The Efficiency and Yield Measurement of the Enzymatic Degumming Process

Abstract

Crude oil obtained by oilseed processing has to be refined before the consumption in order to remove undesirable compounds. These components are commonly eliminated by chemical refining or physical refining methods. The physical refining required a phosphorous content below 10 mg/kg to be successful. Degumming is the first step in the refining process of vegetables oils, and it removes phospholipids and mucilaginous gums that affect quality and storability. The generally practiced methods use water or acid as degumming agent. In recent decades, the oil industry has developed biotechnological processes to replace traditional methods. Enzymatic degumming is an alternative to achieve the low phosphorus levels that are required for physical refining. Compared to traditional processes, the enzymatic degumming technology presents some advantages such as the minimum environmental damage, the reduction in the operation costs and the improved in quality and oil yield.

Keywords: Enzymes; Degumming; Efficiency; Oil Yield

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Abbreviations: PLA1: Phospholipase A1; PLA2: Phospholipase A2;PLB: Phospholipase B; PLC: Phospholipase C; LA: lipid Acyltransferase

Introduction

Degumming is the first step in the refining process of vegetables oils, and it removes phospholipids and mucilaginous gums that affect quality and storability. Traditional degumming that include water, super, total, acid degumming and ultrafiltration processes cannot guarantee the low phosphorus levels that are required for physical refining [1,2]. These techniques are not suitable for oils with high levels of non-hydratable phospholipids [1-3]. Enzyme-mediated degumming is a unique process quite distinct from the well-known acid degumming variations, since both hydratable and nonhydratable phospholipids present in the oil are hydrolyzed to the corresponding lysophospholipids [2,4]. In addition, a reduction in wastewater generated during the refining process, and a reduction in operating costs can be achieved [5]. Some enzymatic degumming processes have been suggested on laboratory and pilot plant scales [2,4,6-10]. The most commonly utilized phospholipase in enzymatic degumming are phospholipase A1 (PLA1) and phospholipase A2 (PLA2) that remove, respectively, the fatty acid from positions 1 and 2 with respect to glycerol [11]. Other enzymes are commercially available for vegetable oils processing. Phospholipase B (PLB) eliminates both fatty acids from the glycerol group [12], phospholipase C (PLC) catalyzes the hydrolysis of phosphate-glycerol bond in phosphatidylcholine and phosphatidylethanolamine and the lipid acyltransferase (LAT), transfers a fatty acid to a sterol present in the oil in order to convert it into a sterol ester [13].

All enzymes cause less oil to be retained by the gums by decreasing the amount of gums and their oil retention, which also contributes to an improved oil yield [3]. The initial research works on enzymatic degumming were focused on soybean and rapeseed oils [4,6,7]. Then, some assays using crude rice bran oil were made [2,14-16]. Others varieties of crude vegetable oils were also investigated as sunflower oil [9,10] and camellia oil [2]. Also, the enzymatic degumming improved the quality of the treated oil, which could mean a benefit for subsequent stages of refining process [9,10]. In the present work, research investigations on the current state of enzymatic degumming process of different vegetable oil are reviewed.

The Enzymatic Degumming Process

In the degumming studies, the assay system comprises a jacketed reactor fitted with lid, a propeller and a thermometer. The reactor is connected to a water bath with water pump and flexible tube. The oil sample is loaded in the reactor, and is heated to achieve the desired temperature. Followed by the addition of citrate buffer or sodium hydroxide the mixture is stirred with automatic mixer to provide a safe large surface area through emulsification. Then, the enzyme solution is added. Commonly, the enzyme requires a certain pH-range, so it is dissolved in a citrate buffer but instead of adding a solution of the enzyme in this buffer. So, the buffer is made in situ by first adding citric acid to the oil, providing a holding time, partially neutralizing this acid with caustic soda and then adding the enzyme [13]. Some studies use this methodology [2,6-8,14,16]. Others authors reported a directly apply of the enzyme-buffer solution on crude oil, without requiring previous steps [9,10] on sunflower oil. Likewise, using rapeseed oils, [4] recommended adoption of enzymatic degumming directly to crude oils. Omission of previous step in the process would lead to reduced operating costs and reduced oil loss. In all cases, the process is performed during desired time, then; the stop reaction is carried out inactivating the enzyme. To recover oil and water phases a centrifuged step is applied.

Discussion

The efficiency and oil yield

The presence of phospholipids can cause oil discoloration and serve as precursor of off-flavors. Therefore, the removal of nearly all of the phospholipids is essential for the production of high-quality finished oil [17]. The composition of phospholipids has historically been determined by either thin layer chromatography or column chromatography [18]. But habitually, in the industries; the measure of the elemental phosphorus in the oil is an indication of the presence of phospholipids. Therefore, the efficiency of the degumming process is estimated based on its ability to reduce the phosphorus content. Several research studies evaluated the efficiency of the process by the residual phosphorous content in the degummed oil. The attention focused in achieved values below 10mg/kg required by physical refining. Soybean oil degummed by PLB from *Pseudomonas fluorescens* BIT-18 decreased phosphorous content to 4.9 mg /kg at 5 h [12]. In the case of rapeseed oil the phosphorus content was reduced to 5 mg /kg using Lecitase® Novo (PLA1 from *Fusarium oxysporum*) [4]. But in rice bran oil the phosphorus content was reduced to 18 mg /kg with the same enzyme and needed a bleaching step to decrease to less than 5 mg /kg [15].In rice bran oil the phosphorous content decreased to less than 5 mg/ kg after 6.5 h with Lecitase®Ultra (PLA1 from *Thermomyces lanuginosus/Fusarium oxysporum*) [14]. Jiang et al. [2] reported that using this enzyme needs 3h to reduce the phosphorous content below to 10 mg/kg in rice brain oil. Using the same oil, others studies reported that after 2 h of incubation period the phosphorous level drecreased below 10 mg/kg [16] and soybean oil was degummed to 6 mg /kg at 5h [7] with this PLA1. However in the case of sunflower oil less time was required to achieved optimal levels of phosphorous using Lecitase ® Ultra [9,10]. Jiang et al. [2] reported that using a mixture of PLC from *Bacillus Cereous* and PLA1 Lecitase ® Ultra higher degumming efficiency was observed in several oil samples, and the combined action was enough to reduce the residual phosphorus below 10 mg/kg with acid pretreatment. Different values obtained suggest that time may vary depending on the initial phosphorous content and type of oil besides the type of enzyme. The yield increase from degumming with enzymes comes from to the formation of free fatty acids using phospholipases and in the case of the acyltransferase sterol ester produced. The lower oil entrainment in the gums fraction, also contribute to this increment. Different measurements were established to determine the oil yield. The measurement of dry matter in the reacted gums [19] and the total mass of oil and gums obtained [10]. Since the separation efficiency of the laboratory centrifuge scale cannot be compared to an industrial centrifuge, some works measured the yield as the formation of free fatty acids obtained by the phospholipids reaction [2,14]. A more accurate approximation was developed for sunflower oil, by the quantitative determination of the acetone-insoluble material in the gums [9]. This estimation might be considered to compare laboratory trial tests with the industrial scale.

Conclusion

Compared to traditional process, the enzymatic degumming is the more efficient and more eco-friendly.

This technique reduced the phosphorus content in the vegetable oils to less than 10 mg/kg, achieving the requirements of the physical refining. However, it is clearly demonstrated that the reaction time, and the operation conditions depends on the initial phosphorous content in the crude oil, oil variety, type of enzyme and the operation conditions. So the measurement of the residual phosphorous content is a good indicator of the efficiency of the process. On the other hand, the oil yield is a measure that is difficult to estimate from the laboratory trials. In this case, the measure should be chosen according to the equipments used. Thought, accurate approximation must be developing in each case. The studies reported suggest that acetone-insoluble material in the gums could be a high-quality assessment of the oil losses.

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