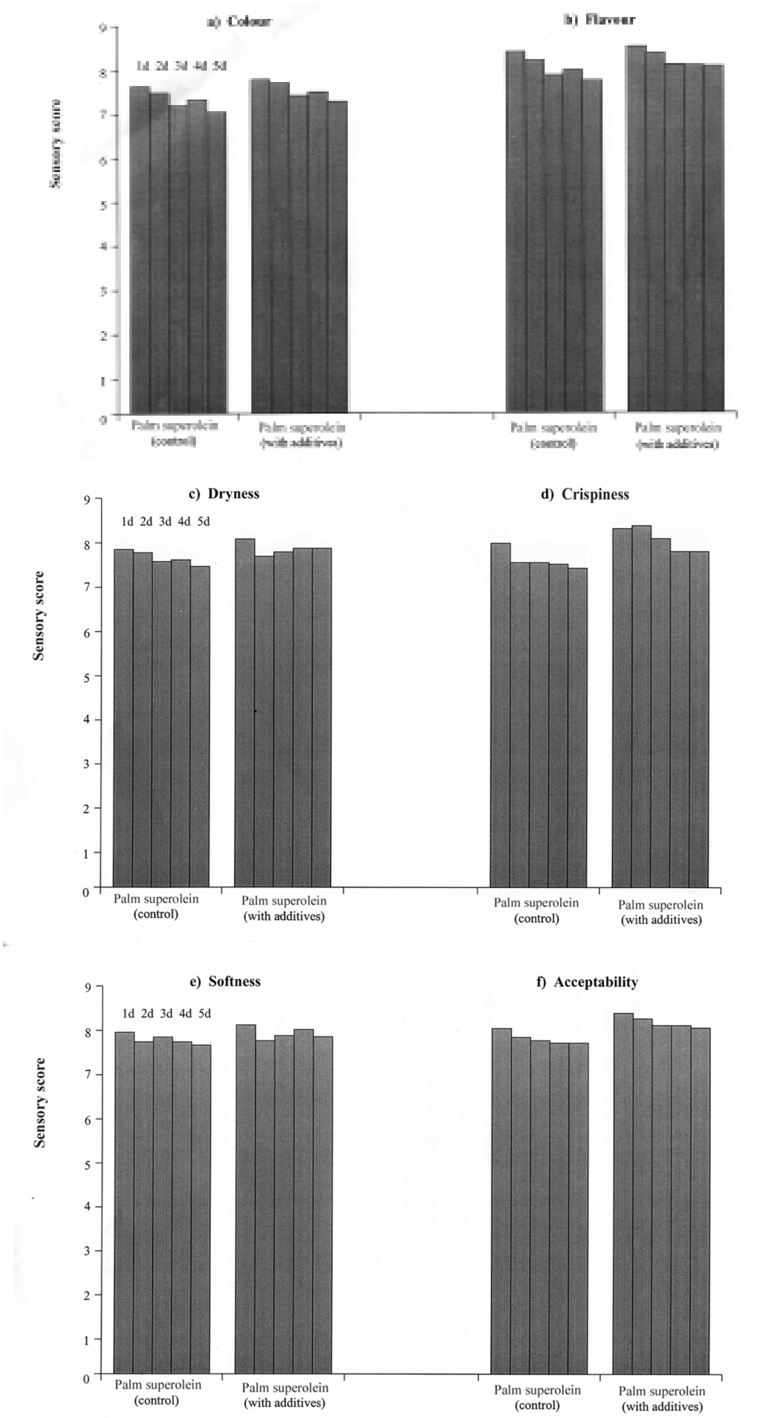

Figure 1. Mean sensory scores of chicken nuggets over five days of frying.

oils and fats by forming a protective film at the air-oil interface (Freeman *et al.*,1973; Ohta and Kusaka, 1979). Data in *Table 3* clearly show that a combination of TBHQ and silicone was effective in preventing deterioration of palm superolein during intermittent/batch frying. These results were attributed to the synergistic effects of the additives.

The average scores by the taster panel over five days are shown in *Figure 1*. There was no significant difference between the average scores for colour, flavour, dryness, outside crispiness or inside softness. Hence, the overall acceptability of the fried chicken nuggets after five days of frying in the two oils was considered good and acceptable.

CONCLUSION

The frying performance of palm superolein without the additives was still good even after five days of intermittent frying.

A combination of 200 ppm TBHQ and 2 ppm food grade silicone was found to significantly improve the quality as well as the frying performance of palm superolein in comparison to the control during intermittent frying of chicken nuggets over a five-day period. The sensory evaluation showed that the chicken nuggets fried in the two oils were good and acceptable.

TABLE 3. SOME CHANGES IN CHARACTERISTICS OF PALM SUPEROLEIN DURING FIVE DAYS OF FRYING CHICKEN NUGGETS

a) PV (meq kg^{-1})

Days of frying (x 8 hr)	Palm superolein (control)	Palm superolein (with additives)
Day 0	0.99	0.90
Day 1	4.77	1.32
Day 3	4.38	2.55
Day 5	7.17	2.41

b) AV

Days of Frying (x 8 hr)	Palm superolein (control)	Palm superolein (with additives)
Day 0	1.87	1.80
Day 1	29.05	13.75
Day 3	43.40	18.32
Day 5	66.15	20.27

c) FFA (%)

Days of frying (x 8 hr)	Palm superolein (control)	Palm superolein (with additives)
Day 0	0.04	0.04
Day 1	0.19	0.15
Day 3	0.45	0.33
Day 5	0.76	0.48

d) Smoke points (°C)

Days of frying (x 8 hr)	Palm superolein (control)	Palm superolein (with additives)
Day 0	229	228
Day 1	209	214
Day 3	188	200
Day 5	182	190

e) OSI (110°C, hr)

Days of frying (x 8 hr)	Palm superolein (control)	Palm superolein (with additives)
Day 0	21	49
Day 1	15	40
Day 3	17	34
Day 5	12	32

f) Tocopherols + tocotrienols (ppm)

Days of frying (x 8 hr)	Palm superolein (control)	Palm superolein (with additives)
Day 0	746	740
Day 1	467	668
Day 3	332	583
Day 5	214	450

g) Polar compounds (%)

Days of frying (x 8 hr)	Palm superolein (control)	Palm superolein (with additives)
Day 0	6.7	6.6
Day 1	9.9	8.4
Day 3	16.0	9.4
Day 5	20.8	11.6

h) Polymer compounds (%)

Days of frying (x 8 hr)	Palm superolein (control)	Palm superolein (with additives)
Day 0	0.45	0.44
Day 1	1.32	1.17
Day 3	2.56	2.02
Day 5	3.80	2.41

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