UDC 665.353.4:665.35:641.7
ISSN 1330-9862

original scientific paper

Deep Fat Frying of French Fried Potatoes in Palm Oil and Vegetable Oil

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Received: February 17, 1997
Accepted: March 21, 1997

Summary

Degradation of palm oil and vegetable oil (a blend of about 80% rapeseed and 20% soybean oil) during deep fat frying of French fried potatoes was investigated. French fries were fried in household fryer in two stages: the blanching was carried out at 160 °C for 5 min and final frying at 180 °C for 4 min. The oil samples were analyzed for free fatty acids, peroxide value, iodine value, p-anisidine value and polar compounds. The oxidative stability (oven test at 98 °C) for palm oil and some vegetable oils (soybean, rapeseed, sunflower oil and a blend of 80% rapeseed and 20% soybean oil) was determined.

Free fatty acids increased during frying, but there was no significant difference between the examined oils, and the final content was below 1%. The mass fraction of polar compounds was about 26% in vegetable oil, and about 17% in palm oil after 44-hour frying. Anisidine value increased more rapidly in vegetable oil than in palm oil. The best oxidative stability between examined oils was expressed by palm oil, and the least by sunflower oil.

Keywords: deep fat frying, palm oil, oxidative stability, vegetable oil

Introduction

Deep fat frying of food is used in households, restaurants and food manufacturing for a large variety of foods. In conditions applied in the frying process (high temperature, presence of water in food, contact of the fat surface with air, presence of fried product particles in the system) a wide variety of chemical reactions take place. The steam will cause hydrolysis of triglycerides, resulting in formation of free fatty acids, mono- and diglycerides and glycerol. The air released into the frying system will initiate a cycle of oxidation reactions involving the formation of free radicals. The fatty acids can react and form polymers and other complex reaction products *(1–3)*. The final effect of these changes may be the decrease of quality and stability of fried product, which is connected with the adsorption of heated fats in fried products. There is also a possibility of harmful influence on the human organism of some thermal degradation products *(2,4,5)*. Consequently, there is a need to define the alteration level at which the fats or oils must be discarded. Quality limits for frying oil should always be set in relation to the quality of the fried product.

Stability and sensory properties of frying oils are influenced by the characteristics of the oil, the product being fried and frying conditions *(6,7)*. The choice and control of oils are important factors in the frying process.

The basic oils in Croatia are sunflower, soybean and rapeseed oil, while corn oil, virgin olive oil and pumpkin seed oil are produced on a smaller scale. The oils used for frying in the kitchen and in the restaurants are usually sunflower oil and a blend of rapeseed oil with soybean oil (with changeable ratio of the components). Some animal fats such as lard or hydrogenated vegetable oils are also used.

Sunflower oil is valued for its high content of linoleic acid (EFA) and optimal ratio of tocopherol and linoleic acid, but this oil is very sensitive to high temperatures.

Good quality rapeseed oil and soybean oil develop an unpleasant room odor when heated to frying temperatures. The high linolenic acid content of these oils has been implicated in their susceptibility to room odor development on heating.

Palm oil which was offered to the Croatian market a few years ago, was unknown to our customers. To get more information about this frying oil, the investigation of palm oil degradation under potato deep fat frying conditions was carried out in our laboratory and compared with the degradation of domestic oil, which was labeled as »vegetable oil«, and was a blend of rapeseed and soybean oil in the ratio of about 80:20.

Experimental

Frying Process

Potatoes, vegetable oil (blend of rapeseed and soybean oil 80:20), palm oil, soybean, rapeseed and sunflower oil were purchased from local market. Palm and vegetable fresh oils were of good quality, as indicated by low initial peroxide value (1.4 and 1.2 mmol O_2/kg), anisidine value (3.7 and 8.7) and free fatty acid content (0.13 and 0.07% calculated as oleic acid). Potatoes were peeled and cut into 1 cm slices by a household slicer and dried with filter paper on the surface before the frying. Moisture content of fresh potatoes was 80%.

French fries were fried in a household fryer with a rotary vessel and a thermostat for temperature regulation. There were »max« and »min« volume indications on inner walls of the fryer. Initially, the fryer was filled with oil up to the maximal level. Oil capacity was 1300 cm^3. In each batch about 500 g of potatoes were deep fried, and about eighteen batches were fried daily (during 7–8 hours). French fries were prepared in two stages: the blanching operation was carried out for four to five minutes at (160 ± 5) °C and the final frying was carried out for three to four minutes at (180 ± 5) °C. Intervals between frying operations were about 15 min. Each day, before frying a fresh portion of oil (25–30%) was added to the remaining oil (up to the »max« indication). The frying process was conducted to the time above which oil was unsuitable for further use (when the mass fraction of polar compounds was above 25 or 27%).

Analytical Methods

During frying, the oil samples were analyzed in duplicate for the following parameters: free fatty acids *(8)*, peroxide value *(9)*, iodine value *(10)*, p-anisidine value *(11)* and polar compounds *(12)*. Color of the oil was assessed visually and foam development was observed at the friture itself.

The moisture content was determined in fresh and fried potatoes by drying at (103 ± 2) °C *(13)*. The fat content in french fries was determined by extraction with hexane for 6 hours in a Soxhlet apparaturs *(14)*.

As the measure of keeping quality of oils, potentially used for frying, the oxidative stability was determined by oven test at 98 °C *(15)* for palm oil and vegetable oil (a blend of rapeseed and soybean oil 80:20) and compared with sunflower oil and pure rapeseed and soybean oil.

Results and Discussion

Free fatty acid (FFA) content has been promoted as an appropriate measure for the decomposition of frying oil, inversely correlating with the value of the smoke point. The development of free fatty acids arises partly from hydrolysis but FFA are also an end product of oxidation. Recommended upper limit of FFA is between 1% and 2% (calculated as oleic acid) *(16)*. The results of FFA determination during frying (Fig. 1) show that there was no significant difference between two examined oils, and it was below the limit value.

Peroxides, which are the primary products of oxidation, are extremely unstable under frying conditions and decompose to give secondary oxidation products. Therefore, peroxide value (PV) was not proved to be a useful test for frying oils (Fig. 2).

p-Anisidine value (AV) is the measure for secondary oxidation products and was used with some success to

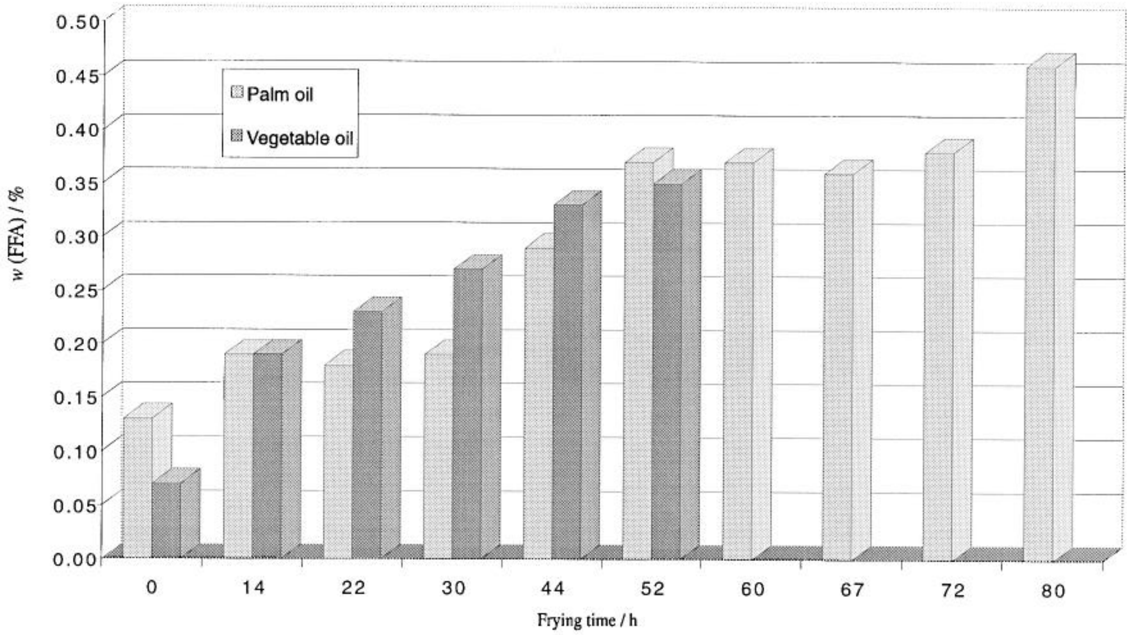

Fig. 1. Free fatty acids in oils during french fries frying

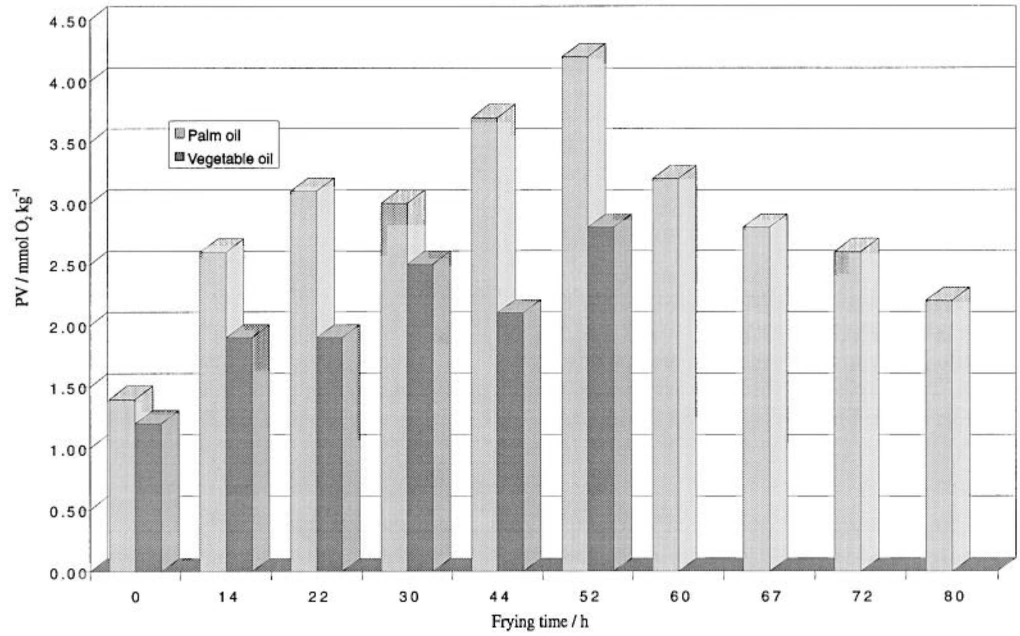

Fig. 2. Peroxide value in oils during french fries frying

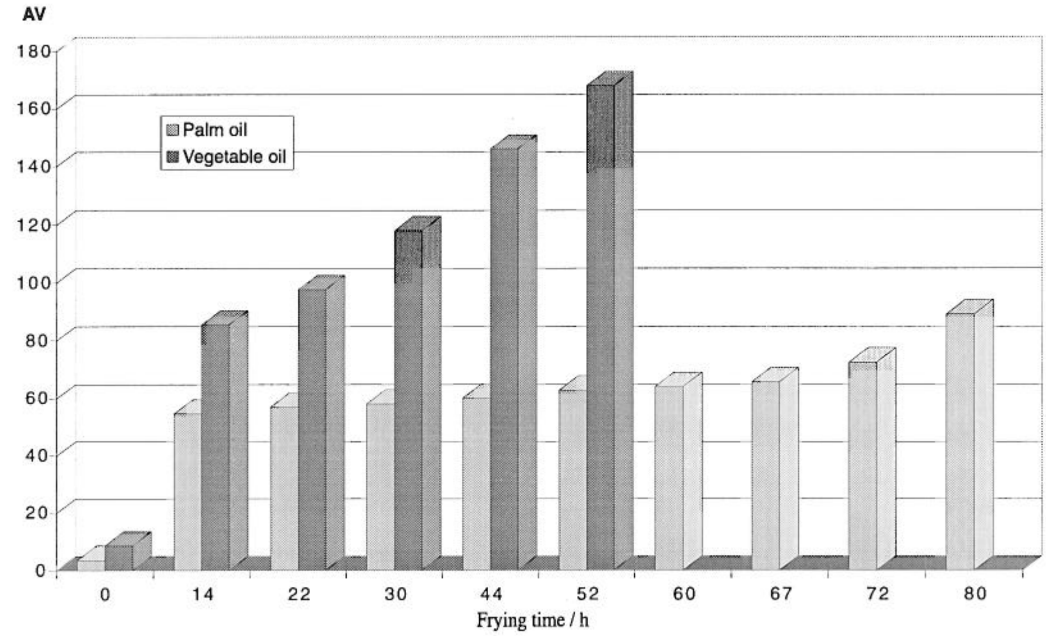

Fig. 3. Anisidine value in oils during french fries frying

follow changes in frying oils during use. The results (Fig. 3) show that AV increased more rapidly in vegetable oil than in palm oil.

Polar compound (PC) determination is the most commonly used methodology to evaluate frying fat alteration and has been included in the regulations of different countries to establish limits of alteration for human consumption *(5)*. Accumulation of polar compounds is indicative of both hydrolysis and oxidation. It is claimed that a fat or oil must be discarded when the mass fraction of its polar compounds is more than 25% (or 27%): it is the limit above which the deterioration of oil is considered to have gone too far. This limit corresponds to the recommended limit for the content of 0.7% oxidized fatty acids (insoluble in petroleum ether) above which frying oil should be rejected *(17,18)*. Guhr and Waibel *(19)* found that 25 and 29% PC corresponds to 0.7 and 1% oxidized fatty acids, respectively. On the basis of PC formation (Fig. 4) the large differences between the used frying oils were evident: by comparing the obtained results we noticed a much faster increase of PC in vegetable oil than in palm oil. The mass fraction of polar compounds ranged from 9.7% in fresh palm oil to 25.7% in palm oil after 80-hour frying; vegetable oil with 4.1% polar compounds at the start reached 26.0% PC after 44-hour frying and fraction of PC increased rapidly to 34.5% after 52 hours. Vegetable oil could not be used for more than 44 hours for deep frying in the household fryer with turnover of oil. Palm oil, under the same conditions showed better resistance and could be used for frying for about 80 hours.

Iodine value (IV) of palm oil and vegetable oil decreased during frying by 6% (after 80 hours) and 5% (after 44 hours), respectively (Fig. 5). The decrease of IV is a useful measure of overall deterioration, but is not convenient in determining whether an oil is suitable for further use.

The development of excessive foam which does not readily disappear is usually an indication that frying oil should be discarded. From the results of this study it was evident that there was no foam development in palm oil during the whole time of frying (80 hours), and in vegetable oil the foam formation started already after 30-hour frying. Color darkness during frying was more intensive and more rapid in vegetable oil than in palm oil.

A total volume of 5.5 L palm oil was used for frying 95 kg of peeled potatoes (during 80 hours) and 4 L of vegetable oil for frying 55 kg of potatoes (during 44 hours).

Fat content of french fries in palm and vegetable oils was 3.5–5.5% and 5.3–6.0%, respectively, and moisture was on the average 53% and 55%.

For quicker assessment of the oxidative stability of oil during storage, some accelerated stability tests have been developed. Most of them are designed to accelerate

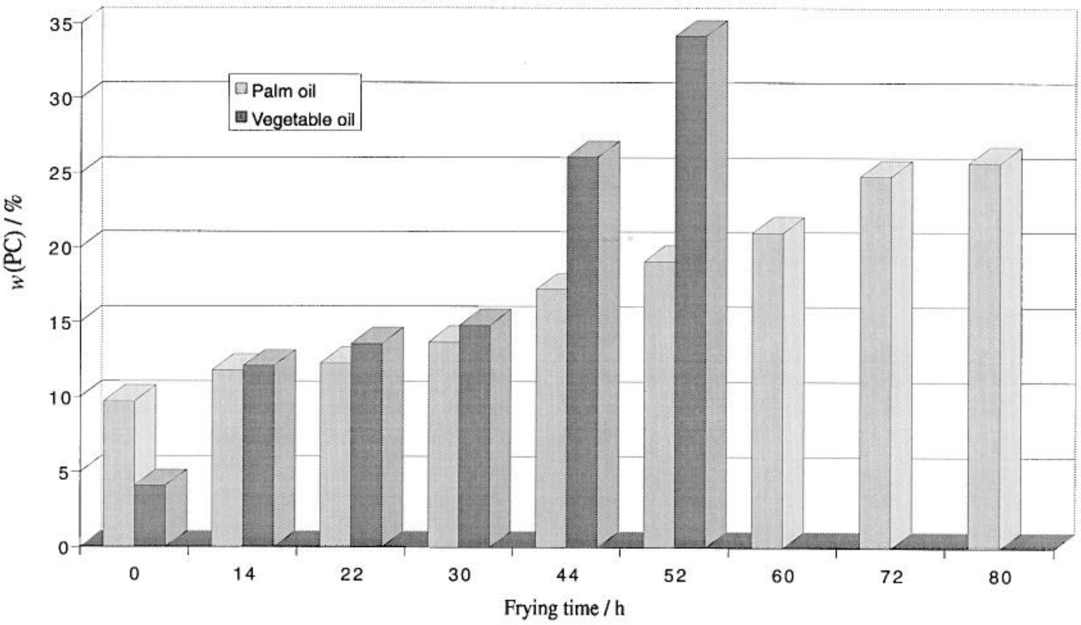

Fig. 4. Polar compounds in oils during french fries frying

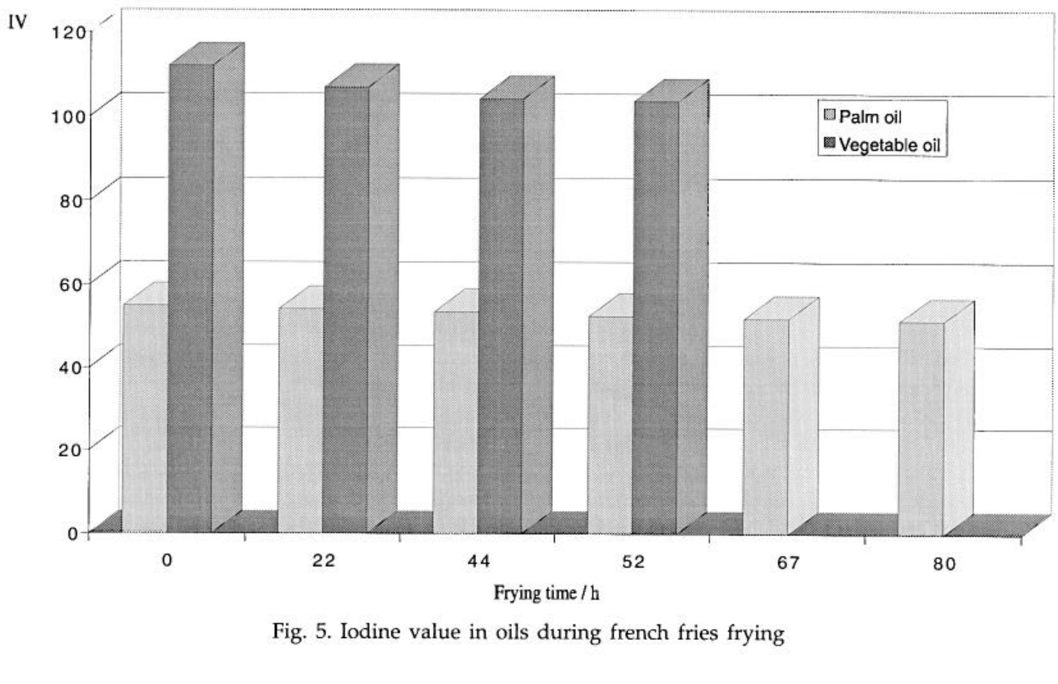

Fig. 5. Iodine value in oils during french fries frying

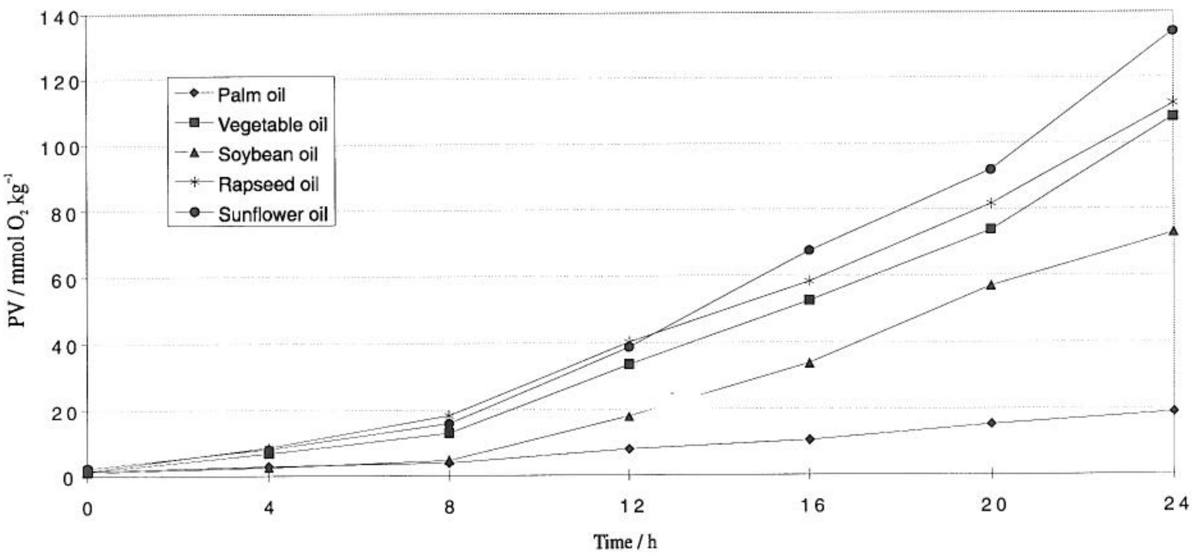

Fig. 6. Oxidative stability of some oils (oven test at 98 °C)

the oxidation process by exposing oil samples to elevated temperatures in the presence of air or oxygen. In this study the oxidative stability of palm oil and several vegetable oils was investigated by oven test at 98 °C in the course of 24 hours with PV determination. From the results, shown in Fig. 6, it is evident that the oxidative stability of examined oils varied significantly: the highest increase of PV (which corresponds to the fastest deterioration and the least stability) was in sunflower oil, then in rapeseed and soybean oil, and palm oil expressed significantly the best stability.

About 50% of fatty acids present in palm oil are saturated, and about 50% unsaturated. Palmitic and oleic acids in closely similar proportions comprise some 80% of the fatty acids, and polyunsaturated linolenic acid is virtually absent *(20)*. This fatty acids composition determines iodine value of the oil (50–55) and confers some stability against oxidation to the oil, as compared to some other vegetable oils with more polyunsaturated fatty acids.

Conclusion

Vegetable oil (a blend of about 80% rapeseed and 20% soybean oil) showed higher rate of deterioration during deep fat frying of potatoes than palm oil. Vegetable oil was unsuitable for further use after 44 hours and palm oil after 80 hours of frying. During these periods the level of polar compounds reached the limit recommended by the regulations for discarding of frying fats (25–27%), while iodine value decreased by 5–6%, and free fatty acids increased to 0.35% and 0.45%, respectively. Anisidine value increased more rapidly in vegetable oil (after 44 hours AV was 140) than in palm oil (after 80 hours AV was 89).

Peroxide value determination is not a useful test for evaluation of frying oils, because peroxides were decomposed under frying conditions.

The oxidative stability of oils assigned for frying, examined by oven test at 98 °C, decreased in this order: palm, soybean, rapeseed, vegetable and sunflower oil.

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Duboko prženje krumpira u palminom i biljnom ulju

Sažetak

Ispitivana je razgradnja palminoga ulja i domaćega biljnoga ulja (miješanoga repičinoga i sojinoga ulja u omjeru oko 80:20) tijekom dubokoga prženja pomfrita. Krumpir je pržen 5 minuta pri 160 °C te 4 minute pri 180 °C u fritezi koja se primjenjuje u kućanstvima. Uzorcima ulja određen je maseni udjel slobodnih masnih kiselina i polarnih spojeva, te peroksidni, jodni i p-anisidinski broj. Određivana je i održivost palminoga ulja u usporedbi s drugim biljnim uljima (čistim sojinim, repičinim i suncokretovim uljem te mješavinom repičinoga i sojinoga ulja u omjeru 80:20) postupkom ubrzanoga kvarenja u termostatu pri 98 °C. Tijekom prženja porastao je udjel slobodnih masnih kiselina u ispitivanim uljima, ali nije prelazio 1%. Nakon 44 sata prženja udjel je polarnih spojeva u biljnom ulju povećan na 26%, a u palminom na 17%. Anisidinski je broj rastao kudikamo brže u biljnom nego u palminom ulju. U uvjetima ubrzana kvarenja palmino je ulje imalo najbolju održivost, a suncokretovo najslabiju.