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Modeling of the lycopene extraction from tomato pulps

Zahra Dolatabadi [a,1], Amir Hossien Elhami Rad [b,1], Vahid Farzaneh [c,*,1], Seyed Hashem Akhlaghi Feizabad [b], Seyed Hossein Estiri [b], Hamid Bakhshabadi [d]

[a] Young Researchers and Elites Club, Sabzevar Branch, Islamic Azad University, Sabzevar, Iran
[b] Food Science and Technology Department, Sabzevar Branch, Islamic Azad University, Sabzevar, Iran
[c] University of Algarve, FCT, Faro, Portugal
[d] Young Researchers and Elites Club, Gorgan Branch, Islamic Azad University, Gorgan, Iran

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ABSTRACT

The inputs of this network were the concentration of pectinase and time of incubation, and the outputs were extracted lycopene and the activity of radical scavenging activity. Two different networks were designed for the process under the sonication and without it. For optimal network, networks' transfer functions and different learning algorithms were evaluated and the validity of each one was determined. Consequently, the feedforward neural network with function of logarithmic transfer, Levenberg Marquardt algorithm and 4 neurons in the hidden layer with the correlation coefficient of 0.96 and 0.99 were respectively observed for the treatments under sonication and without it, furthermore, root mean squared error and standard error values were obtained 0.46 and 0.22 respectively for the treatments under sonication and 0.77 and 0.38 without it as respectively optimal networks. The selected networks could determine the chosen responses, individually and in combined effect of both inputs as well ($R^2 > 0.98$).

1. Introduction

In recent years, revealing the adverse effects of synthetic and colorants additives on different organs of the body, attention of many food industry and nutrition experts has been drawn to identification and extraction of these compounds from plant sources containing them. Tomato is an integral part of the worldwide diet and is a fruit from a plant from the Tomato plant main usage relates to Solanum lycopersicum species, which contains different combinations of antioxidants such as vitamin E, C, carotenoids, flavonoids and phenolics (Borguini, Da Silva, & Torres, 2009). More than 21 types of pigment have been identified and quantified in tomato among which carotenoid lycopene was the main one and has 85–90% of the weight of total carotenoids of tomato (Shi, Maguer, Kakuda, Liptay, & Niekamp, 1999). Tomato also due to containing lycopene as an antioxidant could offer different health beneficials such as anticarcinogenic and antidiabetic potential as has been mentioned by Farzaneh and Carvalho (2015). Tomato is mostly cultivated worldwide for its fruit. Because of its high nutritional value and numerous applications, this plant is accounted as one of the most effectual vegetables. The main part of tomato is used for the conversion to products such as tomato juice, ketchup sauce, paste, pulp and powder (Sogi, Bhatia, Garg, & Bawa, 2005). Lycopene is the main phytochemical compound in tomato and because of its having antioxidants properties, it might neutralize free radicals and prevent from diseases such as cancer, premature aging, cardiovascular problems, osteoporosis, diabetes and many other diseases (Basiri., 2010). So far, several methods have been introduced for extracting lycopene from tomato among which, we could mention extraction through organic solvents (Ottway, 2004), supercritical fluid (Egydio, Moraes, & Rosa, 2010), ultrasound treatment (Eh & Teoh, 2012) and enzymatic method (5). Ultrasound waves are used in applications such as speeding up the processes like dehydration, drying, freezing and thawing, making meat thin, crystallizing lactose and fat, and improving processes such as cutting, mining, wine aging and esterification. Some researchers conducted optimization studies to increase the lycopene performance using the extraction by the treatment of ultrasound-microwave from fresh tomato at 86.4 °C and stated that using ultrasound waves in combination with microwave, within extracting of lycopene, leads to optimal performance with minimal oxidative damage (Lianfu & Zelong, 2008). A group of scientists determined that the effect of ultrasound waves in the extraction of sugar depends on the exposure time and temperature, and indicated hat, the best temperature was 50 °C which increases the extraction efficacy by 30%. When ultrasound is used

* Corresponding author.
E-mail address: farzaneh1364@gmail.com (V. Farzaneh).
[1] These authors contributed equally to this work as first authors.

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to extract fruits' juice, it causes an enhancement in juice extraction efficiency from pulp. In recent years, researchers studied the efficacy of various solvents and ultrasound waves on the extraction of carnosic acid from rosemary plant, and the results showed that using the extraction by the help of ethanol together with continuous stirring has had much lower impact in comparison to using ethyl acetate and butanone, but while using ultrasound waves together with ethanol solvent, made the extraction efficiency showed an enhancement dramatically, so that it is comparable with Butane and ethyl acetate extraction method. Moreover, ultrasound waves lead to a considerable reduction in the quantity of applied solvent and as a result, provide the possibility of using alternative proper solvents which have better economic, health and environmental effects (Albu, Joyce, Paniwnyk, Lorimer, & Mason, 2004). Application of the artificial neural networks in determination and prediction the behaviors of different food properties has been known as a fast and efficient method and nowadays, its use has been expanding. One of the major reasons for the widespread use of this method is the burdensome, costly and long-term measurements of food properties in laboratories by former methods, while this method is a sensitive, reliable, fast, simple and low cost system to monitor the manufactured products (Sumit & Gyanendra, 2012). Using neural networks in food industry is vital and important because of the complexity of connections among factors affecting the quality of food industry and lack of the ability of normal methods in analyzing these relationships, this method can be a solution for this problem and can be used in prediction the quality of the food during the process and after that (10). Several studies has been done on the application of artificial neural networks in modeling various processes of food industry, lately, artificial neural network (ANN) fashions has been exploiting for both modeling and optimization of extraction methods (Cavas, Karabay, Alyuruk, Doğan, & Demir, 2011; Ghaffari Moghaddam & Khajeh, 2011; Sinha, Saha, & Datta, 2012). Further investigations have been performed by various scientists on the application of ANN model on various food products, for instance some researchers have investigated mass transfer using artificial neural network, within extraction procedure from African lemon's peel, drying process of carrot and tomato slices, water absorbance of wheat seeds and fermentation as well as modeling of freezing time and defrosting in various food products (Erenturk & Erenturk, 2007; Goñi, Oddone, Segura, Mascheroni, & Salvadori, 2008; Kashaninejad, Dehghani, & Kashiri, 2009; Lertworasirikul & Saetan, 2010; Menlik, Özdemir, & Kirmaci, 2010; Poonnoy, Tansakul, & Chinnan, 2007). Other group of scientists applied artificial neural network (ANN) model for prediction the quantity of lycopene and beta carotene in some of the selected food samples (Cámara, Torrecilla, Caceres, Sánchez Mata, & Fernández-Ruiz, 2009) but in the best knowledge of the authors no research has been carried out regarding the extraction of lycopene from tomato pulp. Some scientists reported that application of ultrasound waves to tomato pulps before extraction of lycopene, enhances the proficiency of the extraction (Han & Qun, 2007), other report by scientists indicated that optimum conditions for extraction of lycopene from ketchup under the microwave power of 120 w for 20 min under 40 °C, increases the yield of extraction (Liang, Chen, & Qian, 2010). Therefore the present study has been performed to attain simple, fast, precise and efficient model using artificial neural networks in the field of lycopene extraction from tomato pulp under the effect of ultrasound waves and without it.

2. Materials and methods

2.1. Sampling procedure

For this investigation, almost 4 kg fresh tomato pulp was obtained from the processing wastes of tomato paste of line product (attained by hot break method) in July 2014 from Dane Chin industry located in Sabzevar-Iran. Sampling has been performed within three different days in a row as randomly. Afterward the selected samples immediately were shifted to the lab, homogenized and preserved under −20 °C by the day of analysis. For each test, some specific amount of the sample after defrosting was dissolved into buffer acetate solution (0.2 M) and blended vigorously for 10 min. Then the homogenized samples were sealed in glass containers and wrapped by aluminum foils (for protecting against environmental conditions such as, light, oxygen and moisture) and the obtained samples were applied for the analysis (Konwarh, Pramanik, Kalita, Mahanta, & Karak, 2012).

2.2. Chemicals

The Acetate buffer, Acetone, Chloroform and Petroleum as well as sodium sulphate were provided from the Merck company (Germany) and pectinase enzyme was provided from Sigma–Aldrich, standard lycopene and 2, 2 diphenyl-1- picrylhydrazyl ($DPPH^{\cdot -}$) were purchased from Sigma–Aldrich.

2.3. Apparatus

Spectrophotometer (T70 + Vis, PG Instrument Ltd, United Kingdom), evaporator (Nahita series 503, Navarra, Spain), Centrifuge Hettich (universal-320, Germany), Disposable cuvettes were provided from VWR (Leuven, Belgium), Vortex mixer (Stuart, UL-Bibby Sterilin Ltd), Plate-stirrer (VWR, 720 advanced, USA), Incubator Hettich model INCUBOT 770 (automated incubator) and Filter paper was provided from sartorius stedim bio grade 388, shaker IKA (Kika Labortechnik), pH meter (Suntex sp-701), ultrasound bath (Dr.hielscher model UP 2004).

2.4. Lycopene extraction using pectinase enzyme

Lycopene extraction has been performed regarding the method previously described by (Corporation, 1989; Lavecchia & Zuorro, 2008; Merck, 1989; Ranveer, Patil, & Sahoo, 2013; Sogi et al., 2005) with some modifications. Concisely, 100 g of the residue sample together with 120 ml acetate buffer 0.2 M in pH 4.7 was mixed, and then various concentrations of pectinase (30, 35 and 40 mg/kg_{sample}) were added. Afterward, each sample was incubated at 55 °C (according to the enzymes manufacturer rules) for different times of 20, 40 and 60 min. After incubation, the samples were placed at 95 °C for 5 min to inactive the pectinase enzyme. After that, 5 g of each sample was picked up and mixed with the ratio of 1–10 of the solvent (acetone/petroleum ether with the ratio of 1:1). Then the mixture was transferred into the separating funnel and after stirring for 10 min, it was left for 20 min in darkness. The upper phase containing lycopene was separated and passed through filter paper coated with 1 g dehydrated sodium sulphate, then 2 ml of the filtered infusion was transferred to spectrophotometer cuvette (Shimadzu model, Made in Japan) to record the absorption at wavelength of 503 nm.

2.5. Extraction using pectinase enzyme together with ultrasound waves

The entire stages is as the same as Section 2.4 with an extra stage, which is that after adding pectinase to samples, ultrasound waves with the intensity of 24 kHz were emitted for 30 min, and the further phases were performed regarding the method described previously in Section 2.4 (Corporation, 1989; Lavecchia & Zuorro, 2008; Merck, 1989; Ranveer et al., 2013; Sogi et al., 2005).