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Review

Oilseed treatment by ultrasounds and microwaves to improve oil yield and quality: An overview

Mohamed Koubaa [a,*], Houcine Mhemdi [a], Francisco J. Barba [b], Shahin Roohinejad [c], Ralf Greiner [c], Eugène Vorobiev [a]

[a] Sorbonne Universités, Université de Technologie de Compiègne, Département de Génie des Procédés Industriels, Unité Transformations Intégrées de la Matière Renouvelable (UTC/ESCOM, EA 4297 TIMR), Centre de Recherche de Royallieu, B.P. 20529, 60205 Compiègne Cedex, France
[b] Nutrition and Food Science Area, Faculty of Pharmacy, Universitat de València, Avda. Vicent Andrés Estellés, s/n 46100 Burjassot, València, Spain
[c] Department of Food Technology and Bioprocess Engineering, Max Rubner-Institut, Haid-und-Neu-Str. 9, Karlsruhe 76131, Germany

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ABSTRACT

Efficiency is a key point to ensure the profitability in the production of vegetable oils from oilseeds. To maximize the recovery yields of seed oils, the traditional process involves mechanical expression followed by subsequent chemical extraction using organic solvents (e.g. hexane). Besides health, environmental, and economic related issues to the use of organic solvents, thermal treatment of seeds during conventional oil extraction process inevitably leads to chemical changes (e.g. changes in macronutrients such as protein denaturation/degradation in the meal, oil oxidation, and changes in minor constituents such as fatty acids, sterols, phenolic compounds and tocols). Thus, at this stage of development there is a need for new efficient processes that can improve oil yield and its quality from an economical and environmental point of view. Several research groups have investigated the potential of ultrasounds (US) and microwaves (MW) as additional seed treatments to enhance oil yields and to reduce temperature and extraction times with promising results. The present review is devoted to critically discuss the main findings reported in the literature regarding the feasibility of using US and MW as potential tools to improve oil recovery yields as well as its nutritional, sensorial and physicochemical properties.

Contents

1. Introduction

The production of oil from oilseeds is a key element of worldwide competitiveness. Seed oils can be used for different purposes: for human consumption as food (Akpan, 2012), for cooking (Mounts, Warner, List, Neff, & Wilson, 1994), as a source of bioactive compounds

* Corresponding author.
E-mail address: koubaa.mohamed@gmail.com (M. Koubaa).

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and/or nutraceuticals (e.g. vitamins, polyphenols) (Sakai et al., 2010), and for using in the pharmaceutical and cosmetic industries for preparation of different products (Sionek, 1997). The major oilseed crops grown worldwide are: soybean, rapeseed, cottonseed, peanut, sunflower seed, palm kernel, and copra (Daun, Eskin, & Hickling, 2011). Once the oil is extracted from the seeds, a refining process is needed to improve the preservation conditions and nutritional properties (Mirzaee Ghazani & Marangoni, 2013). Moreover, some food industries transform seed oils by specific processes (i.e. hydrogenation) to obtain more stable semi-solid fats. However, scientific evidences have shown that there is a relation between excessive consumption of foods with partially or fully hydrogenated fats and increasing the levels of cholesterol and plasma triglycerides (Han et al., 2002; Pedersen, Muller, Seljeflot, & Kirkhus, 2005; Vega-López, Ausman, Jalbert, Erkkilä, & Lichtenstein, 2006).

The extraction process is one of the key stages in the production of oil from oilseeds. The conventional oil extraction processes are mechanical expression and/or solvent extraction (e.g. using *n*-hexane) (Fig. 1). After extraction, a refining process is usually required to obtain edible oils for human consumption. This process is divided into a series of steps, which are generally: i) degumming, ii) neutralization, iii) washing, iv) bleaching, v) winterization, and vi) deodorization. At the moment, there is a growing demand from oil-producing industries to find the most recent and efficient process, which is not only economic, but also environment-friendly, and nutritious. Such process is required to reduce the consumption of toxic solvents, increase the oil extraction yields, and improve the nutritional quality of the generated oils.

In the last two decades, some research groups have evaluated the potential of using new alternative non-conventional technologies, which are applied alone or combined with other conventional processes, to improve the oil recovery. For instance, the feasibility of using ultrasounds (US) and microwaves (MW) to improve the recovery of oil, nutritional value, physicochemical and sensorial properties have been widely investigated and have proved to be efficient before or during the oil extraction process. This review critically discusses the current and potential applications of US and MW on the major oilseed crops and some other promising crops such as linseed and sesame to 1) improve the oil production yields, 2) enhance the oil nutritional values, and 3) minimize the carbon footprint by reducing the use of fossil-derived solvents. A discussion of the benefits and limitations of the described technologies is also reported.

2. Conventional extraction methods of seed oils

The most common processes used for oil recovery from oilseeds are either physical or chemical (Davies, 2014; Turtelli-Pighinelli & Gambetta, 2012). The physical process, also known as mechanical expression (ME), removes the oil from the seeds by applying mechanical power (Savoire, Lanoisellé, & Vorobiev, 2012). The term "expression" is usually used to indicate a process that mechanically presses a liquid (e.g. oil) out of liquid-containing solids (e.g. seeds) (Khan & Hanna, 1983). This process is generally used when the seed oil content is higher than 20% (w/w) (e.g. rapeseed, linseed), because mechanical pressing of a low-fat oilseed (<20%) yields only 50–70% of the available oil (Bargale, 1997). Two main types of ME commonly used are: i) batch hydraulic pressing (small and laboratory scale) and ii) continuous mechanical pressing (e.g. screw presses). Mainly there are two methods of ME: cold pressing and hot pressing (Savoire et al., 2012). When applying hot pressing, a cooking pretreatment of the seeds is required, whereas no thermal treatment is used for the cold pressing method (Anderson, 1996). Cold pressed oils have better preserved native and organoleptic properties than hot pressed ones, and are more appreciated by consumers (e.g. canola oil) (Prescha, Grajzer, Dedyk, & Grajeta, 2014). However, its oil recovery yields remain lower compared to the hot pressing ones (Azadmard-Damirchi, Alirezalu, & Fathi Achachlouei, 2011).

The disadvantages of using both cold and hot mechanical expressions are that a large amount of oil cannot be recovered mechanically and remains in the press cake (meal) (Anderson, 1996). To overcome this economic-related bottleneck, the solvent extraction (SE) (usually using hexane), is applied to the meal in order to recover the residual oil (Fig. 1) (Gunstone, 2009). This method relies to the diffusional extraction process of seed oils, where the term "extraction" involves the use of a solvent for the separation of a liquid from liquid-solid materials (Khan & Hanna, 1983).

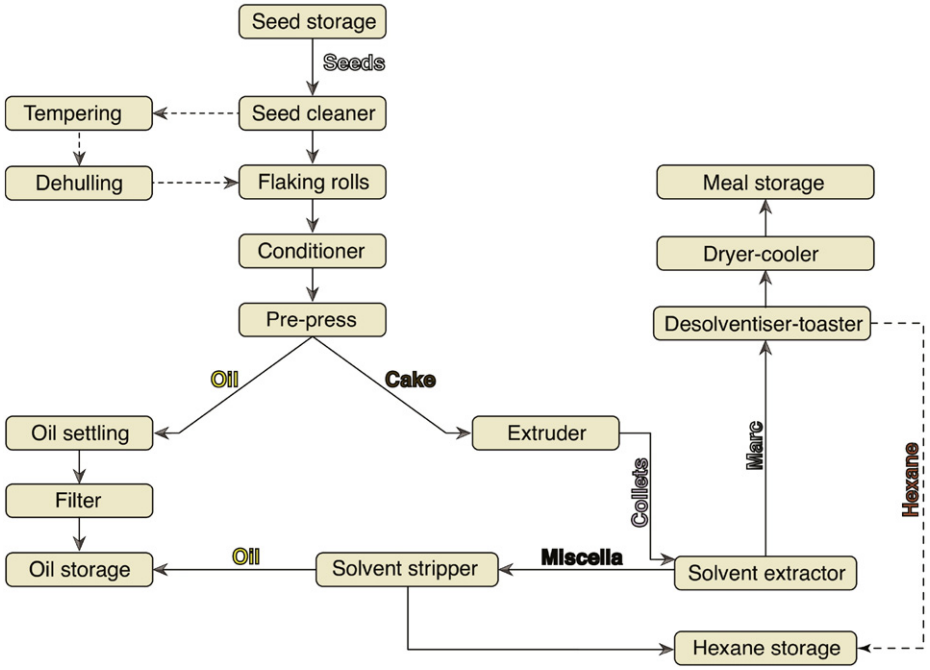

Fig. 1. Industrial oil production process from rapeseed (adapted from Gunstone (2009)).