Comparison of Oxidative Resistance of Traditional and High-Oleic Peanut Oils in Emulsions

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Abstract: The oxidation rate of vegetable oils strongly depends on the content of polyunsaturated fatty acids, natural antioxidants and prooxidants. The resistance of oil against oxidation thus depends very much on the linoleic acid content. Virginia peanut oil (a traditional cultivar, containing 30% linoleic acid) was compared with SunOleic peanut cultivar (containing only 3% linoleic acid). The tocopherol content was rather similar in the two oil samples. Emulsions were prepared using soybean lecithin as an emulsifying agent. The formation of conjugated hydroperoxides was measured at 234 nm. The induction period differred very much in bulk oil, but only moderately in emulsions containing copper ions as prooxidants. The effect of copper ions on the rate of oxidation was lower in SunOleic oil emulsion, compared with the Virginia oil emulsion. Similarly, the effect of sage extracts on the resistance against autoxidation was higher in SunOleic oil emulsions than in Virginia oil emulsions.

Keywords: food emulsions; high-oleic oil; metal catalysis; oxidation; peanut oil

INTRODUCTION

Traditional vegetable oils often contain a high amount of polyunsaturated fatty acids, mainly linoleic acid (e.g. sunflower or safflower oils) and linolenic acid (e.g. soybean and rapeseed oils). In spite of the content of tocopherols and other natural antioxidants, they are slowly oxidized under storage conditions or rapidly during heating. Therefore, high-oleic low-polyenoic oilseeds were developed [1]. They are significantly more stable against oxidation by air oxygen [2]. We compared both a conventional peanut oil cultivar and a high-oleic peanut oil cultivar, and found the oxidative stability of high-oleic peanut oil much higher than the stability of conventional oil [3]. In this paper, we give a comparison of emulsions prepared from the two types of peanut oil.

EXPERIMENTAL

Material. Virginia peanuts were grown in China, SunOleic high-oleic peanuts were developed in Florida, USA [4], and grown in Southern Japan. Peanuts (250 g) were crushed, and oil was extracted at ambient temperature by maceration with 250 ml of hexane, three times, each time for 18 hours at ambient temperature. Hexane was removed under reduced pressure in a rotating evaporator, and the residue was stored under refrigeration. The fatty acid composition and the tocopherol content of the two extracts are given in Table 1. Cupric acetate monohydrate was an analytical reagent, manufactured by Merck, Darmstadt, Germany. Sage leaves (*Salvia officinalis* L.) were obtained from Prof. R. Venskutonis, Kaunas Technical University, Kaunas, Lithuania. Dry leaves (100 g) were extracted by infusion with either acetone or ethyl acetate [5] three times for 12 hours, a litre of solvent being used for each extraction step.

Analytical methods. The method reported by Duh *et al.* [6] and adapted as described in our previous paper [7] was used. Emulsions were prepared by mixing 0.50% peanut oil with 0.5% soybean lecithin. The average droplet size was 0.5–1.5 μm. Cupric acetate was added as a catalyst of oxidation. In some experiments, sage extracts were added as an antioxidant. The emulsion was stored at 40°C under gentle shaking in the dark. For the measurement, 0.1 g of the emulsion was weighed, and filled up to 5 ml with 96% aqueous ethanol. The emulsion became clear during the operation. The course of oxidation was determined by measuring the ultraviolet absorption at 234 nm, due to the formation of linoleic acid hydroperoxides containing conjugated double bond systems.

RESULTS AND DISCUSSION

In our previous experiments, we found SunOleic peanut oil substantially more stable than Virginia peanut oil under Schaal Oven Test conditions at 40°C or at 60°C [8], but in an emulsion the difference in stabilities between the two brands of oil was much smaller. Similar relations were observed in case of rapeseed oil.

In the experiments with lipid emulsions, the oxidation reaction was catalyzed by copper ions [6], otherwise the reaction rate would be very slow at 40°C. Therefore, we studied, how much the rate of oxidation, expressed as the induction period, is affected by the concentration of copper ions. Our results are shown in Figures 1 and 2. The slope of the bilogarithmic dependence between the length of the induction period (IP, in hours) and the concentration of copper ions (C, in mg) was about the same:

log IP = 2.4 – 0.52 log C (for Virginia peanut oil),
log IP = 2.6 – 0.58 log C (for SunOleic peanut oil).

As expected, the difference of reaction rates between the two oil brands decreased with the increasing copper content as the increased rate of free radical production, initiated by copper ions, would tend to eliminate the advantage of lower linoleic acid content in SunOleic peanut oil.

In our previous experiments [9], sage extracts were found efficient as antioxidants in rapeseed oil emulsions, similarly as in rapeseed oil under the Schaal Oven Test conditions [10]. Therefore, we determined the oxidative stability of emulsions of

Table 1. Composition of conventional and high-oleic peanut oils

Component	Virginia peanut oil	SunOleic peanut oil
Saturated fatty acids (%)	18.3	15.1
Oleic acid (%)	51.6	81.5
Linoleic acid (%)	30.0	3.4
Linolenic acid (%)	0.1	traces
Tocopherols (mg/kg)	137	173

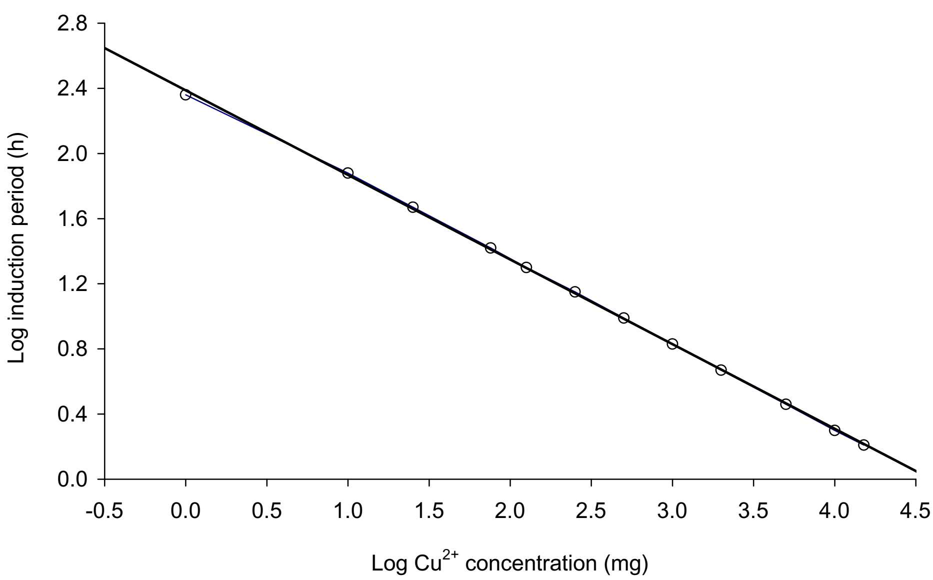

Figure 1. Effect of copper on the oxidation rate of Virginia oil emulsions

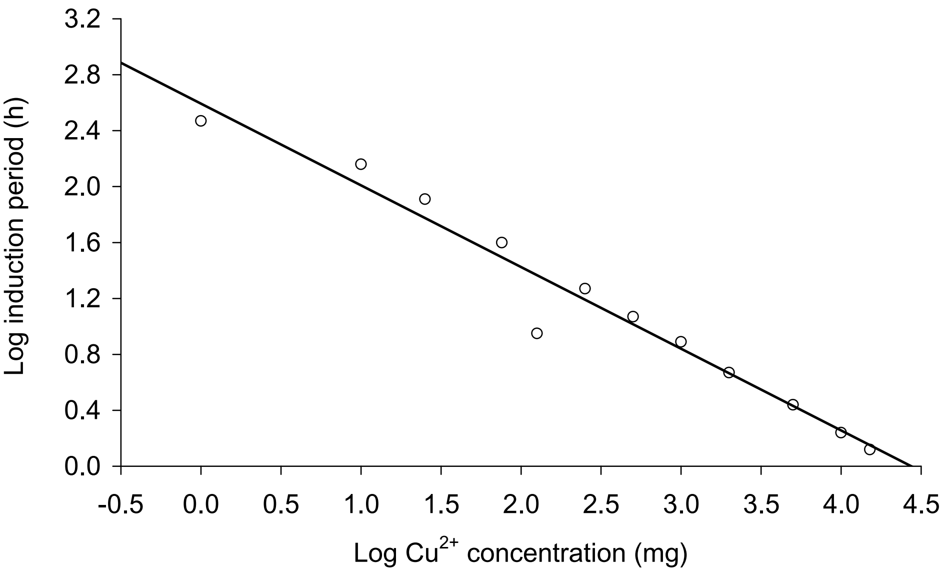

Figure 2. Effect of copper on the oxidation rate of SunOleic oil emulsions

the two brands of peanut oil in presence of sage extracts (Table 2). Smaller additions (0.002%) of sage extracts were not efficient as the active groups of phenolic antioxidants were oxidized by cupric ions. However, in presence of 0.004% sage extracts, when the antioxidants were present in excess, the efficiencies were much higher in case of SunOleic peanut oil than in case of Virginia peanut oil. This effect can be explained by lower content of oxylabile pentadienoic systems present in linoleic acid in SunOleic peanut oil, compared with the conventional Virginia peanut oil.

Table 2. Effect of sage extracts on the induction periods (h) of peanut oil emulsions (15 mg of cupric acetate added)

Extract added	Virginia peanut oil	SunOleic peanut oil
Acetone extract (0.002%)	2.57	3.55
Acetone extract (0.004%)	5.56	18.15
Ethyl acetate extract (0.002%)	2.86	2.99
Ethyl acetate extract (0.004%)	5.03	9.80
Blank	1.69	1.93

Table 3. Effect of the amount of cupric acetate on the induction periods [h] of peanut oil emulsions containing an addition of 0.002 % acetone extract from sage

Cupric acetate [mg]	Sage extract [%]	Virginia peanut oil	Sunoleic peanut oil
3	0	3.7	4.1
3	0.002	5.9	6.1
6	0	2.8	3.0
6	0.002	5.2	5.5
9	0	1.8	2.0
9	0.002	4.5	5.0

As the 0.002% concentration of sage extracts was found inefficient in the presence of 15 mg of cupric acetate, we tested the effect of lower concentrations of copper ions on the efficiency of the acetone extract (Table 3). This extract was prepared from another sample of dried sage leaves, but with a similar content of active substances. Concerning the absolute length of induction period, the addition of 0.002% sage extract was found perceptibly efficient in presence of 3 mg cupric acetate, but it was nearly inefficient at higher concentrations of cupric acetate because the amount of anioxidant was obviously too low. The results show that antioxidants can improve the oxidative stability of high oleic peanut oil more than that of conventional peanut oil, if sufficient amount of antioxidants have been added.

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