Journal of Agricultural Sciences (Belgrade)
ISSN 1450-8109
2020, Vol. 65, No. 1, 61-68
DOI: 10.2298/JAS2001061P

Original paper

Quality parameters of sunflower oil and palm olein during multiple frying

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The refined sunflower and palm oils are used in the food industry for the production of fried potatoes. Literary data have shown that palm oil had less tendency to degradation than sunflower oil due to its fatty acid composition. However, palm olein is a palm oil fraction and therefore has a different composition of fatty acids. The aim of this study was to investigate the quality of the refined palm olein in relation to the refined linoleic type sunflower oil during the production of fried potatoes. The oil samples were used for multiple frying during the seven days (40 minutes per day at a temperature of 165°C). The peroxide value and free fatty acid content (acid value) were determined by standard analytical methods. The results showed that the peroxide value in sunflower oil and palm olein increased by 75.0% and 77.8%, while the acid value increased by 50.0% and 26.8%, respectively, in relation to their initial values in the fresh oil samples. Based on these results, it can be concluded that the palm olein was more suitable for frying. However, this finding cannot be reported with certainty because the quality of the oil depends on many more parameters, not only on those analysed in this paper.

Keywords: sunflower oil; palm olein; peroxide value; acid value

Introduction

Potato frying is a widespread way of preparing potatoes for human consumption. The fried potatoes have a pleasant taste and a crunchy texture that make them very popular with consumers. The most common method of frying potatoes is deep frying in oil in the food industry as well as in the household. In industrial conditions, frying oil is used for a long period of time before being replaced by a new one. The time and high frying temperatures, the presence of moisture and oxygen affect the initiation of chemical and physical changes that deteriorate the oil quality. Numerous volatile and non-volatile compounds are formed in the processes of hydrolysis, oxidation, isomerisation and polymerisation (Choe and Min, 2007). It is very important which kind of oil will be selected for frying, so oils that have more saturated fatty acids in their composition are significantly more stable than those with more unsaturated fatty acids (Grompone, 2005; Matthäus, 2007). As potatoes absorb a certain amount of oil (up to 40%) during frying, a number of undesirable newly formed compounds affect the fried potato quality. Thus, the taste and acceptability of fried potato are deteriorated, but it also becomes unsafe to the health of the consumers. Kita et al. (2005) point out that fried potatoes absorbed less fat by increasing frying temperatures. It is very important to choose the right type of oil that can maintain quality during frying for a long period of time. The most commonly used oils for the industrial potato frying in our country are sunflower and palm oils, or a palm oil fraction (palm olein).

Refined sunflower oil is produced by pressing and extracting sunflower seeds (Grompone, 2005). According to Crapiste et al. (1999), extracted sunflower oil showed a higher oxidative stability in relation to cold-pressed sunflower oil during storage. The dominant

Received: 14/11/2019; Accepted: 28/01/2020; Published: 04/04/2020
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fatty acid in standard (linoleic type) sunflower oil is a linoleic, polyunsaturated, omega-6 fatty acid, followed by an oleic fatty acid, while the linolenic acid content is always less than 0.3%. The low content of linolenic acid is positive because this fatty acid contributes most to the oxidative instability of the oil (Grompone, 2005). Among the saturated fatty acids, palmitic and stearic acids are present in an amount not exceeding 15%. Also, this oil is a rich source of tocopherols, especially alfa-tocopherol (Grompone, 2005).

Malaysia is the world's largest producer of palm oil (Basiron, 2007). Palm oil is obtained by pressing the mesocarp of the palm oil tree fruit (Lin, 2011). Palm oil has approximately the same ratio of saturated and unsaturated fatty acids. Palmitic and oleic acids are the predominant fatty acids, with linoleic and trace amounts of linolenic acid (Lin, 2011; Pande et al., 2012). The high content of saturated fatty acids and the negligible content of linolenic acid make this oil oxidatively stable (Pande et al., 2012). Palm oil contains a significantly higher amount of tocopherols, tocotrienols, carotenoids and chlorophylls in comparison to sunflower oil, and therefore it is oxidatively more stable (Edem, 2002; Pande et al., 2012; Mba et al., 2015). The synergistic effect of β-carotene and tocotrienols can reduce oxidation during potato slice frying at a temperature of 163° C (Pande et al., 2012; Mba et al., 2015). Due to the presence of carotenoid and chlorophyll pigments, palm oil, unlike sunflower oil, has a darker colour. Phospholipids were found in smaller quantities than in other vegetable oils. Similarly, palm oil contains a small amount of phenolic compounds that are responsible for oil browning during frying (Pande et al., 2012). Palm olein is a liquid fraction obtained during the palm oil fractionation process, which involves crystallisation at controlled temperatures and removal of crystals by filtration (Lin, 2011; Pande et al., 2012). Palm olein is different from palm oil in that it has a higher oleic than palmitic acid content.

The aim of this study was to investigate the quality of the refined sunflower oil and palm olein during the multiple deep frying of potatoes.

Materials and Methods

The material for this experiment was purchased at a retail store in Belgrade, Serbia. Refined standard sunflower oil was originally from Serbia, and palm oil fraction (palm olein) originated from Malaysia. Potatoes were produced in Serbia.

Sample preparation. Potatoes (500 g per batch) were cut into sticks and frying was done in two open deep fryers (3 L of oil per fryer), at a temperature of 165°C for a total of 40 minutes (4 minutes per batch of potatoes). The frying process was repeated for seven days (one 40-minute frying per day for both oils, without oil replenishment), and samples of both oils were taken after the first, third, fifth and seventh day of frying. Between frying, the oil was stored in the fryers but with the lids closed. The time interval between the two fryings was about 24 h.

All post-frying and fresh oil samples were compared by standard analytical methods for determination of the peroxide number (peroxide value - PV) and the acid number (acid value - AV). There were ten samples in total: sunflower oil sample before frying (SO), sunflower oil sample taken after the first (SO1), third (SO3), fifth (SO5) and seventh (SO7) frying; palm olein sample before frying (PO), palm olein sample taken after the first (PO1), third (PO3), fifth (PO5) and seventh (PO7) frying.

The peroxide value (PV) [SRPS EN ISO 660:2015], expressed in mmol/kg, was determined by the reaction of oil and chloroform: acetic acid (3:2) with potassium iodide in darkness. The free iodine was then titrated with thiosulfate solution.

The acid value (AV) [SRPS EN ISO 3960:2016], expressed in mg KOH/g, was determined by the titration of a solution of oil dissolved in ethanol: ether (1:1) with an ethanolic solution of potassium hydroxide.

Statistical analysis. Statistical analysis was performed using the statistical software STATISTICA 12 (2013). The results are shown as the arithmetic mean of three replicates ± standard deviation, and the differences between sample groups were determined by Duncan's test. Results were considered at the significance level of α = 0.05. Correlation analysis was carried out using the same program.

Results and Discussion

The results of peroxide and acid values of sunflower oil and palm olein samples before and during potato frying are given in Table 1.

Table 1. The peroxide value (PV) and the acid value (AV) of sunflower oil and palm olein samples before and during potato frying

Samples	AV (mg KOH/g)	PV (mmol/kg)
SO	$0.28^{c} \pm 0.008$	$2.00^{c} \pm 0.004$
SO1	$0.28^{c} \pm 0.016$	$2.30^{c} \pm 0.008$
SO3	$0.28^{c} \pm 0.008$	$2.50^{c} \pm 0.016$
SO5	$0.35^{c} \pm 0.012$	$3.25^{cb} \pm 0.000$
SO7	$0.42^{cb} \pm 0.008$	$3.50^{cb} \pm 0.004$
PO	$0.56^{ba} \pm 0.012$	$2.25^{c} \pm 0.008$
PO1	$0.64^{a} \pm 0.000$	$4.50^{cba} \pm 0.000$
PO3	$0.71^{a} \pm 0.008$	$6.50^{a} \pm 0.004$
PO5	$0.71^{a} \pm 0.000$	$5.50^{ba} \pm 0.008$
PO7	$0.71^{a} \pm 0.004$	$4.00^{cba} \pm 0.000$

Values are presented as means ±SD (n=3); Different letters indicate a significant difference between the sample groups at the significance level of α = 0.05.

Based on these results, it can be seen that palm olein had the free fatty acid content significantly higher in comparison to sunflower oil before frying. Furthermore, the free fatty acid content in sunflower oil and palm olein increased by 50.0% and 26.8% after seven days of frying, respectively, in relation to their initial values in the fresh oil samples. The free fatty acid content in palm olein increased immediately after the first frying, and had constant values after the third frying, while sunflower oil had an increase of the free fatty acid content only after the third frying, but subsequently tended to increase. In the study of Gunnepana and Nawaratne (2015), it was observed that palm olein also had higher values of free fatty acids compared to sunflower oil before the frying process and that both oils showed an increase in the free fatty acid content during multiple frying. Also, according to published results of Gunnepana and Nawaratne (2015), a sudden increase in the free fatty acid content in palm olein after the first frying can be observed. When the acidity of the oil is significantly increased, it is a sign that hydrolytic reactions of the lipids have taken place, resulting in the cleavage of ester bonds and the separation of free fatty acids. Oils with a high content of free fatty acids have a foreign, unpleasant, soapy-acidic and pungent taste (Ebba et al., 2012).

In auto-oxidative processes under the effect of oxygen, light, elevated temperature, moisture and heavy metal ions, the chain reaction in oils produces very reactive peroxides. They can be polymerised and, at higher temperatures, decomposed to carbonyl compounds which contribute to the rancid taste and aroma (Kaleem et al., 2015).

Based on the results obtained in this experiment, it can be concluded that sunflower oil and palm olein had a significant increase in the peroxide value after seven days of frying. Both oils had a similar peroxide value before and after frying. The difference was that palm olein had a significantly faster increase in the peroxide value until the third frying, and after that, it showed a decrease of this parameter. The decrease in the peroxide value of palm olein can be explained by the fact that peroxides can evaporate, decompose and react with other compounds during deep frying (Choe and Min, 2006; Alhibshi et al., 2016). Unlike palm olein, sunflower oil had a gradual increase in the peroxide value during all seven days of frying. The results showed that the peroxide value in sunflower oil and palm olein increased by 75.0% and 77.8%, respectively, in relation to their initial values in the fresh oil samples. Slightly different results can be observed in the research of Gunnepana and Nawaratne (2015). Both oils had a gradual increase in the peroxide value during multiple frying, but palm olein had a significantly higher content of the peroxide value than sunflower oil at the very beginning of the experiment, which in particular affected this parameter increase during frying. According to Gunnepana and Nawaratne (2015), palm olein had neither a sudden increase nor a sudden decrease in the peroxide value.

De Marco et al. (2007) compared the quality of pure palm oil and the blend of sunflower/-palm oil (65/35 vol/vol) during potato frying. The selected blend showed a higher tocopherol content and a lower increment in free fatty acids in relation to pure palm oil, but the other parameters which indicate quality deterioration increased faster in the blend (De Marco et al., 2007). In the research of Aladedunye and Przybylski (2014), high-oleic sunflower oil showed a significantly higher frying stability in relation to palm olein during frying at 185°C for 6 days.

Multiple frying affected the quality of sunflower oil and palm olein. Also, alternating heating and cooling caused the deterioration of oil quality because the oxygen solubility increases in the oil when the oil cools down from the frying temperature (gases are more soluble in liquids at the lower temperature) (Choe and Min, 2007). Based on these results, it can be concluded that palm olein was more suitable for frying. However, this finding cannot be reported with certainty because the quality of the oil depends on many more parameters (water and other volatile compound contents, oil alkalinity, solvent residue, oxidative stability, etc.), not only on those analysed in this paper.

Conclusion

The chemical reactions of hydrolysis, oxidation, isomerisation and polymerisation during deep frying contribute to the deterioration of the oil quality. Numerous compounds are formed such as, among others, free fatty acids and peroxides. In addition to the type of oil, the change in the quality was affected by the period of frying. The results showed that acid values for sunflower oil and palm olein increased by 50.0% and 26.8%, respectively, in relation to their initial values in the fresh oil samples, but palm olein had a higher initial free fatty acid content compared to sunflower oil. The peroxide value in sunflower oil and palm olein increased by 75.0% and 77.8%, respectively, in relation to their initial values in the fresh oil samples. Although palm olein had a greater increase in the peroxide value, a decrease in the peroxide value was observed during frying, unlike sunflower oil, where this parameter had a constant increase. Based on these results, it could be concluded that the palm olein was in some respect more suitable for frying. However, this finding cannot be reported with certainty because the quality of the oil depends on many more parameters, not only on those analysed in this paper.

Acknowledgements

This work was supported by the Ministry of Education and Science of the Republic of Serbia (Grant Nos. 46001, 46010 and 31020).

References

Aladedunye, F., & Przybylski, R. (2014). Performance of palm olein and modified rapeseed, sunflower, and soybean oils in intermittent deep-frying. *Eur J Lipid Sci Technol*, 116(2), 144-152. [**Crossref**] [**Google Scholar**]

Alhibshi, E.A., Ibraheim, J.A., & Hadad, A.S. (2016). Effect of heat processing and storage on characteristic and stability of some edible oils. *6th Int'l Conference on Agriculture, Environment and Biological Sciences (ICAEBS'16), Proceedings*. (105-109). [**Crossref**] [**Google Scholar**]

Basiron, Y. (2007). Palm oil production through sustainable plantations. *Eur J Lipid Sci Technol*, 109(4), 289-295. [**Crossref**] [**Google Scholar**]

Choe, E., & Min, D.B. (2006). Mechanisms and factors for edible oil oxidation. *Compr Rev Food Sci Food Saf*, 5(4), 169-186. [**Crossref**] [**Google Scholar**]

Choe, E., & Min, D.B. (2007). Chemistry of deep-fat frying oils. *J Food Sci*, 72(5), R77-R86. [**Crossref**] [**Google Scholar**]

Crapiste, G.H., Brevedan, M.I.V., & Carelli, A.A. (1999). Oxidation of sunflower oil during storage. *J Am Oil Chem Soc*, 76(12), 1437. [**Crossref**] [**Google Scholar**]

de Marco, E., Savarese, M., Parisini, C., Battimo, I., Falco, S., & Sacchi, R. (2007). Frying performance of a sunflower/palm oil blend in comparison with pure palm oil. *Eur J Lipid Sci Technol*, 109(3), 237-246. [**Google Scholar**]

Ebba, S., Abarintos, R.A., Kim, D.G., Tiyouh, M., Stull, J.C., Movalia, A., & Smutzer, G. (2012). The examination of fatty acid taste with edible strips. *Physiol Behav*, 106(5), 579-586. [**Crossref**] [**Google Scholar**]

Edem, D.O. (2002). Palm oil: Biochemical, physiological, nutritional, hematological and toxicological aspects: A review. *Plant Foods Hum Nutr*, 57(3-4), 319-341. [**Crossref**] [**Google Scholar**]

Grompone, M.A. (2005). Sunflower oil. In F. Shahidi, (Ed.). *Bailey's industrial oil & fat productsedible oils and fat products*. (655-730). Hoboken: John Wiley & Sons, Inc. [**Google Scholar**]

Gunnepana, I.U.K., & Nawaratne, S.B. (2015). Determination of changes occurring in chemical properties of fat repeatedly used for food frying. *Journal of Multidisciplinary Engineering Science and Technology*, 2(12), 3521-3525. [**Crossref**] [**Google Scholar**]

Kaleem, A., Aziz, S., Iqtedar, M., Abdullah, R., Aftab, M., Rashid, F., Shakoori, F.R., & Naz, S. (2015). Investigating changes and effect of peroxide values in cooking oils subject to light and heat. *FUUAST Journal of Biology*, 5(2), 191-196. [**Google Scholar**]

Kita, A., Lisińska, G., & Gołubowska, G. (2007). The effects of oils and frying temperatures on the texture and fat content of potato crisps. *Food Chem*, 102(1), 1-5. [**Crossref**] [**Google Scholar**]

Lin, S.W. (2011). Palm oil. In F.D. Gunstone, (Ed.). *Vegetable Oils in Food Technology: Composition, Properties and Uses*. Oxford, UK: Wiley-Blackwell. [**Crossref**] [**Google Scholar**]

Matthäus, B. (2007). Use of palm oil for frying in comparison with other high-stability oils. *Eur J Lipid Sci Technol*, 109(4), 400-409. [**Crossref**] [**Google Scholar**]

Mba, O.I., Dumont, M.J., & Ngadi, M. (2015). Palm oil: Processing, characterization and utilization in the food industry: A review. *Food Biosci*, 10, 26-41. [**Crossref**] [**Google Scholar**]

Pande, G., Akoh, C.C., & Lai, O.M. (2012). Palm oil: Production, processing, characterization, and uses. *Food Uses of Palm Oil and Its Components*. (561-586). Elsevier, Inc. [**Google Scholar**]

Statistica. (2013). Data analysis software system v.12. USA: Stat-Soft, Inc. [**Google Scholar**]

Parametri kvaliteta suncokretovog ulja i palminog oleina tokom višestrukog prženja

U prehrambenoj industriji se za proizvodnju prženog krompira koriste rafinisano suncokretovo i palmino ulje. Prema literaturnim podacima, palmino ulje ima manju sklonost ka degradacionim promenama u odnosu na suncokretovo ulje, zahvaljujući sastavu masnih kiselina. Međutim, palmin olein je frakcija palminog ulja i samim tim ima drugačiji sastav masnih kiselina. Cilj ovog rada bio je da se ispita kvalitet rafinisanog palminog oleina u odnosu na rafinisano suncokretovo ulje tokom proizvodnje prženog krompira. Uzorci ulja su korišćeni za višestruko prženje tokom sedam dana (po 40 minuta svakog dana, na temperaturi od 165°C). Peroksidni broj i sadržaj slobodnih masnih kiselina (kiselinski broj) određeni su standardnim analitičkim metodama. Rezultati su pokazali da se peroksidni broj u suncokretovom ulju i palminom oleinu povećao 75,0% odnosno 77,8%, dok se kiselinski broj povećao 50,0% odnosno 26,8%, u odnosu na početne vrednosti u uzorcima svežeg ulja. Na osnovu ovih rezultata može se zaključiti da je palmin olein pogodniji za prženje. Međutim, ovaj zaključak se ne može navesti sa sigurnošću jer kvalitet ulja zavisi od mnogo više parametara, a ne samo od onih analiziranih u ovom radu.

Ključne reči: suncokretovo ulje; palmin olein; peroksidni broj; kiselinski broj