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Investigation of quality and stability of canola oil refined by adding chemical agents and membrane processing

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Abstract

Recently, membrane technology has been extensively investigated for purification of vegetable oils due to simple processing, energy saving and many other advantages. In the present study influence of coupling chemical pretreatment and membrane filtration (micelle enhanced ultrafiltration) on quality and stability of canola oil was investigated. It has been conducted on adding chemical agents ($CaCl_2$, EDTA and SDS aqueous solutions) to canola oil miscella before ultrafiltration through polyvinylidenfluoride (PVDF) membrane with molecular weight cut-offs (MWCO) 100kDa and 50kDa in a magnetically stirred flat membrane cell. Operation temperature and pressure was constant at 25 ℃ and 2 bar, respectively. SDS solution lowered phospholipids content almost completely. The reduction of phenolic compounds in SDS- and EDTA-pretreated filtered oil was more noticeable than in the processed miscella. On the contrary, the reduction of FFAs was more in the miscella filtered without any chemical agents. The membrane exhibited no appreciable affinity towards tocopherols and carbonyl compounds in the oil samples. SDS and EDTA played important role in oil oxidation, so that they led to increase in peroxide value. It seems that by adding SDS and EDTA aqueous solution which followed by membrane filtration the quality and stability of canola oil was increased but it couldn't replace for deacidification stage of conventional refining. Then further research should be done to increase the performance for removing FFA by changing chemical agent or membrane material.

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Keywords: $CaCl_2$; Canola oil; Ethylene diamide tetra acetic acid (EDTA); Sodium Dodecyl Sulfate (SDS); Ultrafiltration

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1. Introduction

The methods of vegetable oil processing have not been changed for decades and possess several disadvantages in terms of high energy consumption, waste disposal, loss of nutritional value of oil, formation of trans fatty acids, conjugated dienes and oxidation products [1]. Membrane technology primarily is a size-exclusion-based pressure-driven process and may be a way to overcome many of these problems [2]. In recent years, different studies have been done on degumming, deacidification and decolouration of crude vegetable oils without using any chemicals [1,2]. Nevertheless, there have been a few attempts focusing on enhancing reverse micelle content as well as hydratable phospholipids (PLs) to improve the performance of refining by membranes [3]. The phospholipids present in crude oils are typical amphiphilic molecules due to hydrophobic and hydrophilic groups in their molecules which cause formation of inverse micelles in a non-aqueous system [4]. These micelles would have affinity for other polar components due to large dimensions with hydrophilic polar heads [5]. Colour compounds, some FFAs, and other impurities are trapped by the reverse micelles and removed through suitable semi-permeable membranes [6]. It has been reported that some chemicals such as sodium hydroxide could increase the level of hydratable PLs in crude oil and form of reverse micelles, respectively [1]. It is expected that some other chemicals can impact on PL molecules and enhance the formation of reverse micelles. Ethylene diamide tetra acetic acid (EDTA), is an effective complexing agent because it forms a so stable chelate complex with all polyvalent metal ions including Ca^{2+}, Mg^{2+}, and Fe^{2+}. A previous research showed that EDTA in the presence of phospholipids broke down phospholipid/metal complexes (PA/M^{2+} and PE/M^{2+}) which increased the hydratabilities of phosphorus compounds and allowed subsequent their elimination [7]. In the presence of water, divalent cations such as calcium and magnesium cause to aggregate liposomes of hydratable PLs lead to precipitate and facilitate their separation from oil [8]. It has been reported that the surfactant molecules reversibly assemble into polymolecular aggregates or micelles by gathering the polar heads together in the center of the micelle, and the hydrophobic chains extend into the oil. Micelles are able to encapsulate polar substances within their hydrophilic center [9]. surfactants such as SDS either decrease or enhance permeate flux because of their adsorptive interactions with the membrane surface which is related to electrostatic forces or hydrophobic effects [10]. Since coupling chemicals with membrane technology seems to offer a promising method, in the present study, attempts were made to evaluate the quality and stability of crude canola oil processed by porous polymeric membranes upon the addition of chemicals.

2. Materials and Methods

It has been conducted on adding chemical agents ($CaCl_2$, EDTA and SDS aqueous solutions) to canola oil miscella [3,11] before ultrafiltration through polyvinylidenfluoride (PVDF) membrane with MWCOs 100kDa (M183) and 50kDa (M116) in a magnetically stirred flat membrane cell at pressure 2 bar and temperature 25℃. The R [%] was calculated according to the following equation:

$$R\,[\%] = [1 - C_p / C_f] \times 100 \qquad (1)$$

where C_p and C_f are the concentration of component in permeate and feed, respectively.

The FFAs content was measured by the titration method defined in the American Oil Chemists' Society's Official Methods Ca 5a-40 [12]. The determination of total phenolics content was done