South Africa's Initial Experience in Using Palm Olein Blends for the Manufacture of Pre-Fried French Fries

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INTRODUCTION

South Africa produces considerable quantities of oils and fats with total production averaging 480 000 t yr^{-1}. Sunflower oil is the major oil with production at around 330 000 t annually. This is insufficient for the domestic consumption which in 2002 was around a million tonnes putting the per capita consumption at 23 kg yr^{-1}. Quite large quantities of oils/fats have, therefore, to be imported. Only about 60 000 t oils/fats are exported from South Africa annually, about half of which comprises sunflower oil.

South Africa is predominantly a liquid oil consumer with sunflower oil being the main oil consumed as liquid oil in cooking and frying. Solid fats such as shortening and margarines are mainly utilized by the industrial sector and small amounts of butter and table margarines by households.

Palm oil is the main oil imported by South Africa after sunflower oil, accounting for around 50% of total imports of oils/fats in 2002. In terms of consumption, palm oil at 26% is the second largest after sunflower oil at 37%.

Currently, the main palm oil product imported and consumed by South Africa is RBD palm olein which over the last few years has been showing encouraging growth. In 2002, out of about 179 000 t of Malaysian palm oil products imported, about 45% consisted of palm olein *(Table 1)*. Most of the olein is being used in the industrial frying sector, restaurants and fast food outlets.

In the past, the frying and catering industry of South Africa used locally produced oils such as sunflower and cottonseed oils for frying purposes. However, over the years due to growing demand, local supplies could only satisfy half of total demand and industrial users also started to source oils from outside. A few, especially the fat producers, found that palm oil was technically suitable for their products and more economical than other oils and fats. The frying industry on the other hand was initially sceptical of using palm oil fearing acceptability problems by consumers. The then Palm Oil Research Institute of Malaysia (PORIM) took the initiative to discuss with the Council for Scientific and Industrial Research (CSIR), South Africa, steps to introduce palm olein to the frying industry. A tripartite collaborative project was started involving PORIM, CSIR and Willards Foods for carrying out a frying study. The study evaluated the frying performance of palm olein with pure sunflower oil. The study confirmed that palm olein was an excellent frying oil and conformed to Willards' stringent specifications of quality and performance for frying oil.

Following the success of the collaborative project with Willards, PORIM and CSIR embarked on another frying study involving Heinz Frozen Foods Pty. Ltd. This paper discusses some of the details of the study which was on frying of pre-fried French fries.

HEINZ FACTORY TRIAL

The frying study was on a factory scale. Two types of oil blends were used in the study: Blend A (a blend of sunflower oil and corn oil at 90:10 ratio) and Blend B (a blend of palm olein and sunflower oil at 70:30 ratio). Potatoes were obtained from regular producers and the sugar content was checked to determine their suitability. French fries were prepared and rapidly frozen. The frying run was carried out continuously using the industrial

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frying facility of the factory on the basis of their normal industrial runs. Frying oil was heated to between 160°C and 180°C. Frying oil (250 g) was sampled every 4 hr. This included the start (0 hour) and the end point samples. The frying plant at the time was not fitted with a filter to eliminate food debris during frying. The discard point was therefore not solely determined by the quality of frying oil but rather by the presence of carbonized food debris in the frying oil.

Samples were analysed for the following:

- Rancimat induction periods;
- tocopherol and tocotrienol (vitamin E) levels (CSIR, South Africa);
- tertiary butylhydroquinone (TBHQ) values (CSIR, South Africa);
- total polar compounds (TPC) in all the oil samples (IUPAC-AOAC);
- dielectric constant (food oil sensor model N1-21);
- colour (Lovibond tintometer); and
- free fatty acids (AOCS).

FINAL FRYING TESTS

Products sampled at two stages (mid and end point samples) of the pre-frying run (with each frying oil type) were refried in fresh sunflower oil and the effects of the product on the stability characteristics of the sunflower oil were quantified. Quick methods, free fatty acid (FFA) and dielectric constant (DC) tests were applied to quantify the effects.

RESULTS AND DISCUSSION

Quality of Fresh Oils

Blend A had a FFA contents within the general specifications of oils and fats. The Rancimat induction period of 6.6 hr at 120°C was regarded as satisfactory for an oil containing 78.6 mg kg^{-1} TBHQ. Analysis of Blend A confirmed a high vitamin E value of 72.6 mg/100 g for the unused oil (*Table 2*).

TABLE 1. EXPORTS OF MALAYSIAN PALM OIL PRODUCTS TO SOUTH AFRICA (t)

Palm oil	2001	2002
RBD palm oil	2 819	2 691
RBD palm stearin	41 779	54 531
RBD palm olein	81 498	80 807
PFAD	29 431	31 507
Others	8 080	9 948
Total	163 607	179 484

Source: MPOB (2003).

TABLE 2. QUALITY CHARACTERISTICS OF BLEND A

Sample	FFA	Rancimat IP 120°C (hr)	Total vitamin E (mg /100 g)	TBHQ (mg/1000 g)
Unused oil	0.03	6.6	72.6	78.6

Blend B had a FFA contents of 0.02%. The Rancimat induction period of 6.4 hr at 120°C was lower than expected and on further investigation, it was found that the blend contained only 29.6 mg kg^{-1} TBHQ. The vitamin E content of the blend at 54.7 mg/100 g (*Table 3*) was also lower than in Blend A. Blend B contained some tocotrienols because palm olein consists of about 70% tocotrienols and 30% tocopherols (Mordret and Laurent, 1978). The vitamin E contents of other vegetable oils and fats consist of mainly tocopherols with the absence of tocotrienols (Slover, 1971).

Frying Run

The production run with Blend A ended after 184 hr of continuous frying except for 28 hr (between 20 and 38 hr) where the production was delayed due to heating fuel problems and maintenance. Active frying time was therefore 156 hr. The product yield was 145 t with a throughput of 0.95 t hr^{-1}.

Blend B frying run lasted after 156 hr of continuous frying without interruption, yielding 199 t of finished product and a throughput of 1.27 t hr^{-1}.

The decision to discontinue the frying runs was based on the quality of the frying oil as well as the accumulation of carbonized material in the fryers. The presence of dark particles on the product was an important deciding factor to stop production.

In the frying runs, it is obvious that Blend B performed better than Blend A in terms of product throughput. Higher throughput of Blend B can be explained by the fact that palm olein solidifies faster than sunflower oil. After frying, the hot French fries which absorbed a significant amount of oil need to be cooled down in an ambient pre-cooler before being conveyed

TABLE 3. QUALITY CHARACTERISTICS OF BLEND B

Sample	FFA (%)	Rancimat IP 120°C (hr)	Total vitamin E (mg /100 g)	TBHQ (mg/1000 g)
Unused oil	0.02	6.4	54.7	29.6

to the freezing unit for rapid freezing. The oil absorbed by the French fries and the liquid oil layer on the surface of the French fries needed to be hardened progressively as the temperature dropped. Since palm olein has higher solid fat contents than sunflower oil (*Table 4*), palm olein solidifies faster than sunflower oil in the pre-cooling unit. Since the pre-cooler was designed for sunflower oil, it has an extra cooling capacity when Blend B was used for the frying. Thus, the throughput can be increased to match the extra cooling capacity of the pre-cooler.

TABLE 4. SOLID FAT CONTENT (%) OF SUNFLOWER AND PALM OLEIN AT DIFFERENT TEMPERATURE

Temperature (°C)	Sunflower oil	Palm olein
0	Liquid	61
5	Liquid	55
10	Liquid	38
15	Liquid	19
20	Liquid	3
25	Liquid	Liquid
30	Liquid	Liquid

Source: Razali (2003).

Oil Quality Changes

Figure 1 shows that the rate of FFA formation in Blend A changed after 36 and 156 hours. The 1% of FFA value of this blend was reached after approximately 100 frying hours. Compared to Blend A, Blend B showed a more or less linear rate of FFA formation and also a much lower level. FFA levels in Blend B did not exceed 1% even after 156 frying hours.

Figure 2 illustrates the DC changes during frying of French fries in Blend A and Blend B. DC values of Blend A and Blend B oils differed clearly throughout the frying period. Blend B had about half the DC reading compared to Blend A. It must be pointed out that the DC reading could be affected by the accumulation of food debris causing some deviations at times. However, the FFA and DC values of Blends A and B had reasonably high correlations with regression coefficients of 0.89 and 0.93 respectively. As was the case with FFA, the DC values of Blend B remained relatively low compared to Blend A.

Blend A started with a low TPC value which increased sharply during the first 36 frying hours. Subsequently, the rise in the TPC was quite linear. On the other hand, Blend B started with high TPC, *i.e*. 8.5% but the rate of TPC increase was slower resulting in an

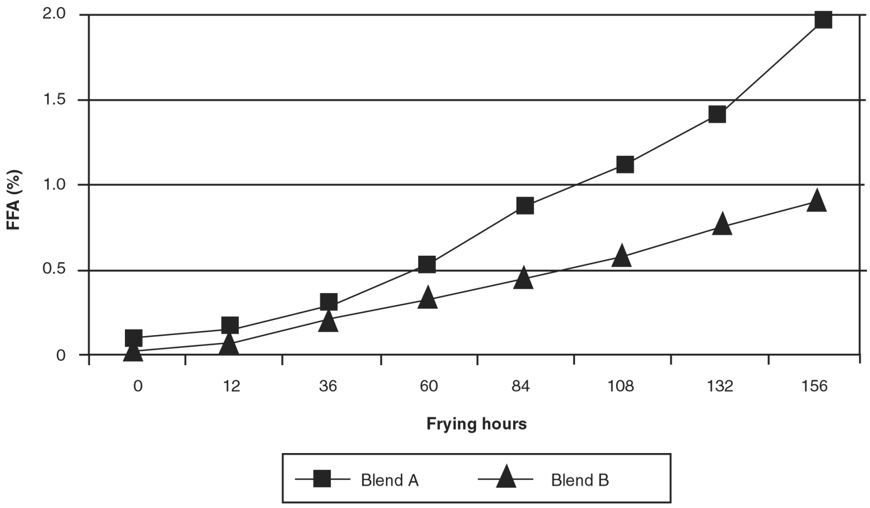

Figure 1. Free fatty acid (FFA) changes during industrial frying of French fries.

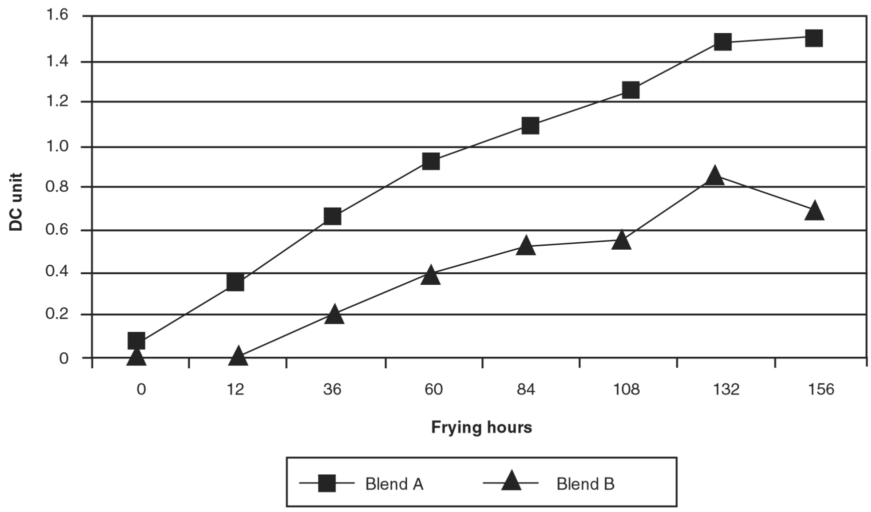

Figure 2. Dielectric constant (DC) unit changes during industrial frying of French fries.

overall lower TPC value than that of Blend A for the remainder of the frying period (*Figure 3*). The reason why Blend B had a high TPC value initially (at zero frying hour) was because palm olein in general has high contents of diglycerides with a range of 5.7%-8.3% and an average of 6.8% (Goh and Timms,1985). Thus, the initial high TPC value of Blend B could be explained by the presence of 70% palm olein.

The Lovibond colour changes of the two frying oils are shown in *Figure 4*. The colour of Blend B was initially higher (darker) than the colour of Blend A but towards the end of the frying run, the colour difference between the two oils was insignificant. This is because the colour rise in Blend B was slower compared to Blend A. A similar observation was made in previous studies (du Plessis and Meredith, 1999;Fauziah *et al.*, 2000; Johari *et al*., 1995) *i.e*. colour development in palm olein is faster than some soft oils. The initial colour of palm olein can be reduced by blending it with other oils. Razali and Iftikhar (2001), found that by treating palm olein with bleaching earth, the initial colour and the colour rise in palm olein can be significantly reduced. In most cases, the colour of the frying oil has no significant effect on the colour of fried foods (Razali *et al*., 1999).

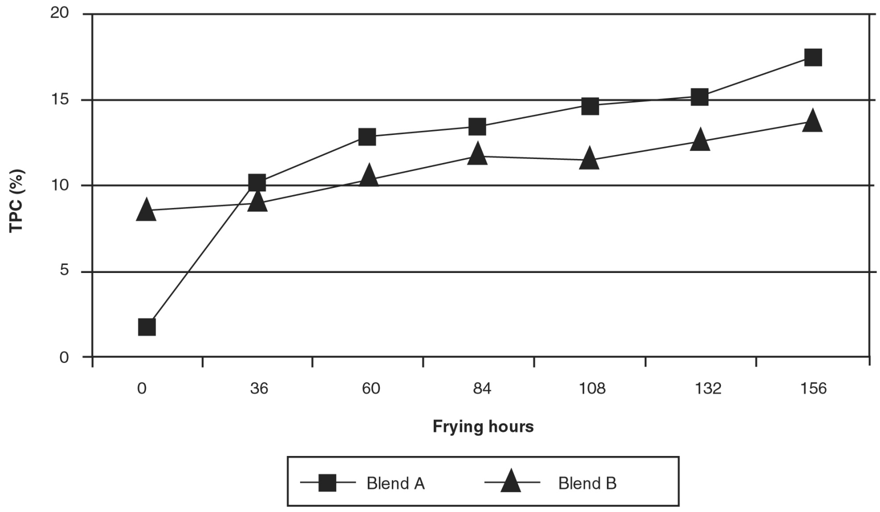

Figure 3. Total polar components (TPC) changes during industrial frying of French fries.

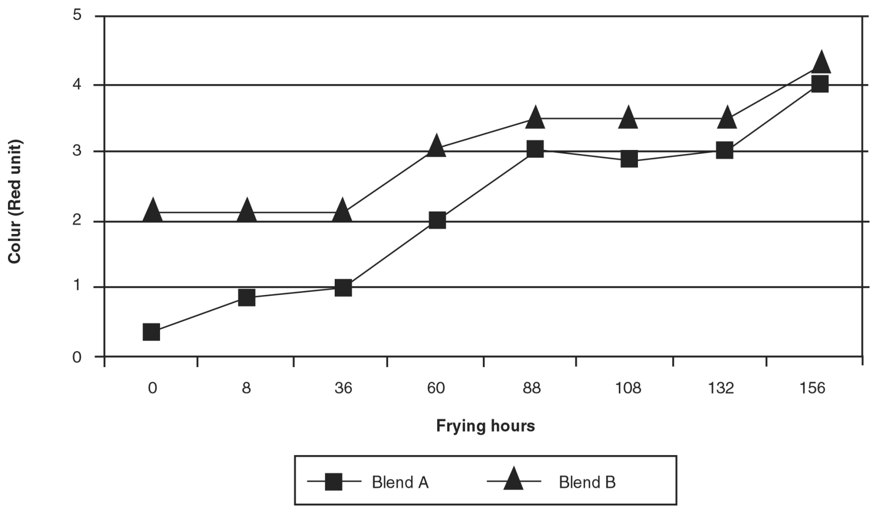

Figure 4. Colour changes during industrial frying of French fries.

The vitamin E changes in Blend A were miniscule during the frying period (72.7 to 67.2 mg/100 g change) while Blend B showed a remarkable retention of vitamin E during the whole frying period (54.7 to 53.0 mg/100 g change). Vitamin E values in Blends A and B did not correlate well with TPC changes of respective blends and in this study seem to be not a good parameter to indicate the state of frying oil quality (*Figure 5*). Contrary to this finding, in a previous frying oil study, it was shown that the total tocopherol content of palm olein was an excellent predictor of oil quality (du Plessis and Meredith, 1999). The recovery in vitamin E levels after 108 frying hours in Blend B could be explained by the top-up oil blended into the used oil. This phenomenon can be explained by further investigations.

Final Frying of Pre-Fried French Fries

FFA and DC were determined immediately after sampling of the final frying oils. *Figures 6* and *7* show the FFA changes in sunflower oil during final frying of French fries pre-fried in Blends A and B. Comparing *Figures 6* and *7*, it can be seen that the quality of French fries has some hydrolytic effects on the sunflower oil during frying. In this case, the values of FFA for end samples were higher than the values of FFA for mid samples. However, the type of oils used for pre-frying had no or very little effect on the FFA of sunflower oil during the final frying of French fries as the graphs show similar trends for French fries from both Blends A and B. Similar trends in DC changes were observed during final frying of French fries in sunflower oil for both blends (*Figures 8* and *9*).

Both FFA and DC values were still well below the discard points even at the 14th frying cycle of the end sample. Since the final frying

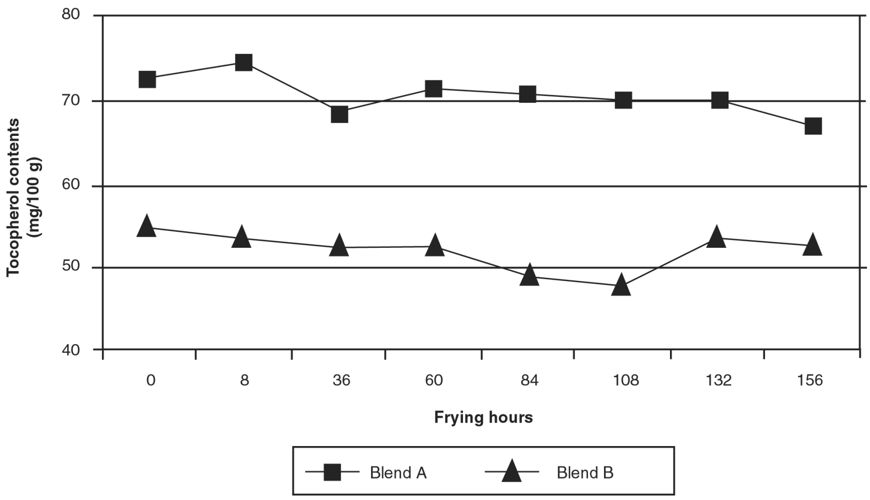

Figure 5. Tocopherol contents changes during industrial frying of French fries.

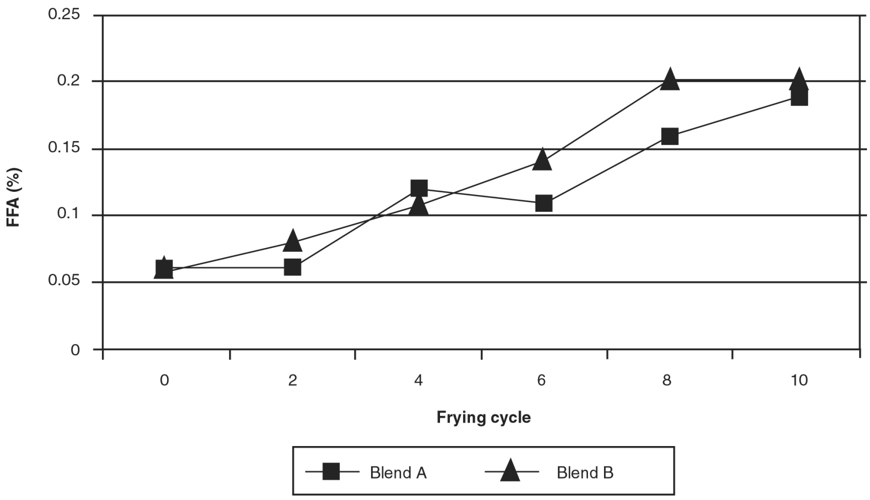

Figure 6. Free fatty acid (FFA) changes during final frying of French fries in sunflower oil (end samples).

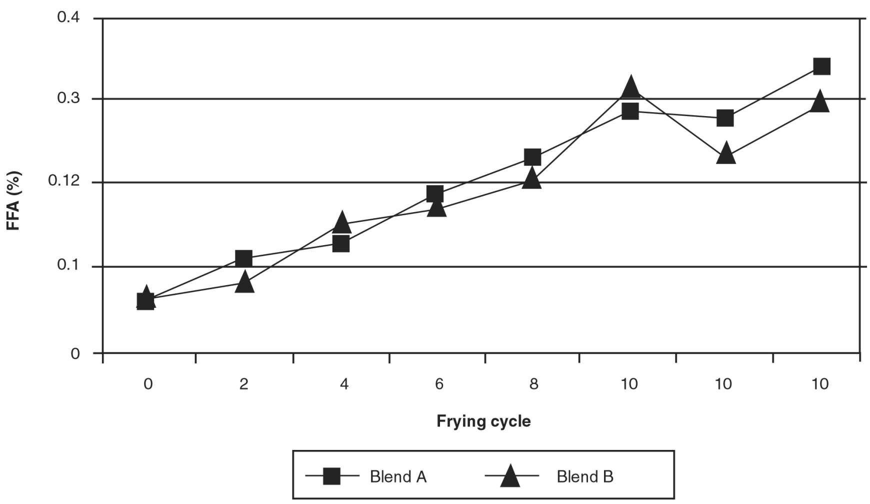

Figure 7. Free fatty acid (FFA) changes during final frying of French fries in sunflower oil (end samples).

was not conducted until its discard point, it can be concluded that both Blends A and B pre-frying oils were comparable and affected the final frying oil in a similar manner.

CONCLUSION

In terms of FFA, DC and polar components formation, Blend B performed better than Blend A as a pre-frying oil of French fries. Blend B also exhibited slower colour increase and tocopherol degradation. Although this study illustrated that Blend B was superior to Blend A, Blend B could have performed much better if a similar level of TBHQ were present in both blends.

Productivity increased by about 30% when Blend B was used for frying. This was due to the smooth frying operation and faster oil solidification during the cooling process. There was also a production breakdown during the frying operation using Blend A that resulted in lower productivity.

The FFA and DC analysis on sunflower oil used for the final frying of French fries showed that the oil quality in the pre-fried products had some effects on promoting FFA and DC in the sunflower frying oil. The magnitude of the effects however, was not conclusive, as the frying oil did not reach its discard point.

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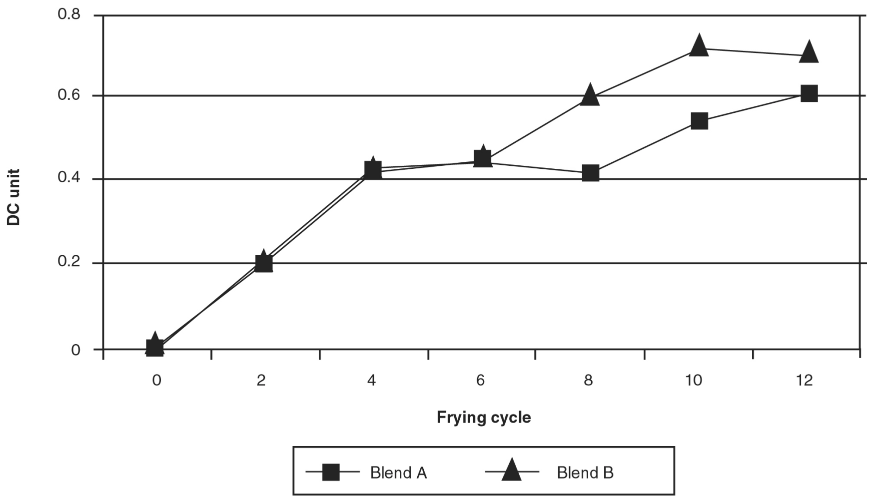

Figure 8. Dielectric constant (DC) changes during final frying of French fries in sunflower oil (mid samples).

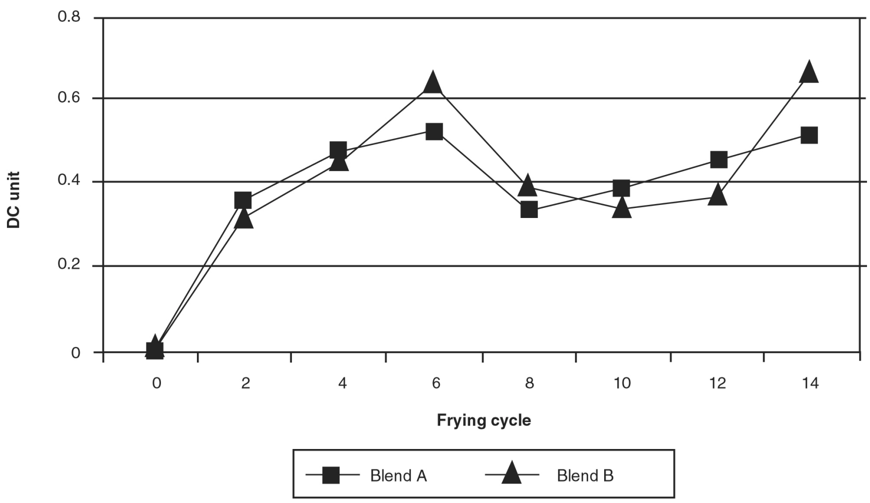

Figure 9. Dielectric constant (DC) changes during final frying of French fries in sunflower oil (end samples).

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