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Enzyme-assisted extraction processing from oilseeds: Principle, processing and application

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A B S T R A C T

Enzyme-assisted extraction processing (EAEP), feasible alternative to screw pressing and organic solvent extraction technologies, is a promising method for the simultaneous extraction of oil and protein from oilseed. This method incorporates comminuting, extraction buffers and enzymes to allow production of a range of oils and proteins although different challenges appear during the process. The demand for acceptable and high free oil yields and purities of protein is always incompatible in many processes. This review article covers technological aspects of EAEP, and discusses the application of enzymes in pretreatment, extraction and demulsification, and explores the quality characteristics and safety of the oils and proteins obtained, focusing particularly on recent application of EAEP at the laboratory and industrial scale.

Industrial relevance:
1. Enzymes are widely used on an industrial scale but mainly as catalysts, and the applications mainly concerning the synthesis of pharmaceuticals, compounds for chemistry of specialty, polymers, etc.
2. At the industrial scale, one advantage of EAEP is environment benefit because it can avoid the risk of organic solvents and particularly hexane.
3. The quality of the products produced by the smooth process is usually higher.
4. EAEP technique is considered as an alternative method to produce valuable products without loss of quality at moderate conditions.
5. Compared with solvent extraction, EAEP is more eco-friendly. Besides that, one of the main advantages of EAEP is the specificity of enzymes.

Contents

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1. Introduction

Enzyme-assisted extraction processing (EAEP) is a promising method for using enzymes to facilitate the recovery of oils and proteins from oilseeds, in which water is used as the extraction solvent which has many advantages compared to conventional extraction. Conventionally, edible oil is produced by extraction with an organic solvent alone or by screw pressing prior to solvent extraction.

Mechanical oil expression from oil-bearing materials is a solid–liquid phase separation process which involves the application of pressure by hydraulic or screw press with or without heat (Ogunsina, Olatunde, & Adeleye, 2014). Although mechanical oil expression has advantages of wide scope of application and low equipment cost, the oil yield is relatively low and the protein loses economic value due to degeneration during mechanical processing.

Although n-hexane is the most prevalent solvent used in the chemical/food industries and achieves crude oil yield of over 96% (de Moura & Johnson, 2009), it's highly flammable, explosive and acute inhalation exposure of humans to high levels of hexane causes mild central nervous system effects, such as dizziness and headache rendering it unsafe to both plant and humans (Wu, Johnson, & Jung, 2009). For instance, it was earlier reported that when fifteen workers in an adhesive bandage factory were exposed to n-hexane, eleven of them showed macular changes and one had central retinopathy (Raitta, Seppäläinen, & Huuskonen, 1978).

In comparison with solvent extraction, the use of an aqueous medium is much safer, environmental-friendly and economical. In addition, it contributes to a much safer and flexible operation, lower energy consumption and operational costs, and lower capital investment. The EAEP products are of superior quality and highly suitable for human consumption.

Oil obtained by EAEP has better quality than that produced using other technologies. Because free fatty acids are neutralized by alkaline conditions during extraction processing, oils produced by EAEP have good oxidative stability and low phospholipid concentration, thus reducing losses of oil during refining processing (Abdulkarim, Long, Lai, Muhammad, & Ghazali, 2005; Bocevska, Karlović, Turkulov, & Pericin, 1993; Zhang, Lu, Yang, Li, & Wang, 2011).

Due to the denaturization of protein or residual solvent, the protein residue is mainly used in the manufacture of compound feed stuffs or fertilizers (Jiang, Hua, Wang, & Xu, 2010). Since the plant protein resource is not utilized optimally, the use of new technologies like EAEP can improve extraction yield, nutrition benefit and functional characteristics of plant proteins.

Despite the advantages, the application of EAEP in the industry is still limited due to long processing time and the high disbursement for the drying process after the enzyme treatment (Dominguez, Sineiro, Nunez, & Lema, 1995; Shah, Sharma, & Gupta, 2005b). Compared to mechanical oil expressing processing and solvent extraction, EAEP consumes more time and has a higher cost of production since the price of enzymes is quite high. In addition, downstream steps, such as centrifugation for separation, emulsification and drying for protein and residues, are quite difficult and time-consuming. Lastly, emulsification is an unavoidable part of the extracted oil, which faces a number of problems.

2. Technical aspects of EAEP

2.1. Principle of EAEP from oilseeds

Extraction processing of oilseeds mainly consists of dispersing the ground oilseeds into water and providing a motive force to free oil from cellular confines (Johnson & Lusas, 1983; Rosenthal, Pyle, & Niranjan, 1996). The microstructure of soybean which is similar to most oilseeds is shown in Fig. 1 (Li, Gasmalla, Zhang, Liu, Bing, & Yang, 2016). Protein bodies are distributed all over the cell and present different particle sizes depending on the component and structure of cell wall oilseeds. These protein bodies contain approximately 60–70% of the total protein present in oilseeds (Snyder & Kwon, 1987). The process of EAEP is illustrated in Fig. 2. Centrifugation was indispensable in subsequent steps to separate the free oil from cream, skim and solids. However, the extraction technology still brings problems such as forming stable emulsion during the process, high cost of enzymes and high effluent generation.

2.2. Factors affecting EAEP from oilseeds

2.2.1. Grinding approaches

The first and critical step during EAEP to improve oil extraction from oilseeds is the operations used to rupture cell walls and release the oil so that it can be recovered as free oil and oil-rich cream.

2.2.1.1. Enzyme-assisted mechanical grinding. In recent years, the application of enzymes as pretreatment during EAEP has been proven to increase oil yields (Li et al., 2012). Use of enzymes as pretreatment breaks the cell wall and facilitates oil extraction. In addition, employing this approach is conducive to avoiding the formation of an oil-in-water emulsion. According to Zúñiga et al., significantly lower residual oil in the meal was found in the case of Chilean hazelnuts (Zúñiga, Soto, Mora, Chamy, & Lema, 2003). Besides, these studies indicated that enzyme pretreatment is applicable to various oilseeds and can be employed prior to both mechanical and solvent extraction methods. The enhancement of oil yield is due to the hydrolytic action of the enzymes on the cell wall and membrane components which facilitate subsequent oil release.

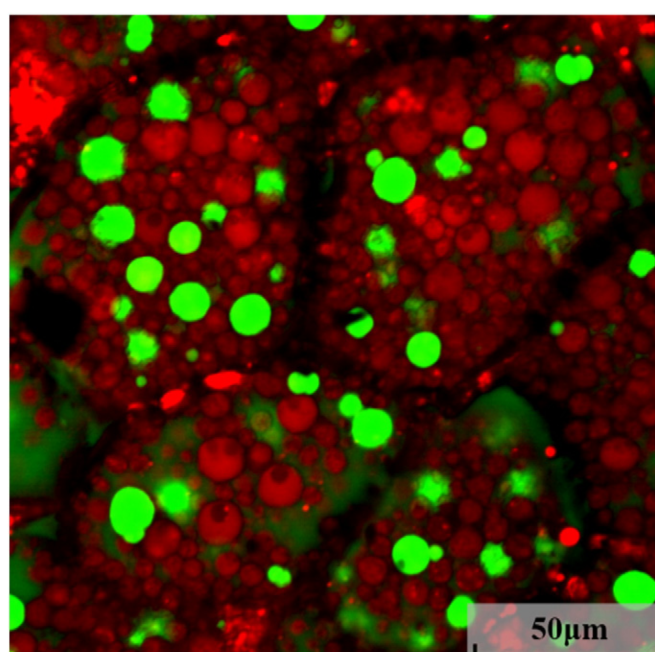

Fig. 1. Confocal micrograph of raw peanut (Li, Gasmalla, Zhang, Liu, Bing, & Yang, 2016).