Extract from pomegranate wastes as an alternative natural additive in foods

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In recent years, there is an increasing interest on the utilization of natural additives for development of functional foods with health-promoting properties. Several fruits and vegetables were found to be a good source of antioxidant polyphenols. Moreover, their antioxidant activities can be comparable with this of synthetic antioxidants, such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) and ter-butylhydroquinone (TBHQ), which are the most common used food additives (Chan *et al*, 2018). However, some studies have reported the harmful effects of synthetic antioxidants on human health. On the other hand, consumers are more and more pretentious when they buy food by demanding products with satisfactory organoleptic characteristics, like attractive color and odor. Thus, researchers are interested in the study of natural antioxidants generated from food industry by-products that have acceptable both organoleptic and antioxidant properties.

Pomegranate is an excellent source of bioactive components with a considerable amount of various phenolic compounds. During pomegranate juice processing large amounts of by-product wastes are generated composed of peels (78%) and seeds (22%) with limited use as animal feed (Cam *et al*, 2013). However, pomegranate peels were found to contain higher amounts of phenolics than the edible fleshy parts and so, over the last decade many researchers have focused on their exploiting in food industry as natural antioxidants. Several studies have been published to extract phenolics from pomegranate peels with various extraction methods. Nevertheless, phenolic compounds can be easily degraded by environmental factors, such as light, oxygen and temperature, losing their antioxidant activity and even producing negative sensory effects on products. One way to improve the stability of these compounds is through microencapsulation whereby the phenolics are encased inside a wall material. Spray drying is the most popular encapsulation technique in food applications, used in 51% of the publications (Labuschagne, 2018). Through this technique, polyphenols could be protected naturally and several problems, such as low solubility, low stability and unpleasant taste, color, and odor, can be overcome.

Numerous food products have been fortified with phenolic compounds from fruits and vegetables. Abid *et al* (2017) reported that phenolic extract of tomato by-products can be used as antioxidant in extending the self-life of butter. Benvenutti *et al* (2019) observed that the incorporation of apple pomace phenolic extract improved the bioactivity and sensorial quality of cider. Similar results were reported from Lorentzo and Munekata (2014), Luca *et al* (2014), and Saponjak *et al* (2016) for the addition of green tea phenolics to pork patties, encapsulated sour cherry phenolics to cake, and encapsulated sour cherry pomace phenolics to cookies, respectively. Concerning the pomegranate peel extract, a number of research works study the antioxidant effect of this extract in various food products, such as cooked chicken (Naveena *et al*, 2008), sunflower oil (Iqbal *et al*, 2008), ice cream (Cam *et al*, 2013), fish oil (Topuz *et al,* 2014), hazelnut paste (Kaderides *et al*, 2015), and beef meatballs (Turgul *et al*, 2016).

In our previous work (Kaderides & Goula, 2018), total phenolics extracted from pomegranate peels by ultrasound-assisted technique were encapsulated by spray drying using orange fiber powder as wall material. However, the final step of a successful encapsulation process is that the encapsulated powder can be easily incorporated in foods.

Thus, in this study, the efficiency of crude and encapsulated pomegranate peel extract in improving the total phenolic content (TPC), antioxidant activity (AA), and self-life of sunflower oil and cookies was evaluated during storage, using Folin–Ciocalteu and DPPH methods and determining the peroxide values (PV). Moreover, sensory evaluation was carried out for the cookies samples. Cookies were enriched with extract at a phenolics concentration of 5000 ppm, whereas in the case of sunflower oil, the phenolic concentration was 500 and 1000 ppm. For the storage study, the cookies products were kept at 25^{o}C for 21 days. Regarding the sunflower oil, due to the time-consuming nature of the testing at storage conditions of 40^{o}C or lower, the simple accelerated method of using oven storage at 60°C for 26 days was carried out. Samples were periodically withdrawn during the storage in order to measure PV, TPC, AA, and color.

According to the results, the incorporation of extracts improved the nutritional value (TPC and AA) of the products and enhanced their storage stability. In the case of cookies, it was observed that a large amount of the phenolic compounds was degraded during baking even if they were encapsulated. However, encapsulation had a significant effect ($p \leq 0.05$) on the preservation of TPC compared to the crude extract. All the sunflower samples containing extract had lower values of PV than the control sample. Concerning the samples of cookies, low PV at all storage times was observed, so these products were highly stable in terms of oxidation. Regarding the sensory evaluation of cookies, the results showed that the enriched products had acceptable sensorial qualities. Compared to the control sample, sensory scores of enriched products showed significant ($p \leq 0.05$) changes in astringency, color, and odor. Color became darker in products enriched with crude extract, partly due to the higher level of polyphenols, whereas it became brighter and more yellow in the case of the encapsulated extract addition due to the wall material (orange wastes). Hence, encapsulated extract addition caused an increase in the scores for color and odor compared to control sample and the product with crude extract. However, the addition of extracts, mainly of the encapsulated one, led to an increase of astringency, but without affecting significantly the final evaluation of products. Thus, the process of encapsulating pomegranate peel polyphenols and their incorporation in foods described in this study represent a promising way for functional food development.

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