Applicability of chitosan for the removal of fat from coconut milk-based wastewater

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ABSTRACT - Batch experiments were conducted to investigate the possibility of using Chitosan, a bio polymer for the removal of fat originated from coconut milk. Identification of optimum parametric conditions for fat adsorptivity was conducted using a synthetic wastewater prepared from commercially available coconut milk. Chitosan powder was made into beads to avoid interferences in taking spectrophotometric readings. Experimental results indicated that chitosan is a potential substance to be used in this context.
Key words: Chitosan; Coconut milk fat; Wastewater

INTRODUCTION

Generation of a considerable amount of wastewater from the processing of coconut milk is unavoidable due to constant cleaning required to maintain the hygiene of the product. The Clean-In-Place (CIP) water used for cleaning the pipelines, washes away a large amount of fat and protein with it. Though many chemical and physical treatment methods have been devised to treat effluent containing fat, little or no attention is given to reuse of fat in a cost-effective manner. Conventional chemical treatment procedures which involve the use of synthetic polymers hinder the reusability of recovered fat due to being impure (Chi & Cheng, 2006).
Chitosan is a bio polymer derived from chitin by deacetylation. It can be used in this context as it possesses non-toxic, biocompatible and biodegradable properties (Kurita, 2006). Indeed, many researches have already been conducted to find applicability of chitosan in the treatment of water and wastewater (Bhatnagar & Sillanpää, 2009). The presence of free amine groups induces a positive ionic charge to chitosan which enhances bond formation with negatively charged fats, proteins and mineral ions (Al-Manhel, Al-Hilphy, & Niamah, 2016). Furthermore, it has been experimentally established that the FBC (Fat Binding Capacity) of chitosan obtained from shrimp waste is 427.98% (Hossain & Iqbal). This fact justifies the eligibility of chitosan to be used for the recovery of fat.
Although some researches have been conducted to find applicability of chitosan as a coagulant to treat wastewater from dairy industry (Chi & Cheng, 2006) none has been conducted in this regard. Though the constituents of the two products are somewhat similar, they vary in quantity while fat content being significantly different (Tetrapak, 2016) (American Association of Cereal Chemists, 1997). This study enables to bridge that gap as the applicability of chitosan for the treatment of wastewater derived from coconut milk-based processes under different conditions are being investigated.

METHODOLOGY

Development of a calibration curve

A coconut milk sample with 64000 μg of fat content (160 μl) was put into 8 ml of absolute ethanol at -20 ^{0}C and was kept at -20 ^{0}C for one hour. It was then centrifuged at 10000 rpm for 15 minutes and allowed to be cooled to room temperature. Half the quantity of the supernatant was transferred to be analyzed in the UV-visible spectrophotometer in the nanometer range from 195 nm to 240 nm. Other half was diluted with a similar quantity of ethanol to be used as the next sample with a fat content of 32000 µg. Likewise, six spectrum curves up to 1000 µg were obtained.

Preparation of the synthetic wastewater sample

100 µl of coconut milk was pipetted into 20 ml of absolute ethanol and the above procedure was followed to obtain the supernatant free of protein. Distilled water was added to it for volume adjustment. (10 ml)

Preparation of chitosan beads

A measured quantity of chitosan powder was dissolved in 5% (w/v) acetic acid with the ratio 30 ml of acid per 1 g of powder and the solution was stirred for 1 hour and left overnight. Using a 1000 µg scale micro-pipette, droplets of chitosan were poured into a solution of sodium hydroxide 10% (w/w) and ethanol 2% (w/w) forming spherical beads. Separated beads were thoroughly washed until a neutral pH was obtained and stored in distilled water.

Effect of pH, chitosan dosage and contact time

pH of the 30 ml samples were adjusted in the range of 4-9. pH was altered using 0.1 M HCl and 10 % w/w NaOH. The adsorbent dosage and the contact time were kept constant at 0.2 g and 15 minutes.
Adsorbent dosage was tested within the range of 25-300 mg by increments of 25 mg. pH was adjusted to its optimum value while contact time was maintained at 15 minutes.
Contact time was examined for the range of 2.5-30 minutes. A time gap of 5 minutes was maintained after the second sample. Optimum pH and dosage values were used in this set of experiments.

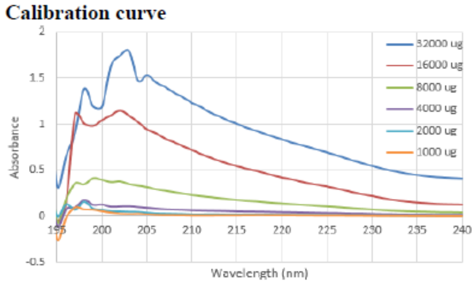


Figure 1. UV spectral curves for different coconut milk fat content

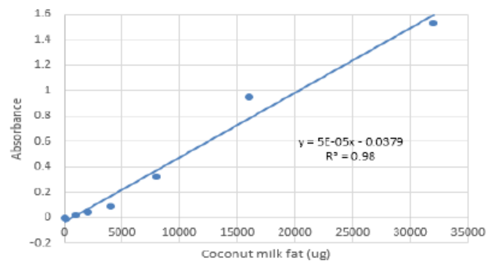


Figure 2. Calibration curve at 205 nm

RESULTS AND DISCUSSION

From Figure 1 it is apparent that the wavelength that best follows the Beer-Lambert Law lies beyond 204 nm. 205 nm was selected as it is experimentally identified that at higher

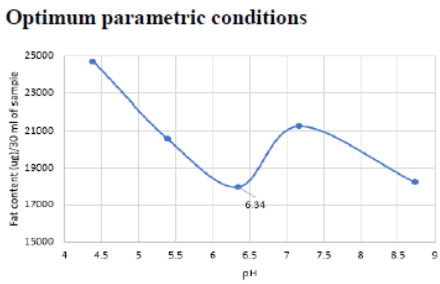
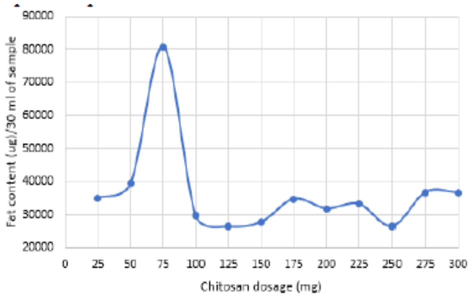


Figure 3. Fat content of treated sample vs. sample pH

There appears to be two pH values which will give the maximum adsorption tendency showing a minimum point in the plot near neutral pH value and at a higher pH value. Generally, coconut milk-based wastewater shows acidic conditions. Thus, CIP used in that process will most probably be alkaline. Therefore, overall pH value of the wastewater will not be a value significantly exceeding the neutral level.



Hence, in an economical point of view, it can be concluded that the optimum pH value as 6.34.

It is apparent that somewhat constant adsorption level is achievable after a certain point which is 125 mg. But the level shows a slight upward inclination. It may be due to excessive chitosan dose resulting in the re-stabilization of colloids which hinders the process of coagulation. Therefore, 125 mg per 30 ml sample can be regarded as the optimum

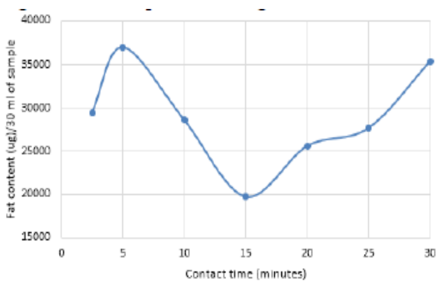


Figure 5. Fat content of treated sample vs. contact time

dosage.

It can be observed that there is a precise minimum point in the graph which indicates the maximum adsorption. In a general sense, either a negatively inclined or a horizontal graph is expected beyond the optimum point with the notion that higher the contact time, higher will be the adsorption if not constant. It may be because of the experimental errors or may be due to desorption that may occur because of the extended contact time.

CONCLUSION

The experiments conducted resulted in an optimum pH of 6.34, an optimum dosage of 125 mg per 30 ml of wastewater while 15 minutes was the optimum contact time. In most of the experiments, it is apparent that the initial fat content has been reduced at least by one third of the initial amount which is a good development.

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