Palm Oil: The Solution to Over-Used Oil in South Africa

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INTRODUCTION

In South Africa, more than 100 000 t used frying oils are sold as cooking oils to the poor communities annually. While there is nothing wrong with the use of used oils/fats within the regulated specifications, they are, unfortunately, highly oxidized, unstable and, worse, may contain as high as 75% polymers. In animal studies, highly oxidized and degraded substances caused adverse biological effects including growth retardation, diarrhoea, cellular damage, *etc.* and even death (Kock *et al*., 2002). Highly oxidized fats also contain toxic compounds such as liposoluble contaminants like PAHs, PCBs and dioxins (Haw, 2003). Consequently, South Africa has strict regulations prohibiting the use of over-used oils in food preparation. By legislation, frying establishments are prohibited to use oil containing polymerized triglyceride (PTG) breakdown levels (also known as polymers) of 16% and above or total polar compounds (TPC) of 25% and above (Anon, 1996). Oils containing less than 16% polymers are regarded as safe and can also be distributed for further use in food preparations (Kock *et al*., 2002). During an international symposium on deep fat frying in Hagen, March 2000, several European Union (EU) countries accepted varying levels of PTG (10%-16%) and TPC (24%-27%) as the discard points for frying oil (Anon, 2000).

Realizing the potential hazards of using abused oils/fats, the South African Frying Oil Initiative (SAFOI) was formed in 1994 to educate and guide both consumers/buyers towards tested/stable cooking/frying oils through awareness campaigns, training of fryer operators/health officials, seminars, publications and introduction of the Seal of Approval, a certification that endorses the quality and stability of frying/cooking oils. In addition to enforcing the regulatory limits by the Department of Health, SAFOI promotes the use of more stable oils for frying so that less used oils above the regulatory limits are re-used for human consumption (Kock *et al*., 1996). Palm olein was noted as a more stable frying oil than the soft oils from 7000 used oil samples drawn from frying establishments across South Africa since 1997 by Environmental Health Officials: not a single palm oil product over-used in frying has been detected. This was because palm oil is stable against oxidation at high temperatures. Kock *et al.* (2003) calculated the inherent stability (IS) of oils and fats (*Table 1*) and found that palm olein had the lowest IS value, which means it was the most stable oil of all those calculated. This stability is attributed by its predominant oleic and palmitic acids which are both stable against oxidation. The contents of susceptible fatty acids against oxidation, *i.e.*, linoleic and linolenic acids are only about 12% and 0.2%, respectively. High contents of natural antioxidants, *i.e.*, vitamin E (tocopherols and tocotrienols), in palm oil/olein provide extra protection against oxygen attack. Crude palm oil contains 600-1000 ppm vitamin E (Siew, 2005) and refined palm oil, palm olein and palm stearin retain, respectively 69%, 72% and 76% of the original levels in crude palm oil (Sundram, 2005).

The stability of palm oil has been well established through research done worldwide. Many studies have concluded that palm oil or palm olein is comparable to hydrogenated oils in terms of frying performance, if not better (Zeddelmann and Wurziger, 1973; Toregard and Eriksson, 1979). Palm oil/olein not only has a higher oxidative stability index (OSI) than the soft oils (Razali, 2005) but it also extends the shelf-life of fried foods (Masashi *et al*., 1985; Augustin *et al*.,

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TABLE 1. CALCULATED INHERENT STABILITY OF SELECTED OILS AND FATS

Soyabean	7.0
Canola	5.5
Cottonseed	5.4
Olive	1.5
Palm olein	1.3
Sunflower	6.8

Note: Lower value, higher inherent stability.
Source: Kock *et al.* (2003).

1988), increases productivity (Johari *et al*., 2003) and does not produce a soapy taste nor form a sticky gum inside the fryer (Razali *et al.*, 2001). Due to its excellent frying properties, palm oil/olein is used in industrial deep frying of instant noodles and snack foods, flash frying of potato sticks and deep fat frying in restaurants and fast food chains. However, there has been no study to determine the stability of palm oil in extensive batch frying, as is the case in restaurant operation.

Since restaurants and the food service industry are the major users of frying oils, a study on extensive frying was conducted by the Lipid Technology Group, University of the Free State, South Africa, to determine the frying life (to regulatory limits) of palm and sunflower oils. The study also tried to find a means to reduce the over-use of oils/ fats.

SPUR FRYING TRIAL

This trial was performed at Golden Cloud Spur Restaurant, Bloemfontein, South Africa. Two frying oil brands each of palm oil (SupaCrisp) and sunflower oil (Sunseed) were used for frying over two months. Palm oil was used in the first month and sunflower oil the next. The restaurant had three fryers, one each for potato chips, onion and calamari rings. The frying conditions practised by the restaurant were as follow:

Fryer capacity: 20 litres
Frying temperature: 180°C
Frying period:
One month, 15 hr day^{-1} (0900-2400 hr)

At the start of the frying trial, all the three fryers were filled with fresh oil (*Figure 1*). A sample of 50 ml oil was taken from each fryer everyday at 0800 hr. The calamari fryer was then topped up with the used oil from the onion fryer and the oil from the chip fryer used to top up the onion fryer. Fresh oil was used to top up the chip fryer. Sometimes the onion and calamari fryers were topped up with fresh oil during the day, *i.e.*, when the oil level dropped below the set minimum. The residual oil (when too dark in colour) was recovered from the fryers and the volumes measured. Subsequently the oil throughput as well as yields was calculated. A customer acceptance survey of the fried foods was carried out by distributing a five-point facial hedonic scale (1 = bad, 5 = excellent) *smiley face* questionnaire for the chips, onions and calamari to customers before they left the restaurant.

RESULTS AND DISCUSSION

This extensive frying study involved a long period of about 30 days of long hours (15 hr) intermittent frying and was done according to the frying procedures of the restaurant. Palm oil was chosen because it is durable under extreme frying conditions while sunflower oil was selected as control because it is the major cooking and frying oil in South Africa. In this study, only PTG, TPC and fatty acid composition (FAC) were analysed. PTG and TPC are the legislated parameters used to indicate the discard points of frying oil in South Africa. As the used oils are sold to the poor, it is important to ensure that the PTG and TPC of the discarded oil are within the regulatory limits. FAC analysis was conducted to verify the type of oil used for frying and to observe if any particular fatty acids were preferentially oxidized. A customer acceptance test was also conducted because it is the customer who finally decides whether the fried food is acceptable or not.

Chips Fryer

The PTGs of palm oil remained below 5% throughout the trial period of 31 days and fluctuated within a narrow range (average 3.6%; range: 1.9%–4.9%). The PTGs of sunflower oil throughout the trial of 29 days were higher, about twice those of palm oil. The PTG range was also wider (average 8.1%; range: 6.3%-13.8%). The average TPC of palm oil was 16.1% with a range of 10.7%-22.3% while that of sunflower oil was higher at 21.1% with a range of 15.6%-30.3%. Towards the end of the trial for sunflower oil, the TPCs were already above the regulatory limit of 25%. Chips fried in palm oil received consistently higher rating from the customers (average 4.7 points; range: 4.5–5.0 points) while those of sunflower were lower with some of the scores below 4 points (average 4.4 points; range: 3.5–5.0 points) (*Figures 2, 3, 4* and *Table 2*).

Figure 1. The fryer in the kitchen of Spur Restaurant.

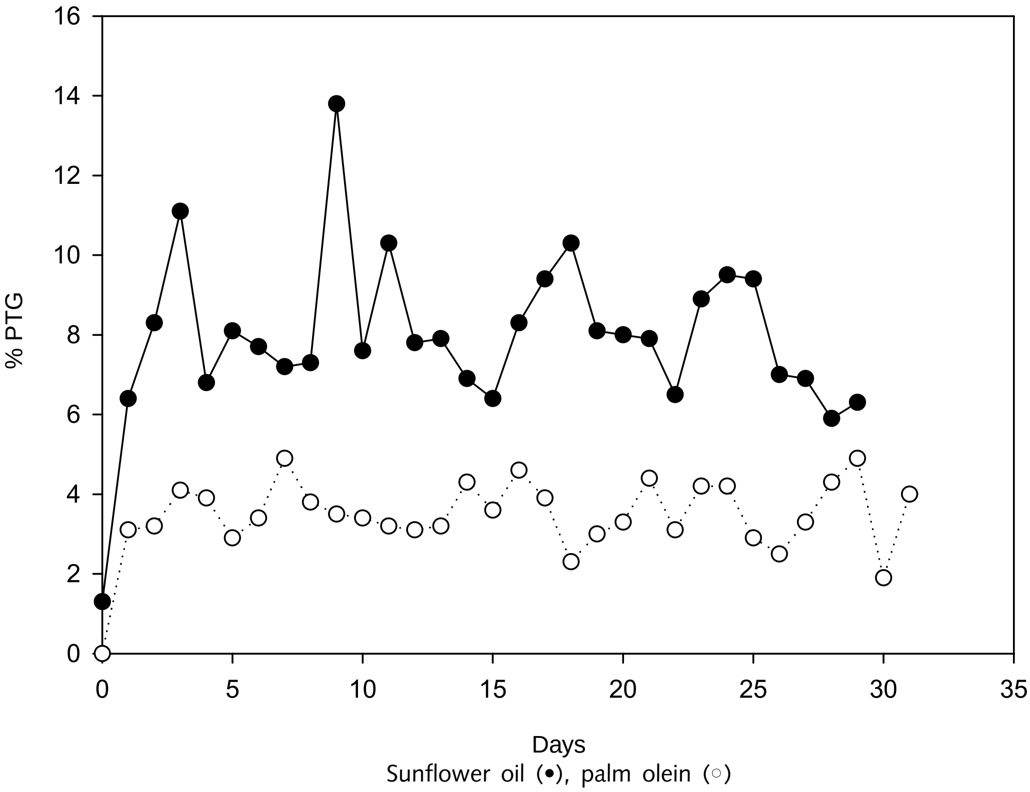

Figure 2. Percentage polymerized triglycerides (PTG) of oil in chips fryer.

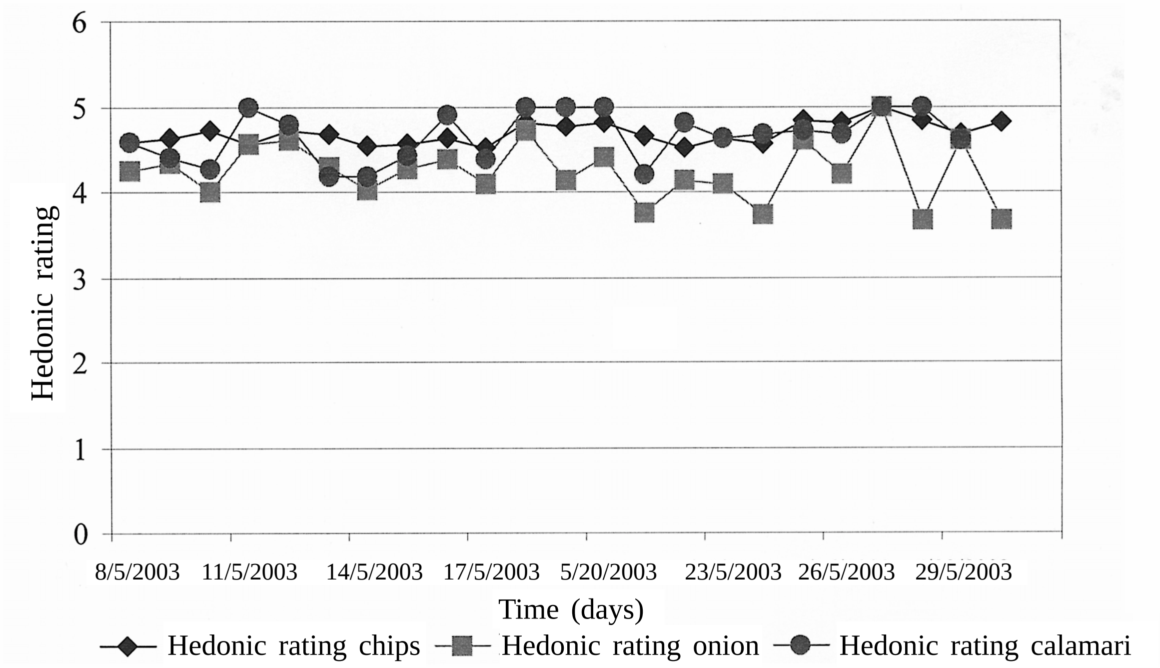

Figure 3. Consumer acceptability for foods fried in palm oil.

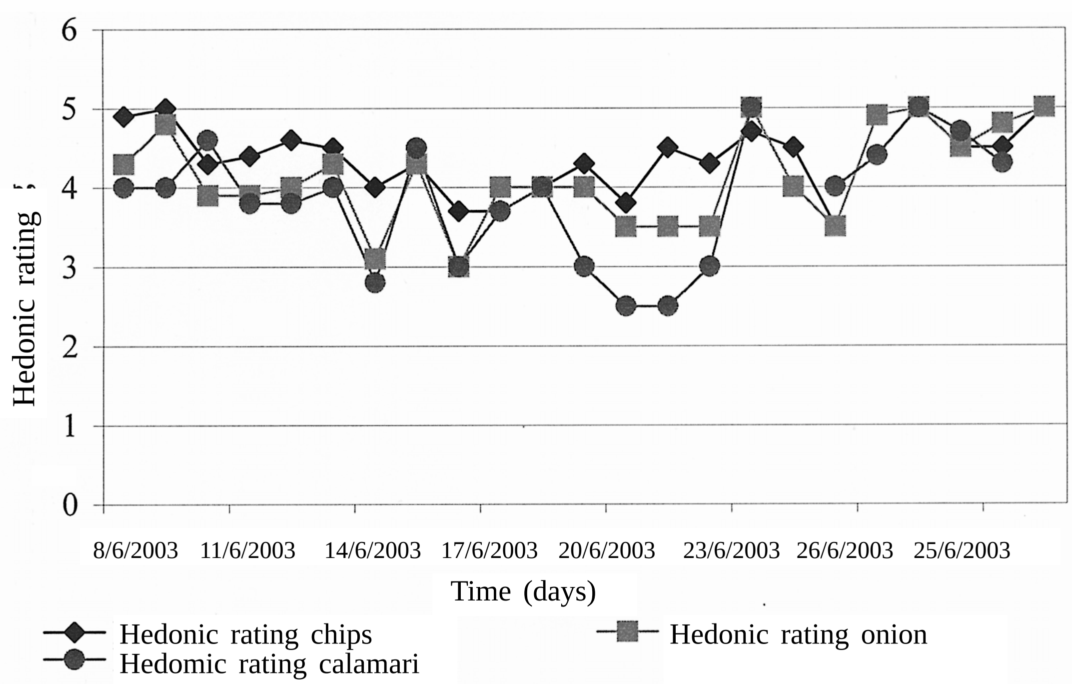

Figure 4. Consumer acceptability for foods fried in sunflower oil.

TABLE 2. SUMMARY OF PTG, TPC, CUSTOMER ACCEPTANCE AND OIL CONSUMPTION

Characteristic	Fryer	Palm olein	Sunflower oil
PTG (%)	Chips	3.6 (1.9–4.9)	8.1 (6.3–13.8)
	Onion	3.1 (1.5–4.9)	9.1 (5.5–13.0)
	Calamari	5.3 (2.4–9.8)	9.9 (4.7–14.6)
TPC*(%)	Chips	16.1 (10.7-22.3)	21.1 (15.6-30.3)
	Onion	17.5 (10.7-25.9)	24.3 (14.3-33.4)
	Calamari	17.4 (10.1-24.6)	23.4 (16.6-33.0)
Customer acceptance (point)	Chips	4.7 (4.5–5.0) n = 563	4.4 (3.5–5.0) n = 108
	Onion	4.2 (3.7–5.0) n = 509	4.1 (3.0–5.0) n = 104
	Calamari	4.7 (4.2–5.0) n = 194	3.8 (2.5–5.0) n = 65
Food fried (kg)	Chips	4 298	3 130
	Onion	1 101	1 152.5
	Calamari	127.33	96.49
Total (kg)		5 526.33	4 378.99
Total oil used (kg)		1 170	1 224
kg food/kg oil used		4.7	3.6

Notes: n = number of customers surveyed.
*Only samples on days 1, 10, 20 and 30 were analysed.

Onion Fryer

For the onion rings fried in palm oil, similar results were obtained with an average PTG value of 3.1% (range: 1.5%-4.9%). Higher PTGs were observed with sunflower oil with an average of 9.1% (range: 5.5%–13.0%) (*Figure 2*). The average TPC of palm oil was 17.5% with a range of 10.7%-25.9%. Higher TPCs were observed with sunflower oil with an average of 24.3%, just below the regulatory limit, in the range of 14.3%-33.4%, indicating that some of the oil had exceeded the limit at the end of the trial (*Table 2*). For palm oil, a very high customer rating was obtained for the onion rings (average: 4.2 points; range: 3.7–5.0 points) (*Figure 3*). A high rating was also obtained for the onion rings fried in sunflower oil (average: 4.1 points; range: 3.0-5.0 points) but with a bigger spread (*Figure 4*).

Calamari Fryer

For both oils, higher PTG values were obtained for the calamari fryer than from their chips and onion fryers (*Figure 6*). While the average PTG value for palm oil was 5.3% (range: 2.4%–9.8%), that of sunflower oil was almost twice as high (average: 9.9%, range: 4.7%–14.6%). The highest (*i.e.* 14.6%) in the range was very close to the 16% limit. The TPCs of palm and sunflower oils in the calamari fryer were almost similar to the ones in their onion fryer. The fluctuating curves of PTG values for both oils in the calamari fryer were sharper than the curves of the oils in the chips and onion fryers. However, the palm oil curve was of a narrower spread than that of sunflower oil. The sharper curves were probably due to faster deterioration of the oils in the calamari fryer as it was the deteriorated oil from the onion fryer. Even topping up the deteriorated oil with fresh oil did not help much in improving the quality of the oil as it degraded quickly.

The PTG regulatory limit of 16% is also found to be at the higher side because from this study, it was observed that while the TPGs are still within the regulatory limit, the TPCs have exceeded it. A lower limit of 10% as in some other countries would be more suitable.

In general, calamari fried in sunflower oil received a lower score (average: 3.8 points, range: 2.5-5.0 points) by the customers than fried in palm oil (average: 4.7 points, range: 4.2-5.0 points) Thus, the quality of frying oil influenced the customer acceptance of the fried foods. du Plessis *et al*. (2000) mentioned that when a frying oil reaches the regulatory limits, it is no longer organoleptically acceptable. In this case, some of individual customer scores were less than three points for calamari fried in sunflower oil because the oil was heavily deteriorated, causing increased surface oil pick up. The observation that surface oil pick up reduced the customer acceptance can also be seen from the lower scores for the onion rings compared to those for the chips and calamari because the onion rings absorbed more oil

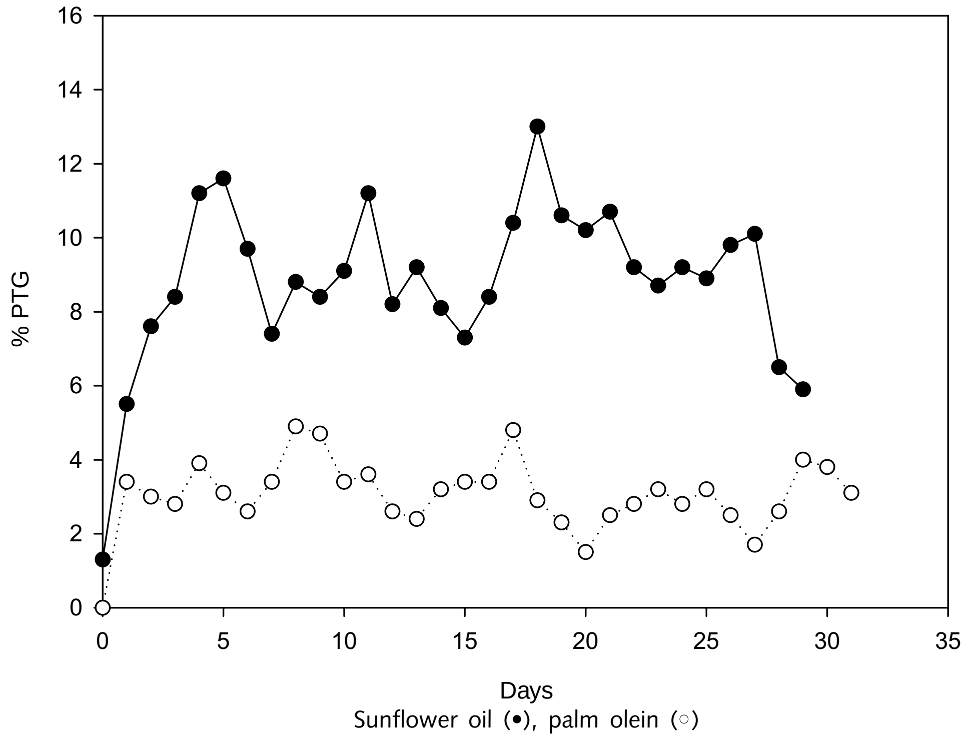

Figure 5. Percentage polymerized triglycerides (PTG) in oil for frying onion rings.

than the other two products (*Figure 3*). In the case of sunflower oil, the oil in the calamari fryer was so heavily deteriorated that the surface oil pick up was more than the oil absorbed by the onion rings, hence, the lower customer acceptance (*Figure 4*). By comparing *Figures 3* and *4* with the development of PTG and TPC during the frying, it can be concluded that higher PTG caused higher oil pick up by fried foods and consequently, lower customer acceptance. This was because the PTG of palm oil in the calamari fryer remained low, thus, the calamari fried in it maintained a high customer rating despite the higher TPC values, while sunflower oil in the calamari fryer had higher PTG values with lower customer rating on the fried calamari. However, all these observations would need to be confirmed.

Fatty Acid Profile

For both oils in the chips, onion ring and calamari fryers, the fatty acid profiles were within their standard specifications and remained so throughout the runs, indicating that pure palm oil and sunflower oil were used (*Figures 7* and *8*). For palm oil, there was no particular fatty acid preferentially oxidized. However, the palm oil supplied might not have been well homogenized from batch to batch as can be seen from the higher palmitic acid contents at some points of the trial. For sunflower oil, there was a decreasing linoleic acid content towards the end of the trial. The fatty acid variation throughout the study was less in palm olein than in sunflower oil.

Oil Consumption

When palm oil was used, 1170 kg were needed to fry 5526.33 kg food (*i.e.* 4.7 kg food/kg oil). The food comprised 4298 kg chips, 1101 kg onions and 127.33 kg calamari (*Table 2*). However, when sunflower oil was used, 1224 kg were needed to fry 4378.99 kg food (*i.e.* 3.6 kg food/kg oil). The food comprised 3130 kg chips, 1152.5 kg onions and 96.49 kg calamari. These results indicate that more sunflower oil is needed to fry the same amount of food. This was due to the fact that surface oil pick up by the food was more with sunflower oil, especially when it was heavily deteriorated with TPGs and TPCs nearing or crossing the regulatory limits. A similar observation was made by Razali and Badri (2003) with chips fried in palm oil, palm olein, soyabean oil and hydrogenated soyabean oil for five consecutive days, 8 hr per day. The French fries done in soyabean oil absorbed more fat than in the other three oils because it contained higher PTG.

CONCLUSION

Sunflower oil was much less stable than palm oil over the 29-day trial in the frying of chips, onion rings and calamari rings by the Spur process. On average, when frying calamari, palm and sunflower oils degraded more than when the other foodstuffs were fried because of the reasons

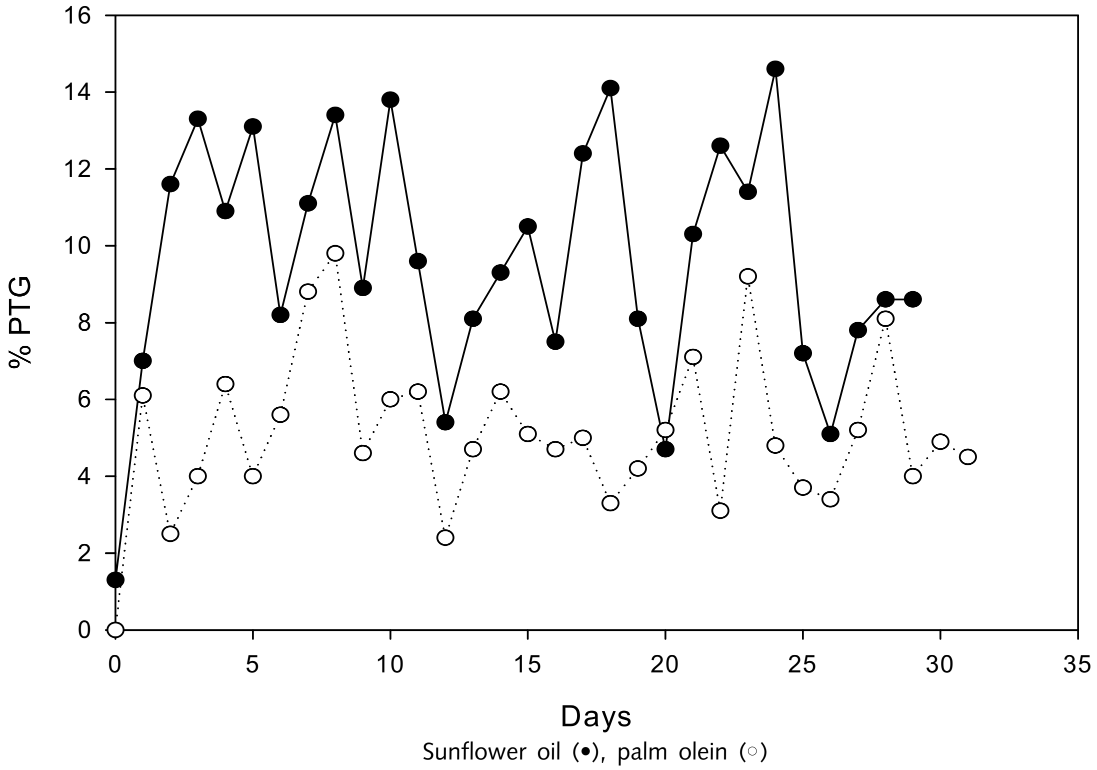

Figure 6. Percentage polymerized triglycerides (PTG) of oil in the calamari fryer.

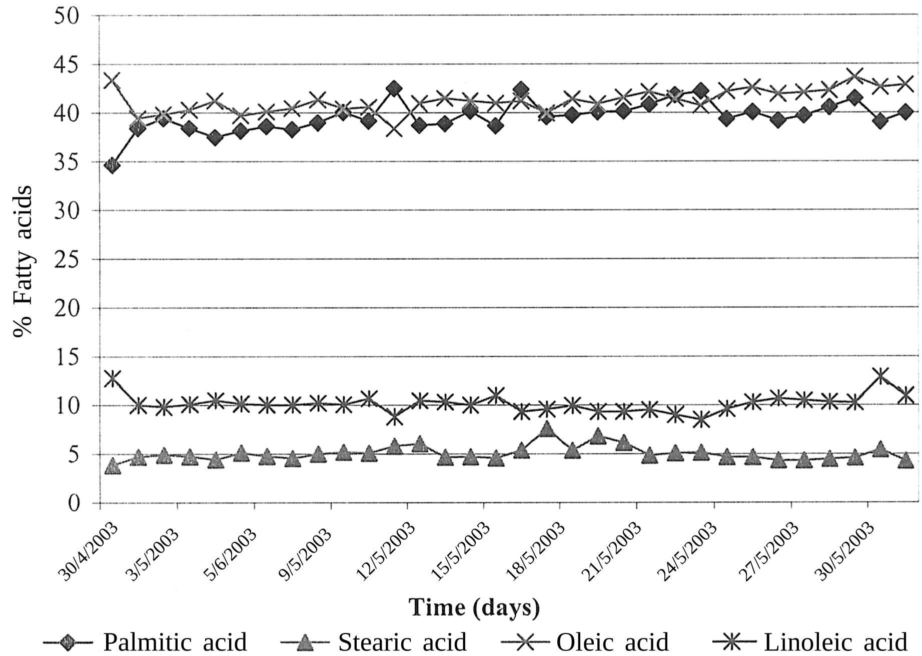

Figure 7. Fatty acid changes in palm olein in the chips fryer during frying.

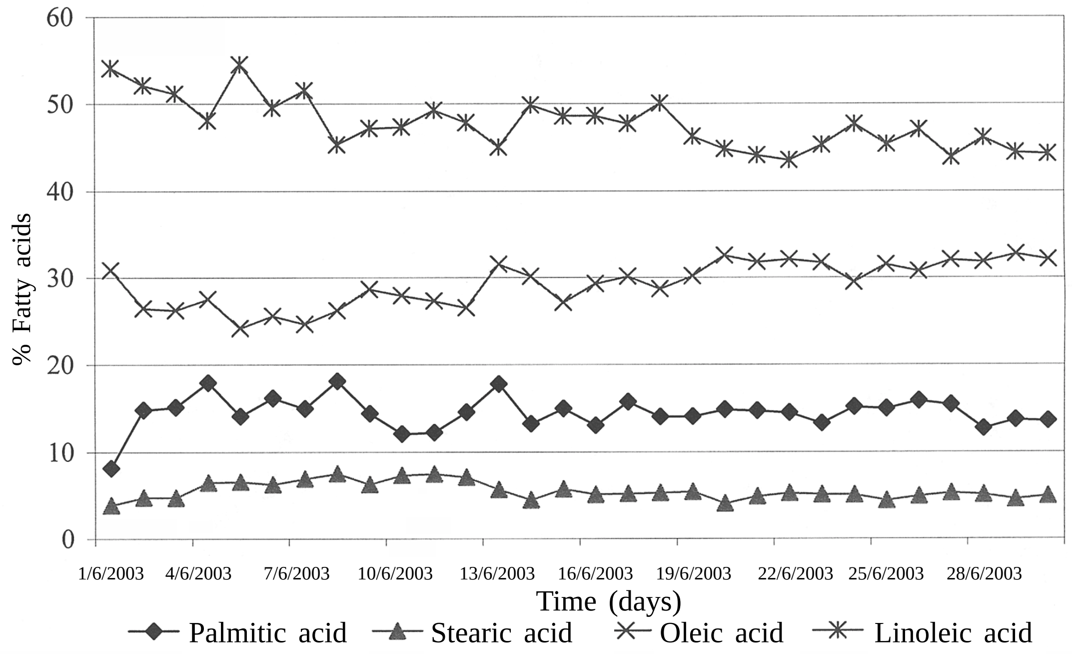

Figure 8. Fatty acid changes of sunflower oil in the chips fryer during frying.

mentioned earlier. The maximum breakdown levels of 13.8% PTGs for chips, 13.0% PTGs for onions and 14.6% PTGs for calamari, with sunflower oil were much higher and closer to the regulatory limits than the levels with palm oil, *i.e.* maximum values of 4.9%, 4.9% and 9.8%, respectively.

Similar observations were made on TPC. The average TPCs of palm oil after frying chips, onion and calamari were 16.1%, 17.5% and 17.4%, respectively, all below the regulatory limit of 25%. However, at the end of the trial, the TPC readings were close to or slightly over the limit. The average TPC readings of sunflower oil for the chip, onion and calamari fryers were 21.1%, 24.3% and 23.4%, respectively. It is obvious that at the end of the trial, the TPC readings of sunflower oil from all the fryers were well above the regulatory limit of 25%.

More food was prepared per unit oil with palm oil (*i.e.* 4.7 kg/kg oil) than sunflower oil *(i.e.* 3.6 kg/kg oil). This was because the sunflower oil degraded faster and the degraded oil had a higher surface oil pick up by the foods.

There was no obvious difference between the average customer acceptance of the chips and onions fried in both oils although the foods fried in sunflower oil obtained the lowest individual ratings. However, there was a significantly better customer acceptance of calamari rings fried in palm oil compared to the rings fried in sunflower oil.

Both palm and sunflower oils did not reach the regulatory limit of 16% PTG after a month of frying although the sunflower oil had almost double the PTG value of palm oil. But the oils had reached or were close to the regulatory limit of 25% TPC after, respectively, 20 and 30 days of frying. Thus, sunflower and palm oils should be discarded, respectively, after 20 and 30 days of frying when the Spur frying procedure is used.

Further studies on the best frying practices for restaurants are needed to derive the best frying practices as a balance between cost and quality.

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