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Modeling quality changes in tomato paste containing microencapsulated olive leaf extract by accelerated shelf life testing

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ABSTRACT

In this research, Arrhenius equation accelerated shelf life testing (ASLT) were applied to predict color and pH indices of bulk tomato paste containing microencapsulated and non-encapsulated olive leaf extract. Seven samples of tomato paste containing 500 and 1000 ppm non-encapsulated olive leaf extract (NC 500 and NC 1000), 500 and 1000 ppm microencapsulated olive leaf extract (C 500 and C 1000), and 500 and 1000 ppm sodium benzoate (B 500 and B 1000) along with control sample were prepared and investigated at three temperatures of 30, 40 and 50 (°C). Control and B 1000 samples, respectively yielded the highest (0.022 day^{-1}) and lowest (0.003 day^{-1}) rate constants for both color and pH change. In the case of pH and among different treatments, the lowest and highest activation energies, E_a were related to NC 500 and B 1000 samples, respectively; interestingly pH rate constants of encapsulated samples were higher than non-encapsulated ones and even higher than benzoate sample (only at the level of 500 ppm). Also, ASLT procedure could estimate changes in color of C 500 and pH of C 1000 samples better than other samples (during storage time).

1. Introduction

Tomato is one of the most important vegetables in the world, with an annual global production of 145 million tons (Ikeda et al., 2013), which is characterized by its taste, color, and flavor and provides vitamins such as Vitamin C, carotenes and other valuable nutrients (Banat et al., 2002). Accordingly, preservation of tomato and its products is of commercial importance (Shi et al., 2008). Most storage time studies on tomato products concern dried tomatoes (Giovanelli and Lavelli, 2002). Thermal processing of foods is primarily intended to inactivate pathogens and other deteriorative microorganisms; but at the same time, it occasionally leaves behind a destructive effect on nutrients and some organoleptic properties including texture and color (Barreiro et al., 1997). More recent researches, carried out to improve the storage time of tomato products, involved application of some novel technologies including ultrasound (Adekunte et al., 2010), high pressure processing (Hsu et al., 2008), combined thermal-high pressure (Rodrigo et al., 2006), high-intensity pulsed electric fields (Aguiló-Aguayo et al., 2008) and thermosonication (Wu et al., 2008) to guaranty the least changes in physicochemical properties of tomato products during storage time; however, application of microencapsulation technique for this purpose has not been investigated yet.

Microencapsulation is defined as a process in which tiny particles are surrounded by a coating to form small capsules (Jafari et al., 2008) and build a barrier between the

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component in the particle and the environment to preserve initial features of the product for a long-term storage (Calvo et al., 2010). Olive leaf contains phenolic compounds, amino acids, vitamins and minerals; that regards as one of the resources with the largest and richest poly phenolic compounds among the plants (Rafiee et al., 2012b; Rahmanian et al., 2014). Researches have shown that phenolic compounds available in olive leaf display antimicrobial, antifungal and anti-AIDS effects (Guinda, 2006; Rahmanian et al., 2015).

So far, application of microencapsulation to maintain properties of food products during storage time has been studied in a few cases. Ezhilarasi et al. (2013) applied freeze drying for microencapsulation of Garcinia fruit extract and studied its effect on bread quality. Bread with whey protein isolate encapsulates exhibited higher volume, softer crumb texture, desirable color and sensory attributes than non-encapsulated samples. Çam et al. (2014) applied microencapsulation for pomegranate peel phenolics and addition of microencapsulated ingredient to ice cream which displayed significant improvement for antioxidant activities of the enriched ice creams compared with control sample. In another research, it was demonstrated that there was no significant difference between the antioxidant activities of un-encapsulated and encapsulated clove extracts in soybean oil (Chatterjee and Bhattacharjee, 2013). Moreover, encapsulated clove powder allowed controlled release of the antioxidants; besides, no pro-oxidative activity at the initial stage of storage was observed contrary to that obtained with un-encapsulated clove extract. Gallardo et al. (2013) examined mixture of several wall materials to microencapsulate linseed oil by spray drying for functional food application and evaluated their resistance to oxidation through the accelerated Rancimat test. Recently, Taghvaei et al. (2014) and Mohammadi et al. (2016) applied encapsulated and nano-encapsulated olive leaf extract in improving the oxidative stability of soybean oil and they found promising results.

These days, consumers increasingly demand products with high quality of appearance, texture, taste and flavor aspects whilst keeping their nutritional value (after applied processes). For this purpose, determining properties of food products during their shelf life is very critical in the research and development centers of the food industry, since provides information regarding the time during which the product appropriately retains its quality. This prediction could be performed by measuring quality attributes through ASLT under extreme conditions (Lavelli and Giovanelli, 2003); also, this test could be beneficial to specify the effects of different storage temperatures on quality properties of food products in some cases where the environmental conditions exceed the limits. The most common model for these purposes is Arrhenius equation, since it creates a precise relationship between temperature and reaction rate constant (Córdova et al., 2011); for example, Nisha et al. (2005) studied degradation kinetics of some quality parameters in a legume by application of Arrhenius equation and observed different kinetic parameters, such as rate constant and activation energy, of the reaction. Pedro and Ferreira (2006) used ASLT as a novel approach for determining the shelf-life of commercial concentrated tomato products and they reported zero and first order kinetic reactions for the quality factors of the product.

In the case of bulk tomato paste (compared with aseptic one), probability of post-contamination is very high and there is a need to make some appropriate changes through the product processing, assuring the safety of this product during long-term storage. Our objective was to compare color and pH indices (as two main quality factors) of tomato paste having microencapsulated and non-encapsulated olive leaf extract with control samples and the counterparts containing commercial preservatives (sodium benzoate) by application of ASLT; also, our aim was to model changes in color and pH indices of all samples by Arrhenius equation and ASLT for the first time.

2. Materials and methods

2.1. Materials

Tomato paste with Total Soluble Solids (TSS) of 33.5 (°Brix) and from a special batch was provided by Kamnoosh food industries (Gorgan, Iran). Methanol, Folin–Ciocalteu reagent, sodium carbonate, Gallic acid, maltodextrin and sodium benzoate were purchased form Merck Company, Germany. Olive leaves of Cronaiky variety were prepared from agricultural research center of Kordkuy (Iran).

2.2. Microencapsulation of olive leaf extract

2.2.1. Sample preparation

Olive leaves were collected, rinsed and cleaned. Then, they were dried in an oven (WNB 22, Memert, Germany) at 40 °C and kept in hermetic bags in a freezer (WVG301, Whirlpool, U.S.) at −18 °C. Before experiments, samples were ground by a Lab mill (T 3800, Toosshekan Co®, Iran) into a powder (sieve 60 mesh) (Rafiee et al., 2012a).

2.2.2. Extraction process

Extraction was carried out by methanol 80% and water as solvent and a household microwave (CF3110N-5, Samsung, South Korea). Olive leaf powder was put into a volumetric flask along with solvent (50:1 w/v). During stirring the suspension with a magnet, microwave irradiation was performed for 10 min (10s on and 1 min off). After cooling to the room temperature, the solution was passed through a number 1 Whatman filter paper, concentrated by a rotary vacuum evaporator(RV05 Basic, IKA, Germany) and was dried by a freeze dryer (FDV5503, Epron, South Korea) (Rafiee, 2009). The dried sample was stored at 4 °C until further later use.

2.2.3. Determination of phenolic compounds

Total polyphenols (P_{total}) of the extracts were determined using the Folin–Ciocalteu colorimetric method. 20 μL diluted extract, 1.16 mL distilled water and 100 μL Folin–Ciocalteu reagents were mixed. After 1–8 min, 300 μL aqueous solution of sodium carbonate (20% w) was added. The tubes (after shaking thoroughly) were put in a water bath at 40 °C; after 30 min, their absorbance rates were measured by a spectrophotometer (T80+, PG instrument Ltd., U.K.) at 760 nm and the results were expressed as mg Gallic acid (GA) equivalents per each g of dried extract (DE). The calibration curves were prepared by using GA. Data were reported as a mean value for three measurements (Rafiee et al., 2011).

2.2.4. Microencapsulation

25 g maltodextrin were added gradually to 70 mL distilled water (at 50 °C) during stirring with heater-stirrer (RH Basic, IKA, Germany) and kept at ambient conditions for 18 h. Then, 6.25 g olive leaf extract was added gradually to wall material solution (maltodextrin) which was stirring vigorously.