Contents lists available at ScienceDirect

Food and Bioproducts Processing

journal homepage: www.elsevier.com/locate/fbp

Production of free lutein by simultaneous extraction and de-esterification of marigold flowers in liquefied dimethyl ether (DME)–KOH–EtOH mixture

Panatpong Boonnoun[a], *Pemika Tunyasitikun*[b], *Weerawat Clowutimon*[b], *Artiwan Shotipruk*[b,*]

[a] *Department of Industrial Engineering, Faculty of Engineering, Naresuan University, Phitsanulok 65000, Thailand*
[b] *Chemical Engineering Research Unit for Value Adding of Bioresources, Department of Chemical Engineering, Faculty of Engineering, Chulalongkorn University, Phayathai Road, Bangkok 10330, Thailand*

ARTICLE INFO

Article history:
Received 25 July 2017
Received in revised form 4 October 2017
Accepted 6 October 2017
Available online 14 October 2017

Keywords:
Lutein
Liquefied dimethyl ether
Solvent extraction
De-esterification
Marigold flowers
Simultaneous process

ABSTRACT

Extraction of xanthophylls from marigold flowers using liquefied dimethyl ether (DME) was investigated. The most suitable DME extraction condition was found to be 33:0.5 (w/w) DME to dried marigold flowers ratio and at 35 °C, giving 20.65 mg of total xanthophylls/g of dried marigold flowers. Following extraction, the suitable de-esterification conditions to convert the extracted lutein fatty acid ester (the major compound in xanthophylls) to free lutein, a more bio-available form, were determined to be 2.5%w/v KOH–EtOH, at 35 °C for 4 h. While employing the most suitable conditions in each of the two steps gave favorable free lutein yield (16.65 mg free lutein/g dried marigold flowers), a one-step process in which simultaneous extraction and de-esterification carried out at the most suitable condition: the DME to dried marigold flowers ratio 33:0.5 (w/w), EtOH to dried marigold flowers ratio 10:0.5, 5% KOH–EtOH concentration, at 35 °C for 1 h, could lead to about 20% improvement (20.71 mg free lutein/g dried marigold flowers). Furthermore, the results from this study suggested that wet marigold samples could possibly be used both in the DME extraction for xanthophylls and in the simultaneous process to obtain free lutein.

1. Introduction

Marigold (*Tagetes erecta*) is an ornamental plant originated in Mexico, but nowadays has been grown widely in tropical and subtropical regions of the world including South-East Asia (Lin et al., 2015a). The plant has been around Thailand for many years and is grown commercially all over the country for cut flowers used in Buddhist ceremonies and for use in poultry industry to provide yellow color to the skin of broilers and egg yolks. The key constituents in the marigold flowers that are responsible for the natural yellow color are xanthophylls, oxygenated carotenoids, and of which, approximately 60–70% is lutein (Gong et al., 2012).

Lutein ($C_{40}H_{56}O_2$) is a dihydroxy carotenoid with two ionone rings at each end of the molecule. Known not only as an important food colorant, lutein has also been well documented for its several health benefits including prevention and remedy of age-related macular degeneration (Prommuak et al., 2008; Luengo et al., 2014; Tian et al., 2015) and cancers, as well as enhancement of immune functions (Park et al., 1998; Siriamornpun et al., 2012). Given its relatively high amount of lutein in marigold flowers and its large market size ($150 million in the US) (Ho et al., 2015), extraction of marigold lutein for nutraceutical application is therefore becoming very attractive. Indeed, the worldwide market for lutein extracted from marigold flowers is expected to grow to US$308 million by 2018 (Lin et al., 2015b).

Lutein naturally occurs in the acylated form, in which it is chemically bound to various types for fatty acids, with the majority being lutein fatty acid diesters, due to the two hydroxy groups at the ionone rings. In marigold flowers, the main lutein fatty acid esters are lutein

* *Corresponding author.*
E-mail address: Artiwan.Sh@chula.ac.th (A. Shotipruk).
https://doi.org/10.1016/j.fbp.2017.10.002