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Enhancing of oxidative stability and quality attributes of olive oil using spirulina (*Arthrospira platensis*) nanoparticles

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ABSTRACT

This study was performed to evaluate the effect of spirulina whole cell (Sp-WC) and spirulina nanoparticles (Sp-NPs) as an antioxidant in olive oil (OO) under accelerated storage at 60 ± 1 °C up to 49 days. Sp-NPs were incorporated into freshly OO at 0.25, 0.5, and 1% (*w/v*), Sp-WC at 0.5% (*w/v*), and both of them compared with 0.01% BHT and 0.01% α-tocopherol as a reference and without antioxidant as the control sample. The kinetic rate of oxidation markers and shelf life (assuming Q10 value of 2.0 for lipid oxidation) of OO were estimated. Sp-NPs exhibited a high phenolic content and antioxidant activity. In Sp-NPs-treated samples, the contents of thiobarbituric acid (TBA), peroxide, *p*-anisidine, totox, K_{232}, and K_{270} were significantly lower than the control. The rate constant (k) was low in OO with BHT and 1% Sp-NPs compared with other treatments. Chlorophyll content in olive oil containing Sp-NPs was improved during the storage. The antioxidant indices and sensory attributes of oil samples including Sp-NPs were significantly higher than that of the control. These results confirmed that Sp-NPs were more effective in retarding oxidation, improving oil color, and extending shelf life (up to 475 days at 25 °C).

1. Introduction

Olive oil is one of the most important edible oils in Egypt and highly consumed worldwide. It is a good source of monounsaturated fatty acids (MUFAs) which has beneficial impacts on health (Caporaso et al., 2015). However, olive oil (OO) has a short shelf-life during storage (Kehili, Choura, Zammel, Allouche, & Sayadi, 2018) due to partially elimination of phenolic compounds during the refining process (García, Ruiz-Méndez, Romero, & Brenes, 2006). Therefore, OO becomes more prone to oxidation and change in quality attributes, which requires the antioxidants addition to prolong its shelf life, improve the acceptability, and enhance nutritional value (Kehili et al., 2018).

Although for more than 50 years, synthetic antioxidants like butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) have been successfully used to prevent edible oils oxidation however, they are under consideration for possible health risks (Ben-Ali, Dhouib, Damak, & Allouche, 2014). Hence, natural antioxidants are receiving much attention in recent years such as potato peels (Jeddou et al., 2016), algal extracts (Alavi & Golmakani, 2017a; 2017b), tomato peels (Kehili et al., 2018), and pomegranate peels (Morsy, Mekawi, & Elsabagh, 2018). Natural antioxidants have many advantages such as safety, consumer acceptance and health-beneficial properties (Asensio, Nepote, & Grosso, 2012).

Spirulina (*Arthrospira platensis*) is a non-toxic blue-green alga (cyanobacterium), naturally growing in sea-water or cultivated. It has been approved as a generally recognized as safe (GRAS) as food by (FDA, 2002). The global annual production of spirulina powder around 3000 tons, but no data are available in Egypt (Alavi & Golmakani, 2017a). Spirulina (Sp) is a rich source of phycocyanin, carotenoids, biliprotein pigment, proteins, and vitamins (Ovando et al., 2018). Moreover, Sp contains potent antioxidants and superoxide radical scavengers (Shabana, Gabr, Moussa, El-Shaer, & Ismaiel, 2017), and possesses antimicrobial activity (Elshouny, El-Sheekh, Sabae, Khalil, & Badr, 2017); and therefore, it is used as a health ingredient (Ovando et al., 2018). One study by Wang, Pan, Sheng, Xu, and Hu (2007) reported that the antioxidant activity of Sp extract was higher than α-tocopherol, but it was lower than that of BHT. In recent years, the antioxidant effect of Sp extracts has been investigated in Kilka oil (Golmakani, Keramat, Moosavi-Nasab, & Moosavian, 2017), in beef sausage (Luo et al., 2017), in yogurt (Barkallah et al., 2017), and snack foods (Lucas, de Morais,

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