Curcumin Extraction using Ultra sonication: A Review

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ABSTRACT

The paper focusses on the extraction of curcumin from turmeric (*Curcuma longa*) with various means of enhancing the product quality on basis of purity and yield. The paper contains discussions based on the various setups for Ultrasound assisted extraction (UAE). The intended effects of the former mentioned setups on the extraction performed by various researchers and the various factors and their effects are discussed as well. The effect of the various parameters on UAE process is discussed as well.

Keywords: curcumin, extraction, UAE process.

INTRODUCTION

Curcumin is the principal curcuminoid of *Curcuma longa* commonly known as turmeric, a member of the ginger family. It is sold in the market as a food supplement, cosmetics ingredient, food flavoring, and as a food coloring product. Curcumin has been shown to possess wide range of pharmacological activities including anti-inflammatory, anti-oxidant, wound healing and anti-microbial effects[1][2][3]. In general, turmeric consists of about 13% (w/w) moisture, 69% (w/w) carbohydrates, 5% (w/w) fixed oils, 6% (w/w) volatile oils, 5% (w/w) proteins, and around 1–6% yellow pigment curcuminoids [4],[5],[6], while commercially available curcumin contains 77% curcumin, 17% demethoxycurcumin and 3% bisdemethoxycurcumin from the herb Curcuma longa [7]. Various methods for extraction are usually based on maceration methods along with various circulation techniques which require a long time along with high consumption of energy and chemicals to be used as solvents amongst which the traditional types such as Soxhlet extraction, maceration are more popular while the non-conventional types such as microwave assisted extraction, ultrasound assisted extraction, supercritical gas extraction and enzyme assisted extraction are considered as formidable alternatives due to their lesser extraction time and lesser solvent consumption. As ultrasound passes through a liquid, the expansion cycles exert negative pressure on the liquid and create cavities in the liquid. This occurs when the negative pressure exceeds the local tensile strength of the liquid, which varies with the surface tension, vapor pressure and viscosity of the liquid. These bubbles will absorb the energy from the sound wave and grow during the expansion cycles and recompress during the compression cycle. The increase in pressure and temperature caused by the compression leads to the collapse of the bubbles, which causes shock wave that passes through the solvent, enhancing the mass transfer within the plant materials [8]. Ultrasound assisted extraction increases the yield of extraction due to the breakdown of cellular wall structures and therefore increases the interaction of extraction solvent with the intracellular compounds. The following parameters are usually offered for variation in an Ultrasonic-assisted extraction setup; pulsed duration/interval, type of solvent, solid to solvent ratio, extraction time, extraction temperature, raw material particle size, ultrasonic power, where the usual setups are based off where the sonication is provided by an ultrasonic horn in a vessel or transducers are annealed on the walls of a vessels to provide sonication.

EFFECT OF OPERATING PARAMETERS

Pulsed duration/interval (Only for PUAE)

Ming Li et al. performed pulsed ultrasound-assisted using an ultrasonic horn with a fixed amount of turmeric and varying amounts of ethanol as extracting solvent for the pulsed duration of 1,3 and 5 s. They deduced that optimum ratio was 3/1 (s/s) pulsed duration/interval time. The yield of curcuminoids tended to decrease with the increase of interval time when the pulsed duration time was fixed at various times and it was more effective than CUAE (Continuous ultrasound-assisted extraction). It was also recommended to decrease the interval time during the application pulsed sonication.

Type of solvent and concentration

Ming Li et al. deduced that the yield significantly increased with an increasing ethanol concentration up to 82-84%.

S.R. Shirsath et al. performed PUAE while studying the effect of type of solvents such as ethanol, methanol, ethyl acetate, acetone. The most effective solvent was deduced to be ethanol (72% extraction extraction (9.18 mg/g)) since it has higher polarity, low viscosity, low surface tension. Using methanol and acetone also resulted in similar results of extraction due to acoustic cavitation taking place very easily in solvents with low viscosity and surface tension.

Sh. Rouhani et al. performed extraction in an ultrasonic bath with 10 minutes of extraction time at 3 pH varying concentrations of ethanol (70-96%) and found optimum concentration in 70 % with 0.007 mol/L concentration. It deduces that the certain amount of water decreases the viscosity of mixture increasing its effect of sonication and better mass transfer due to swelling of plant materials and the extraction effectiveness decreases after a certain concentration due to increase of mixture polarity.

Vivekananda Mandal et al. concluded that 80% v/v ethanol-water showed the best results with a maximum yield of 3.95 % w/w of curcumin for the same reason as Sh. Rouhani et al. deduced.

Wakte, P. S. et al. performed UAE using a ultrasonic bath of fixed power of 150 W using, dry powder of 20 g turmeric which exposed to the ultrasonic waves for various time periods 1, 3, 5 and 7 mins with a mass to solvent ratio of 1:3 w/v where ethanol and acetone were used as solvents. The ethanol as an extracting solvent showed 32.85 % yield and acetone as an extracting solvent showed 40 % yield. The same optimum extraction time was achieved for extraction process with pre-soaking the turmeric powder in ethanol and water for 24 hrs achieved maximum yield of 66.66% for ethanol (pre-soaked in water) and 71.42% for acetone (pre-soaked in water).

Solid to Solvent Ratio

S.R. Shirsath et al. found out that 1:25 Solid to solvent ratio the optimum (72% of sample extracted) [29]. The yield of the process was in increasing order as the ratio increased up to 1:25 then decreased further ahead. However, there are various other papers belonging to plant-based product extraction which show contradicting results [8],[9],[10]. Thus, the optimum value of solid to solvent ratio is specific to the system under investigation and needs to be established experimentally. Also, using a large amount of solvent is not considered to be cost-effective due to high operating cost of solvents and energy consumption required during the subsequent separation.

Extraction Time

The optimum extraction times were all over the place with time varying from 15 mins for ultrasonic bath for Sh. Rouhani et al. and 30 mins for Foozie Sahne et al. and 70 minutes of extraction for Vivekananda Mandal et al. using an ultrasonic bath apparatus and it concluded that the extraction time exceeding 40 minutes usually leads to a decrease in yield due to dissociation of curcumin structure due to prolonged exposure to ultrasound waves. These processes also seem to have around the same yield (approx. 4%).

Wakte, P. S. et al. concluded that the optimum irradiation time was at 5 mins after which there was no increase curcumin content.

Extraction Temperature

S.R. Shirsath et al. varied the temperatures in the ultrasonic horn setup from 25-55 °C where a water bath was set up around the vessel to control the temperature. with ethanol as a solvent, solid to solvent ratio of 1:25, raw material particle size of 0.09 mm, ultrasonic power of 250 W and frequency of 22 kHz for an extraction period of 1 h. The optimum extraction temperature is deduced to be 35 °C (9.54 mg/g) [14,29]. The extraction yield tends to increase with increasing temperature due to increase in solute diffusivity and solubility thus, increasing the yield to a certain limit where there is a possibility of product degradation and it ends up being inefficient due to increased energy requirement. Foozie Sahne et al. varied the temperatures from 25-40 °C found similar findings with the optimum temperature being at 35 °C with 3.92% yield.

Raw material particle size

Shirsath et al. (72% of extraction) concluded that the decrease in particle size leads to improved extraction due to increased contact area and reduction of required diffusion paths.

Ultrasonic Power and frequency

Shirsath et al. studied the effects of ultrasonic power under extraction conditions of solvent as ethanol, temperature of 35 °C, solid to solvent ratio of 1:25, particle size of 0.09 mm, ultrasonic frequency of 22 kHz the yield will always increase with increasing power (250 W). An increase in ultrasonic power from 130 to 250 W resulted in a yield increase from 5.99 mg/g (47%) to 9.18 mg/g (72%). However, this type of increase may get difficult to handle as it is difficult to cool a system in application of increasing power. The increasing power attributed to the larger amplitude of ultrasound travelling through the solvent giving intense collapse of cavities and hence the enhanced physical effects including cracked or damaged cell walls, increased solute diffusion, interfacial turbulence and local energy dissipation.

Shirsath et al. also performed extraction at two different frequencies as 22 kHz and 40 kHz and obtained results that extraction of curcumin at 22 kHz was 9.18 mg/g (72%) which is higher than 6.40 mg/g (50.2%) obtained at 40 kHz.

CONCLUSION

The different types of extraction methods were discussed and various setups of Ultrasound-assisted extraction and their own parameters and their effects were investigated where similar results and reasonings were observed for some parameters such as raw material particle size, ultrasonic power and frequency, extraction temperature and solvent type and concentration thus concluding the effect of those parameters. There was still an uncertainty in the extraction time parameter which occurred due to variation in setups and difference in base conditions for the process. Ultrasound assisted extraction still shows as a promising alternative to the traditional methods since it requires lesser time and utilizes lesser solvents therefore being more environmentally friendly.

REFERENCES

[1] Ana Ramirez-Boscá, Alfonso Soler, Miguel Angel Carrión Gutierrez, Juan Laborda Alvarez, Eliseo Quintanilla Almagro, "Antioxidant Curcuma extracts decrease the blood lipid peroxide levels of human subjects" Geroscience, 1995, 18(4), 167-169.

[2] Prasad S, Tyagi AK, Aggarwal BB, "Recent developments in delivery, bioavailability, absorption and metabolism of curcumin: the golden pigment from golden spice", Cancer Res Treat, 2014, 46(1), 2-18.

[3] Boyanapalli SS, Kong AN, "Curcumin, the king of spices: epigenetic regulatory mechanisms in the prevention of cancer, neurological, and inflammatory diseases", Curr Pharmacol, 1(2), 129-139.

[4] Daria Jovičić, Antun Jozinović, Manuela Grčević, Emilija Spaseska Aleksovska, Drago Šubarić, "Nutritional and health benefits of curcumin", Food in Health and Disease, 2017, 6(1), 22-27.

[4] M. B. Patil, S. V. Taralkar, V. S. Sakpal, S. P. Shewale, R. S. Sakpal, "Extraction, isolation and evaluation of anti-inflammatory activity of curcuminoids from curcuma longa", International Journal of Chemical Sciences and Applications, 2011, 2(3), 172-174.

[5] Priyanka Joshi, Shashi Jain, Vimal Sharma, "Turmeric (Curcuma longa) a natural source of edible yellow colour", International Journal of Food Science and Technology, 2009, (44), 2402-2406.

[6] Govindarajan V.S., "Turmeric-Chemistry, Technology and Quality", CRC Crit. Rev. Food Sci. Nutr. ,1980, 12 (3), 199–301.

[7] Huang M.-T., Ma W., Lu Y.-P., Chang R. L., Fisher C., Manchand P. S., Harold L.Newmark and Allan H.Conney. Effects of curcumin, demethoxycurcumin, bisdemethoxycurcumin and tetrahydrocurcumin on 12-O-tetradecanoylphorbol-13-acetateinduced tumor promotion, Carcinogenesis, 1995, 16(10), 2493–2497.

[8] Z. Lou, H. Wang, M. Zhang, Z. Wang, "Improved extraction of oil from chickpea under ultrasound in a dynamic system",2010, J. Food Eng, (98), 13–18.

[9] S. Zhao, K. Kwok, H. Liang, "Investigation on ultrasound assisted extraction of saikosaponins from Radix Bupleuri", Sep. Purif. Technol, 2007, (55), 307–312.

[10] J. Dong, Y. Liu, Z. Liang, W. Wang, "Investigation on ultrasound-assisted extraction of salvianolic acid B from Salvia miltiorrhiza root", Ultrason. Sonochem, 2010, (17), 61-65.

[11] Sh. Rouhani, N. Alizadeh, Sh. Salimi, T. Haji-Ghasem, "Ultrasonic Assisted Extraction of Natural Pigments from Rhizomes of Curcuma Longa L.", Progress in color, colorants and coatings summer, 2009, 2(2), 103-113.

[12] Ming Li, Michael O. Ngadi, Ying Ma, "Optimization of Pulsed Ultrasonic and Microwave-Assisted Extraction for Curcuminoids by Response Surface Methodology and Kinetic Study", Food Chemistry, 2014, (165), 29-34.

[13] S.R. Shirsath, S.S. Sable, S.G. Gaikwad, S.H. Sonawane, D.R. Saini, P.R. Gogate, "Intensification of extraction of curcumin from Curcuma Amadausing ultrasound assisted approach: Effect of different operating parameters", Ultrasonics Chemistry, 2017, (38), 437-445.

[14] Vivekananda Mandal, Saikat Dewanjee, Ranabir Sahu and Subhash C. Mandal, "Design and Optimization of Ultrasound Assisted Extraction of Curcumin as an Effective Alternative for Conventional Solid Liquid Extraction of Natural Products", Natural Products Communications, 2009, 4(1), 95-100.

[15] Foozie Sahne, Maedeh Mohammadi, Ghasem D. Najafpour, Ali Akbar Moghadamnia "Extraction of bioactive compound curcumin from turmeric (curcuma longa l.) via different routes: A comparative study" Pak. J. Biotechnol., 2016, 13(3), 173 – 180.

[16] Wakte, P. S., Sachin, B. S., Patil, A. A., Mohato, D. M., Band, T. H., Shinde, D. B., "Optimization of microwave, ultra-sonic and supercritical carbon dioxide assisted extraction techniques for curcumin from Curcuma longa", Separation and Purification Technology, (2011), 79(1), 50–55.