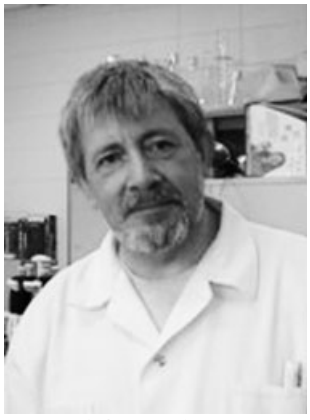
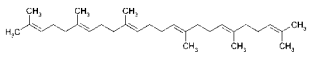


Ryszard Amarowicz



Chemical structure of squalene

Editorial

Squalene: A natural antioxidant?

Squalene (see left) is a triterpene and an intermediate in the biosynthesis of sterols in the plant and animal world [1]. The richest known source of squalene is shark liver oil. In vegetable oils, squalene is found over broad ranges [2]. For example, in flaxseed, grape seed, and soybean oils it is not detected, but is quite prominent in peanut (1.28 g/kg), pumpkin (3.53 g/kg), and olive oils (5.99 g/kg). Squalene is the main component of skin surface polyunsaturated lipids and shows some advantages for the skin as an emollient and antitumor compound [3]. The triterpene has also been found to have protective activity against several carcinogens.

Conforti *et al.* [4] reported an antioxidant effect of squalene in a model of lipid peroxidation of liposomes; the IC_{50} value for squalene was 0.023 mg/mL. An ethyl acetate extract of *Amaranthus caudatus* examined using the same method was 20-fold less active. The regeneration of α-tocopherol by squalene in photo-oxidation studies was suggested by Psomiadou and Tsimidou [5]. This is in line with the hypothesis of Kohno *et al.* [6].

Squalene showed slight antioxidant activity when assayed by the crocin bleaching method [7]. In the same study, squalene demonstrated a synergistic effect with α-tocopherol and β-sitosterol. The authors suggested that squalene could act as a competitive compound in the crocin bleaching reaction, thereby reducing the rate of oxidation.

Results of Dessi *et al.* [8] showed that during temperature-dependent autoxidation and UVA-mediated oxidation, squalene acts mainly as a peroxyl radical scavenger. Yet, no radical scavenging activity was observed using the DPPH radical in 2-propanol [1]. Pure squalene assayed by the L-$ORAC_{FL}$ method exhibited an antioxidant activity of 0.74 μmol Trolox-equivalents/g [9]. The rate constant (k_o) of quenching of singlet oxygen by squalene is reported to be similar to that of butylated hydroxytoluene (BHT) [6]. The electron donating characteristics of the methyl groups of squalene are essential to the large observed k_o.

Squalene, subjected to accelerated oxidation in a Rancimat apparatus at 100°C, showed a negligible antioxidant effect [10]. From experiments of Psomiadou and Tsimidou [1], a concentration-dependent moderate antioxidant activity of squalene – when stored at 40 and 62°C in the dark – was evident, which was stronger then the case of olive oil compared to that found for sunflower oil and lard. The authors concluded that the weak antioxidant efficacy of squalene in olive oil may be explained by competitive oxidation of the various lipids present, which leads to a reduction in the rate of oxidation. In the study of Dessi *et al.* [8], the oxidative stability of polyunsaturated fatty acids was affected by squalene. This natural compound at a molar ratio to PUFA as 1:7 inhibited the oxidation of arachidonic and docosahexaenoic acids by 50%. The inhibition of oxidation of linoleic acid was determined to be 22%. Furthermore, squalene exerted a significant antioxidant activity in mild UVA-mediated PUFA oxidation.

In experiments with rats, the combined administration of squalene and a PUFA concentrate resulted in a significant ($P < 0.05$) reduction in the level of lipid peroxidation in the heart tissue [11]. According to Hauß *et al.* [12] squalene – since being a highly lipophilic compound – can readily pass across the PUFA-rich lipid bilayer into intracellular compartments; this is believed to aid in its capabilities as a potent antioxidant. Squalene was found to be a much stronger scavenger of hydroxyl radicals than endogenous reduced glutathione (GSH) [13].

During storage and in technological processes, squalene exhibited great stability. The losses of squalene during 6 months of dark storage of virgin olive oils at room temperature ranged from 26 to 47% [14]. However, contrasting findings were reported by Psomiadou and Tsimidou [15]. In their study an insignificant decrease of squalene content was observed in virgin olive oils stored in the dark at room temperature for 24 months. In photo-oxidation studies, squalene loss has been confirmed (4-12%) [5]. Under accelerated storage conditions (60°C), squalene showed high stability in extra virgin olive oil. A loss of <20% was observed within the induction period [16]. The processing stability of squalene in amaranth was investigated by Tikekar *et al* [9]. These authors reported that squalene was stable during all processing operations with a maximum loss of only 12% during roasting (20 min at 150°C). Squalene was also stable during pan-frying of French fries in different edible oils [17].

In summary, squalene is a hydrophilic natural antioxidant. Its antiradical and antioxidant properties depend on the model system employed for the study. Nevertheless, investigations of the antioxidant properties in animal and human models are still required

Ryszard Amarowicz
Editor
Division of Food Science, Institute of Animal Reproduction and Food Research,
Polish Academy of Sciences, Olsztyn, Poland

References

[1] E. Psomiadou, M. Tsimidou: On the role of squalene in olive oil stability. *J Agric Food Chem*. 1999, **47**, 4025–4032.

[2] C. I. G. Tuberoso, A. Kowalczyk, E. Sarritzu, P. Cabras: Determination of antioxidant compounds and antioxidant activity in comercial oilseeds for food use. *Food Chem*. 2007, **103**, 1494–1501.

[3] Z.-R. Huang, Y.-K. Lin, J.-Y. Fang: Biological and pharmacological activities of squalene and related compounds: Potential uses in cosmetic dermatology. *Molecules* 2009, **14**, 540–554.

[4] F. Conforti, G. Statti, M.R. Loizzo, G. Sacchetti, F. Poli, F. Menichini: *In vitro* antioxidant effect and inhibition of α-amylase of two varieties of *Amaranthus caudatus* seeds. *Biol Pharm Bull.* 2005, **28**, 1098–1102.

[5] E. Psomiadou, M. Tsimidou: Stability of virigin olive oil. 2. Photo-oxidation studies. *J Agric Food Chem*. 2002, **50**, 722–727.

[6] Y. Kohno, Y. Egawa, S. Itoh, S. Naganka, M. Takahashi, K. Mukai: Kinetik study of quenching reaction of singlet oxygen and scavenging reaction of free radical by squalene in n-butanol. *Biochim Biophys Acta*. 1995, **1256**, 52–56.

[7] E. Finotti, M. D'Ambrosio, F. Paoletti, V. Vivanti, G. Quaglia: Synergestic effect of α-tocopherol, β-sitisterol and squalene on antioxidant activity assayed by crocin bleaching method. *Nahrung* 2000, **44**, 373–374.

[8] M. A. Dessi, M. Deiana, B. W. Day, A. Rosa, S. Banni, F. P. Corongiu: Oxidative stability of polyunsaturated fatty acids: effect of squalene. *Eur J Lipid Sci Technol.* 2002, **104**, 506–512.

[9] R. V. Tikekar, R. D. Ludescher, M. V. Karwe: Processing stability of squalene in amaranth and antioxidant potential of amaranth extract. *J Agric Food Chem*. 2008, **56**, 10675–10678.

[10] R. Mateos, M. D. Domínguez, J. L. Espartero, A. Cert: Antioxidant effect of phenolic compounds, α-tocopherol, and other minor components in virgin olive oil. *J Agric Food Chem*. 2003, **51**, 7170–7175.

[11] N. Dhandapani, B. Ganesan, R. Anandan, R. Jeyakumar, D. Rajaprabhu, R. A. Ezhilan: Synergistic effect of squalene and polyunsaturated fatty acid concentrate on lipid peroxidation and antioxidant status in isoprenaline-induced myocardial infarction in rats. *African J Biotechnol.* 2007, **6**, 1021–1027.

[12] T. Haußß, S. Dante, N. A. Dencher, T. Haines: Squalene is in the midplane of lipid bilayer: implications for its function as aproton permeability barrier. *Biochim Biophys Acta*. 2002, **1556**, 149–154.

[13] B. Das, H. Yeger, H. Baruchel, M. H. Freedman, G. Koren, S. Baruchel: *In vitro* cytoprotective activity of squalene on a bone marrow versus neuroblastoma model of cisplatin-induced toxicity: implications in cancer chemotherapy. *Eur J Cancer* 2003, **39**, 2556–2565.

[14] P. Manzi, G. Panfili, M. Esti, L. Pizzoferrato: Natural antioxidants in the unsaponifiable fraction of virgin oils from different cultivars. *J Sci Food Agric*. 1998, **77**, 115–120.

[15] E. Psomiadou, M. Tsimidou: Stability of virgin olive oil. 1. Autoxidation studies. *J Agric Food Chem*. 2002, **50**, 716–721.

[16] K. Hrncirik, S. Fritsche: Relation of the endogenous antioxidant system and the quality of extra olive oil under accelerated storage conditions. *J Agric Food Chem.* 2005, **53**, 2103–2110.

[17] Pan-frying of French fries in three different edible oils enriched with olive leaf extract: Oxidative stability and fate of microconstituents. *LWT – Food Sci Technol.* 2009, **42**, 1090–1097.

