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RESEARCH ARTICLE

Changes in quality characteristics of coconut oil during deep frying

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ABSTRACT

Reuse of coconut oil, especially for deep frying of various foods is a common practice in domestic and commercial food preparations in Sri Lanka. A study was carried out to find out whether there are any changes of quality characteristics of repeatedly deep-fried coconut oil. Reused coconut oil (18 samples) used for deep frying were collected from home kitchens, street food outlets and commercial food outlets. Simultaneously fresh coconut oil samples as reference samples were also collected. Moisture content, free fatty acids content (FFA), peroxide value and iodine values of fresh and deep-fried coconut oil samples were determined using AOAC methods. Results showed that all the fresh coconut oil samples (FCO) had moisture contents higher than 0.4 %, while 22 % FCO has a FFA contents higher than 0.8 % , and were not within the SLS standards (0.8%). Iodine values of 88 % FCO confirmed to the SLS standards indicating most of the commercially available coconut oils are not adulterated and 83% of FCO had Peroxide values below 2meq/kg. Coconut oil samples used for deep frying (DFCO) showed significantly lower moisture contents than respective FCO, and 80% of DFCO had FFA contents confirming to SLS Standards. However, peroxide and iodine value of DFCO showed significantly increased values compared to corresponding FCO. This may be due to the contribution of the unsaturated fatty acids from food material used for frying.

Key words: Coconut oil, Repeated frying, Moisture, Free fatty acids, Peroxide value and Iodine value

INTRODUCTION

The food habits of people have been changed since recent past due to various reasons. Today many people prefer to eat ready to serve food at small to large scale restaurants and from street food outlets. Most of such foods are cooked using deep frying or shallow frying. Reuse of deep frying oil is a common practice in domestic and commercial places. Coconut oil is the widely used and popular deep-frying oil in Sri Lanka.

Oil is heated to high temperature reaching 180-200^{o}C when food material is deep fried. Series of physical and chemical changes of oil are taken place during these temperatures. When deep frying oil is exposed to moist air, a broad spectrum of chemical reactions occur in cooking media. Peroxidation is the most common chemical reaction that occurs in oil and fat at high temperature. This reaction produces large amounts of chemical components (Wasowicz *et al*, 2004). Formation of free radicals, free fatty acids, aldehyde,

ketones, water are some of the chemicals formed as a result of peroxidation. Therefore, excessive use of repeatedly deep-fried oil in food preparations can cause deleterious effects on health as some of those compounds are harmful for consumption (Shastry *et al*, 2011; Chacko and Rajamohan, 2011; Gupta *et al*, 2014; Lenog *et al*, 2015; Lobo *et al*, 2010). Oil / fats containing unsaturated fatty acids produce comparatively higher amounts of free radicals and oxidized products compared to those of saturated oil / fats. The free radicals in oils will get into the food being deep fried and are not recommended for edible purposes. Coconut oil is saturated (approximately 92 %) and therefore, it produces lower oxidized products compared to unsaturated fatty acids rich oil and fats. Therefore, coconut oil is comparatively safer to reuse.

The reactions involved in deep frying change chemical and physical nature of the oil. When food is deep fried, moisture present in the food is evaporated by absorbing heat from fat. Then the moisture turns in to steam. This steam will remove volatile components in the fat which is continuously being heated to high temperature. Edible cooking oil consists of long chain fatty acids. Cooking oils like soya and sunflower are rich in poly- unsaturated fatty acids while olive oil and peanut oil are rich in monounsaturated fatty acids. In contrast, coconut oil is rich in saturated fatty acids. The chemical composition of oil plays a vital role for being stable or unstable during deep frying process.

Non-volatile components are also present in oil / fat subjected to repeat frying. These components are fatty acids formed as a result of hydrolysis of fat molecules, Colour compounds formed due to caramalization and oxidized products. These components will be present in fat permanently. Therefore, even the saturated fats such as coconut oil will change chemical and physical characteristics when used for deep frying.

The objective of this study is to investigate the changes occurring to the quality of deep-fried coconut oil (DFCO) collected from different places in Wennappuwa area in the Puttalam district. The findings are useful to decide whether the repeatedly used coconut oil is still safer to use or not. Further, the information would be useful to study effects of reused oils for improving the mechanism of reusing frying oils reducing costs in deep frying.

MATERIALS AND METHOD

Coconut oil samples (18) were collected from different places in Wennappuwa area in the Puttalam district. The coconut oil samples which have been used for deep frying (DFCO) were collected from different places simultaneously with the fresh samples (FCO). Samples were collected from take away food outlets, street *wade* vendors, hostels, households and Chinese restaurants located in the study area. The history of the usage of samples were also recorded. All the samples were stored at refrigerated condition until analysis are carried out. Samples were analyzed for moisture content (SLS, 2009), free fatty acid content (SLS, 2009), peroxide value (AOAC, 2012) and iodine values (AOAC, 2012). The details of the samples used for the study is given in Table 1.

Table 1: Samples used for the study

Sample No	Type of cooking	No. of times reused
01	Deep frying fish	twice
02, 03, 04	Deep frying fish	twice
05	Deep frying chicken	once
06, 08	Deep frying fish	once
07	Deep frying fish	once
09,10,11,12	Reused for different purposes	More than twice
13,14,15	Reused for deep frying wade	More than twice
16, 18	Reused for deep frying different types of foods	More than twice
17	Reused for deep frying different types of foods	More than twice

RESULTS AND DISCUSSION

The figure 1 shows the deviation of moisture content of fresh and reused coconut oil samples from SLSI values recommended for coconut oil in Sri Lanka. According to the data almost all the fresh oil samples showed higher moisture content than the 0.4 % which is recommended for coconut oil by SLSI standard (32:2017) . Therefore, locally available coconut oil contain higher moisture contents. However, after deep frying, the moisture contents reduced compared to the corresponding FCO (Figure 2). The reason for this may be explained as the evaporation of moisture at the deep-frying temperature. Therefore, 16 coconut oil samples used for deep frying show moisture content below 0.4 %. Sample 5 and 18 which showed high moisture content have been used for deep frying chicken and different types of food respectively (Table 1). The cooking temperature of coconut oil ranged between 165^{o}C and 180^{o}C. At this temperature, excess moisture is evaporated. Further, the moisture of the fresh food being deep fried also evaporated from the cooking media due to high temperature. However, complete moisture evaporation may not be achieved during deep frying.

The amount of moisture evaporation can depend on the type of the food being fried and the duration of deep frying. However, moisture is evaporated around 100^{o}C and therefore, evaporation of moisture from the frying media results decrease of moisture after deep frying is accepted.

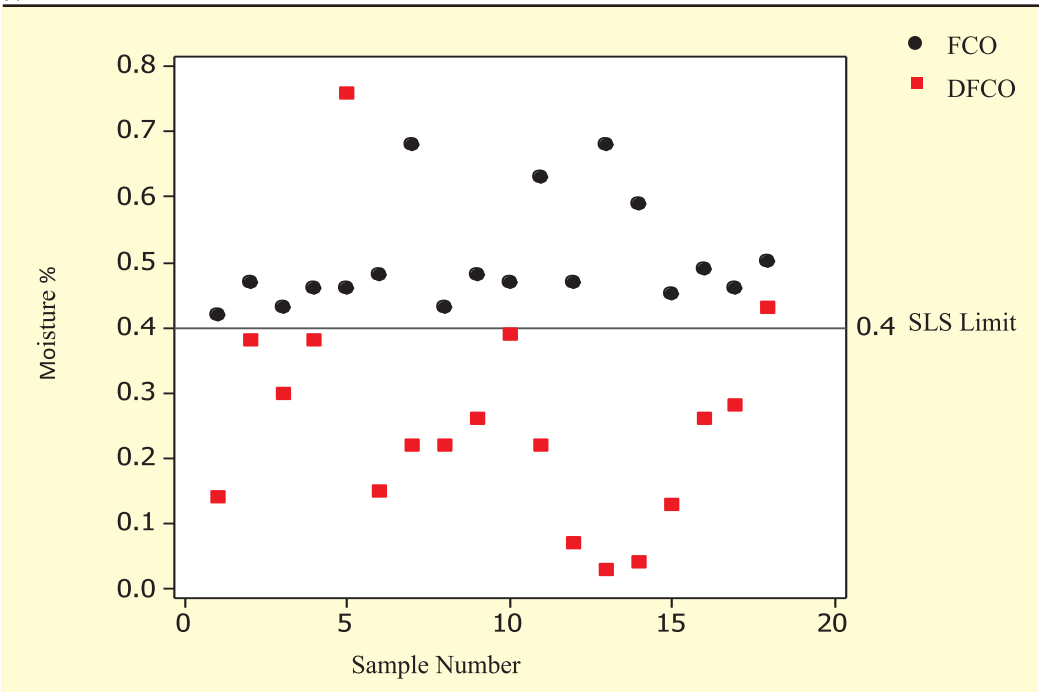

Figure 1: Deviation of moisture content of FCO and DFCO samples form SLS standards

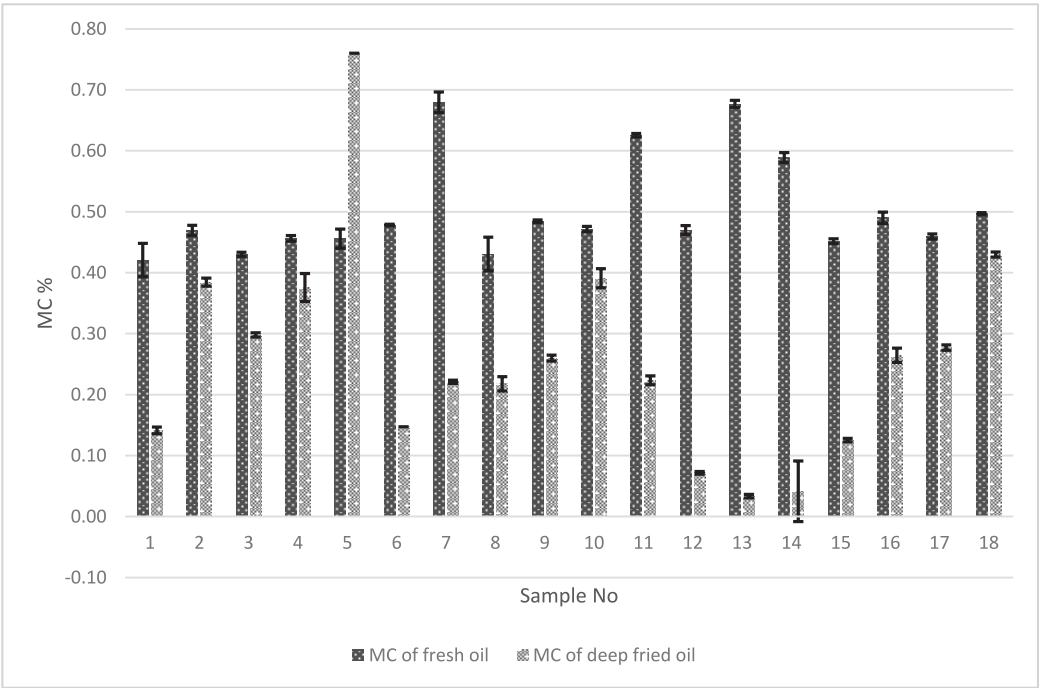

Figure 2: Moisture contents of fresh and used coconut oil samples

The Figure 3 shows the deviation of free fatty acids content of fresh and reused coconut oil samples from SLS value recommended for edible coconut oil. Free fatty acids formation of fats and oil takes place due to lipolysis (Bockisch, 1998). According to the Figure 3, only 5 samples out of 18 fresh samples (28 %) had exceeded the SLS value recommended for FFA of coconut oil. Therefore, 13 samples collected with reused coconut oil samples had accepted FFA content. Further, only 3 out of 18 DFCO have exceeded the SLS limits of FFA recommended for coconut oil. The Figure 4 shows that there is a significant reduction of that free fatty acids content after deep frying ($p<0.05$). This trend was observed from 60 % of the repeatedly fried samples (Figure 4). In addition to that, 77 % of the coconut oil samples used for deep frying confirmed to the SLS limits for FFA content. Although it is significantly reduced, major portion of the free fatty acids has remained with the oil. This indicates that free fatty acids are not easily volatile and therefore with usage, accumulation FFA occurs in oil. Increase of FFA during repeated frying has been observed by previous workers (Houhoula *et al.*, 2003; Choudhary and Grover, 2013). Triglycerides bonds of fats and oils are broken leaving free fatty acids and mono, di, tri glycerol in the fats and oil. These chemical components change the structure of fats and oil. They add chemical components responsible for off flavor and tastes and make the oil unacceptable for cooking or frying.

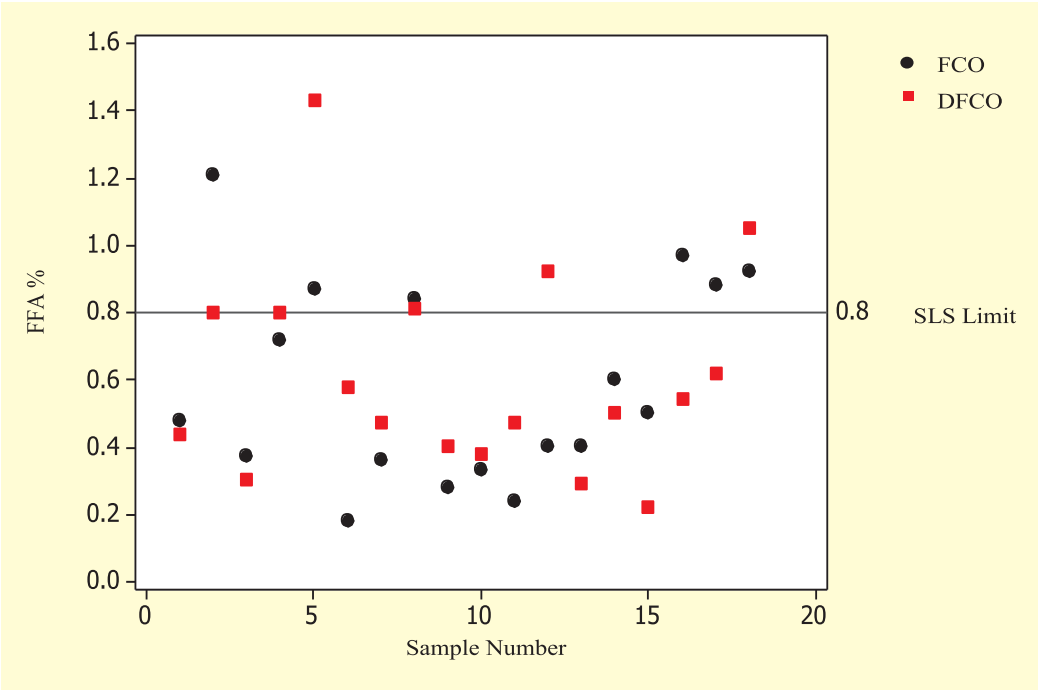

Figure 3: Deviation of free fatty acids content of FCO and DFCO from SLS value

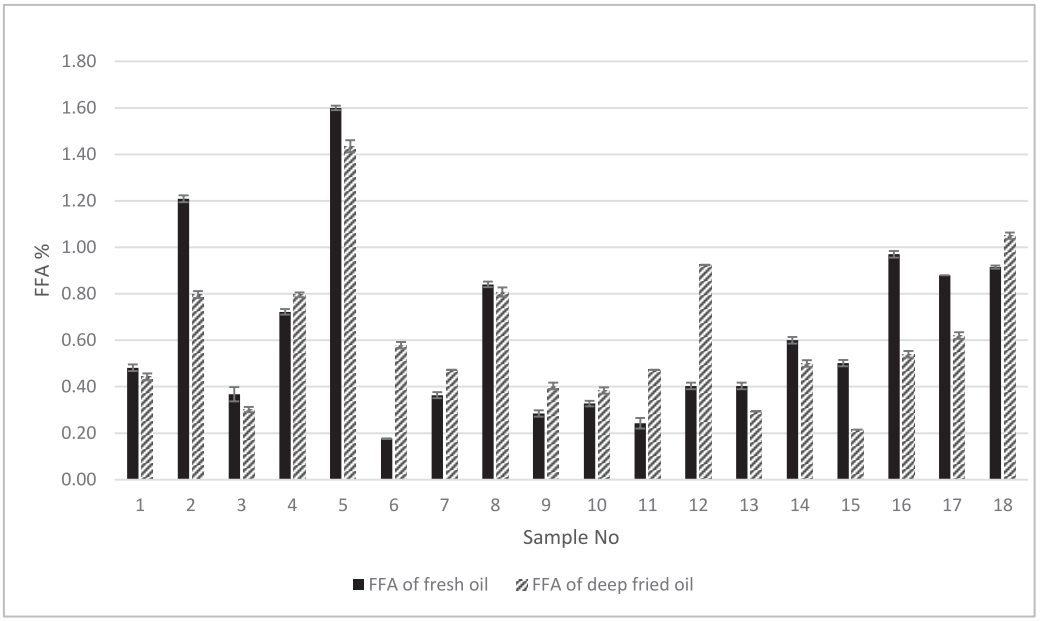

Figure 4: FFA contents of fresh and used coconut oil samples

The deviation of peroxide value of FCO and DFCO from SLS value for edible coconut oil is shown in Figure 5. Peroxide formation is the result of series of reactions initiated between oxygen and unsaturated double bonds in fatty acids in the oil. Thermal oxidation and auto oxidation can take place adding series of chemicals to the oil. These are free fatty acids, water, aldehydes, ketones, hydro peroxides, free radicals and alcohols. These chemicals are formed due to peroxidation of fats having unsaturated fatty acids. Coconut oil contains 5-10 % oleic acid and 1.0 – 2.5 % linoleic acids. Therefore, coconut oil can form peroxides. However, fats and oils having higher percentage of saturated fatty acids form less peroxides than fats and oils having higher percentage of unsaturated fatty acid. Therefore, coconut oil forms lesser amounts of peroxides than other unsaturated fats and oils. Results in Figure 6 shows that peroxide values of most of the fresh coconut oil samples are within the accepted level. According to the data, only 17 % of fresh oil samples have just exceeded the peroxide value accepted for coconut oil. The Figure 6 shows that peroxide value of almost all the fresh samples increased after deep frying. According to the Figure 6, the peroxide value of DFCO were significantly increased compared to the PV of FCO. The increase is 2-8-fold of samples used for deep frying different type of foods. However, there is no any relationship between fresh coconut oil and coconut oil obtained from deep frying for the formation of peroxides.

The formation of peroxides in deep fried oil has been observed by other researchers as well, for example, Zahir *et al* (2014) reported that peroxide value increased with repeated frying in corn oil up to second frying with potatoes while it decreased in the third frying. Similarly, they reported that peroxide value of mustard oil increase at first frying and it decreased second and third frying. Therefore, the increase of peroxide value during repeated

frying in coconut oil observed in this study is accepted. However, fresh samples containing lower peroxide values did not show significant increase after frying. According to Kubow (1992) peroxides containing food can cause harmful effects on health. A study carried out by Shastry *et al* (2011) showed increase in cholesterol, triglycerides and LDL levels in the Wistar rats treated with reused oils. They observed swelling of liver cells and chronic inflammatory cells infiltration of the Wistar rats. Therefore, oil containing high peroxide values should not be reused for cooking.

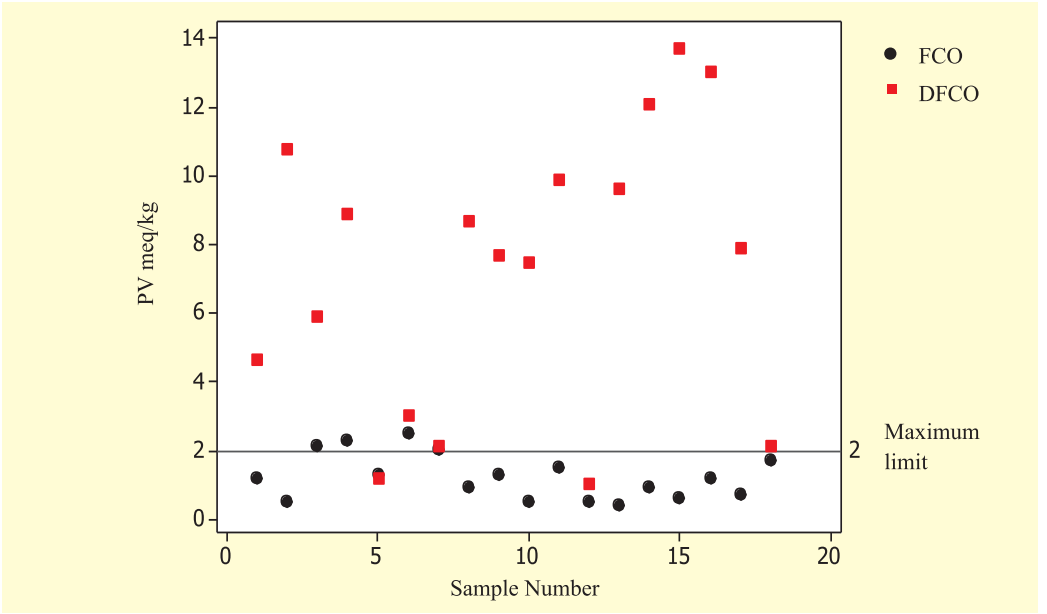

Figure 5: Deviation of peroxide value of fresh and used coconut oil samples from SLS limits

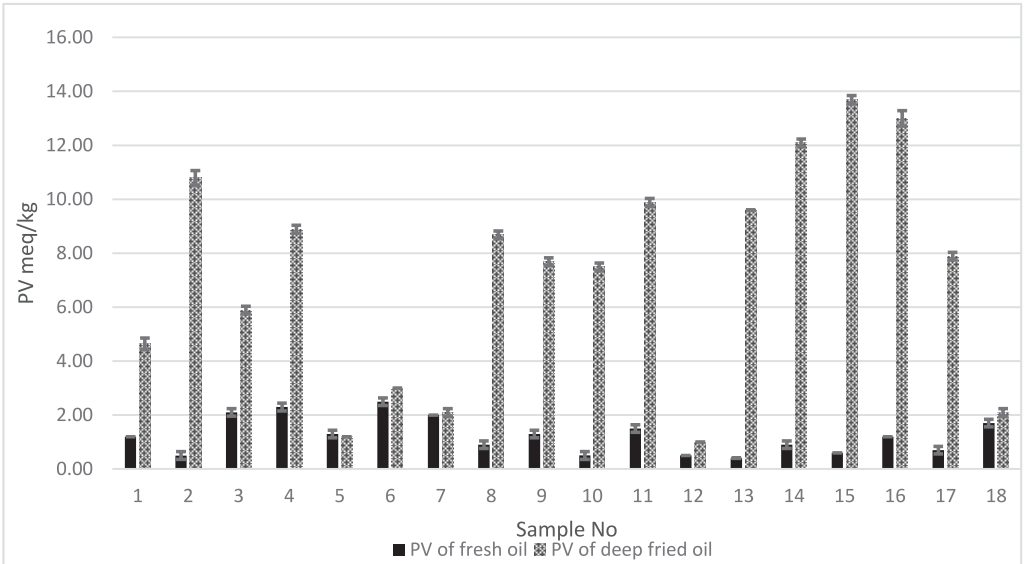

Figure 6: Peroxide Values of fresh and used coconut oil samples

Iodine value measures the degree of unsaturation in fats and oils. It also determines the degree of stability due to oxidation as fatty foods with unsaturated acids are susceptible to oxidation. Iodine values of vegetable oils such as sesame, soya, corn and mustard oil which are highly saturated ranged between 188-195, 189 - 195, 103-110 and 169-176 respectively. The iodine value of coconut and palm kernel oils ranged 6-10 and 14-17 respectively. Therefore, coconut oil is relatively stable oil. The stability of coconut oil is also shown by the low peroxide value of coconut oil samples collected for the study (Figure 5) where peroxide value of fresh coconut oil is below 2 meq/ kg. The peroxide value of the coconut oil did not increase beyond 14 meq/ kg after it was used for deep frying. Iodine value of fresh coconut oil ranged 6-11 (figure 7) which is the accepted range of pure coconut oil (Bockisch, 1998). Two samples of fresh coconut oil show higher iodine values compared to the values recommended for coconut oil. The reason for this higher iodine value is due to adulteration with another source of oil. Figure 7, shows that the iodine value of DFCO exceeded the value recommended for coconut oil. The increase is due to addition of another oil or addition of unsaturated fatty acids rich oil from the food being fried. Figure 8 shows that the increase of iodine value is significantly higher compared to the corresponding fresh coconut oil samples. Most of the coconut oil samples have been used for deep frying of fish (samples 1,2,3,4,6 and 8). Therefore, the increase of iodine value can be occurred due to oil from fish. Fish oil has higher iodine value ranged between 105 -190 (Bockish, 1998). Therefore, the mixed oil in cooking media has higher iodine value. Choudhary and Grover (2013) reported that iodine value of rice bran oil reduced significantly when it is used for deep frying vegetables, *Pakoda* (Traditional Indian snack). However, Shastry et al (2011) observed increase of iodine value of reused palm oil and sunflower oil collected from fast food outlets and restaurants. The results are comparable with the present study where the samples collected from different commercial and domestic food preparations showed higher iodine value than the corresponding fresh coconut oil.

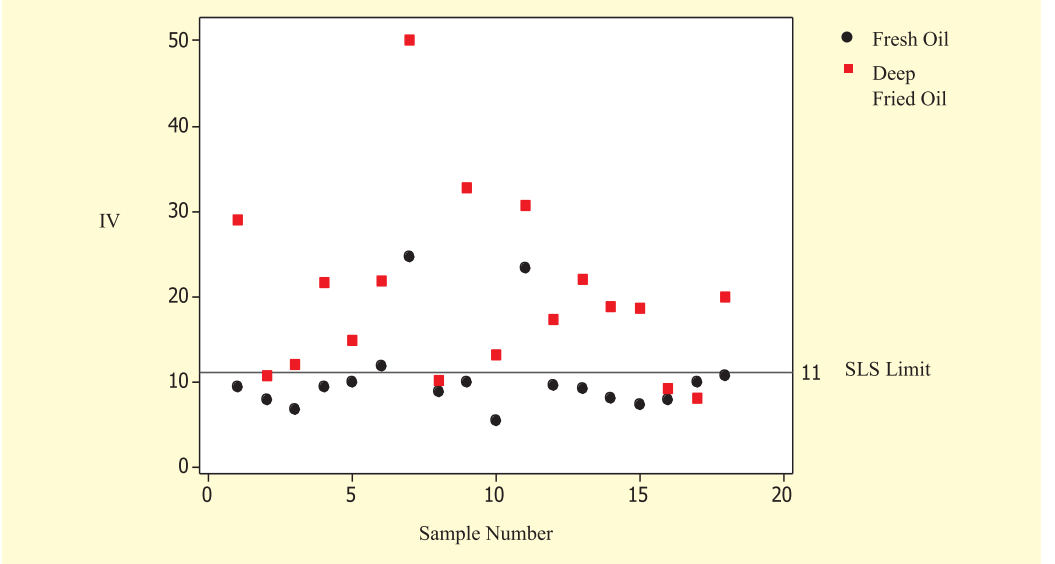

Figure 7: Deviation of iodine value of fresh and used coconut oil samples from SLS limit

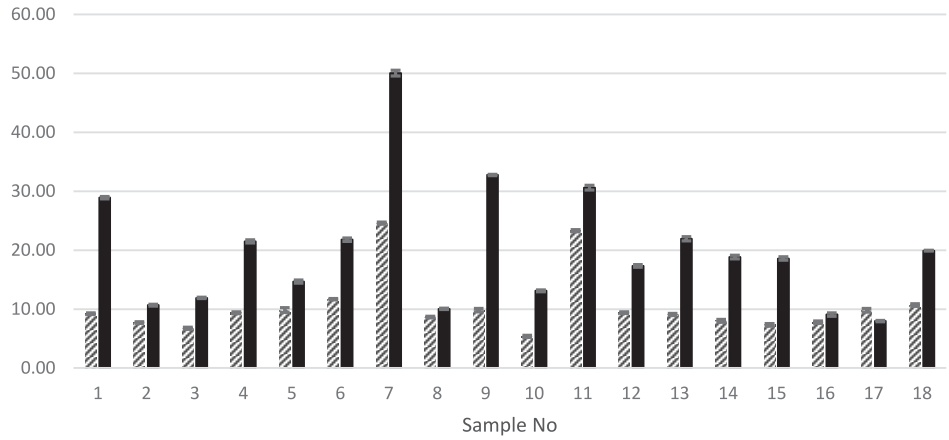

Figure 8: Iodine values of fresh and reused coconut oil samples

CONCLUSION

The results of the present study confirmed that the moisture and free fatty acid content in DFCO were within the SLS standards of edible coconut oil. However, an increase in peroxide and iodine value observed in DFCO, indicates that reuse of coconut oil for deep frying should be limited, based on the type of food material that is fried. Further studies are needed to find out the method to utilize coconut oil used for deep frying.

REFERENCES

1. AOAC. (2012). Official methods of analysis, 19th edition. Association of official analytical chemists, Washington, DC, USA.
2. Bochisch, M. (1998). Fats and oils hand book. AOCS press, Champaign, Illinois, USA.
3. Chacko, C., & Rajamohan, T. (2011). Repeatedly heated cooking oils alter platelet functions in cholesterol fed Sprague Dawley rats. *International Journal of Biological & Medical Research, 2*(4), 991-997.
4. Chousdhary, M., & Grover, K. (2013). Effect of deep fat frying on physiochemical properties of rice bran oil blends. *Journal of Nursing and Health Science*, *1*(2), 1-10.
5. Gupta, R., Vind, S.K., Singh, S.P., Kuma, S., & Kumar, M. (2014). The effect of different deep-fried vegetable oil on cardiovascular system in rats model. *World Journal of Pharmaceutical Research, 3*(7), 1130-1139.
6. Houhoula, D. P., Oreopoulou, V., & Tzia, C. (2003). The effect of process time and temperature on the accumulation of polar compounds in cotton seed oil during deep fat frying. *Journal of*

Science Food Agriculture, 83, 314-319.

7. Leong, X. F., Ng, C. Y., Jaarin, K., & Mustafa, M. R. (2015). Effects of repeated heating of cooking oils on antioxidant content and endothelial function. *Austin Journal of Pharmacology and Therapeutics*, *3*(2), 1-7.
8. Lobo, V., Patil, A., Phatak, A., & Chandra, N. (2010). Free radicals, antioxidants and functional foods: Impact on human health. *Pharmacognosy Reviews*, *4*(8), 118-126.
9. Shastry, C. S., Patel, N. A., Joshi, H., & Aswathanarayana, B. J. (2011). Evaluation of effect of reused edible oils on vital organs of Wistar rats. *Nitte University Journal of Health Science, 1*(4), 10-15.
10. SLS. (2009). Sri Lanka Standard 313: Part 2/ section 1:2009. Methods for analysis of animal and vegetable fats and oils. Sri Lanka Standard Institute, 17, Victorial place, Elvitigala Mawatha, Colombo 08, Sri Lanka.
11. Wsowicz, E., Gramza, A.M.H.M., Jelen, H., Korczak, J., Malecka, M., Szkudlarz, M.M., Rudzinska, M.,… & Wojtasiak, R. Z., (2004). Oxidation of lipids in food. *Polish Journal of Food and Nutrition Sciences*, *13*(54), 87-100.
12. Zahir, E., Saeed, R., Hameed, M.A., & Yousuf, A. (2014) Study of physicochemical properties of edible oil and evaluation of frying oil quality by Fourier Transform-Infrared (FT-IR) Spectroscopy. *Arabian Journal of Chemistry*, *10*(2), S3870-S3876.