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Effect of pasteurization on protein and fat contents remaining in coconut milk

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ABSTRACT

Fouling is generally observed at heat transfer surface in pasteurization of coconut milk. Fouling is unwanted because it reduces heat transfer efficiency and requires regular cleaning. In order to prevent fouling formation and to improve cleaning, fouling mechanisms must be known. Hence, this work aimed to study mechanisms of coconut milk fouling by observing protein and fat contents remaining in coconut milk under pasteurization for different times. Size of fat globules in the treated coconut milk was also observed. It was found that protein in coconut milk decreased with increasing pasteurization time whereas protein in foulant increased with pasteurization time. Hence, the results suggested that fouling involved deposition of denatured protein. Denaturation of protein also caused agglomeration of fat globules in coconut milk which were observed to increase in size with pasteurization time. Fat content in pasteurized coconut milk decreased with pasteurizing time. Fat content of coconut milk foulant also tended to increase with pasteurization time. Hence, it could be explained that the bigger fat globules became unstable in an aqueous phase and deposited with the denatured protein. Nevertheless, fat content in the foulant fluctuated significantly. Further work must be done to explain the fluctuation as well as to study components of the foulants at different layers in order to establish coconut milk fouling mechanisms.

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INTRODUCTION

Fouling is the accumulation of unwanted material on processing surfaces. Fouling of a heat exchanger is undesirable in heat treatment process mainly because it reduces heat transfer efficiency. Moreover, costs associated with cleaning are high Fouling deposit could be classified into 5 categories which are (i) precipitation fouling (ii) biological fouling (iii) chemical reaction fouling (iv) particulate fouling(v) corrosion fouling (Kazi, 2012).

Coconut milk is the liquid obtained by mechanical extraction of grated coconut pulp. It is a complex biological fluid typically composed of fat, protein, carbohydrate and minerals.

As an oil-in-water emulsion, some components of coconut milk may lose their rheological properties or denature and form deposits on the heating surfaces (Narataruksa *et al.,* 2010). The percentage of fat in coconut milk is adjusted depending upon local requirement, which can be between 15 and 40% (Seow and Gwee, 1997). Pasteurization is generally used to extend the shelf life of coconut milk. In Thailand, there are two main types of pasteurization processes of coconut milk: (i) batch and (ii) continuous pasteurization processes. Fouling is also a problem found with pasteurization of coconut milk. As little work has been done on coconut milk fouling, cleaning protocols used in the coconut milk industry simply follow the cleaning protocols of milk. Saikhwan *et al*. (2015) studied swelling and cleaning behaviours of coconut milk foulants and reported that the swelling behaviour was similar to that of milk foulant. However, cleaning behaviour was different. Clearly, optimizing cleaning without know the fouling mechanisms is not straight forward.

Hence, this work aimed to study fouling mechanisms of coconut milk. Since, coconut milk foulant was reported to be similar to Type A milk deposit but contained more fat (Saikhwan *et al*., 2015), it was assumed that both protein and fat could involve with fouling formation. This work, therefore, investigated effects of pasteurization on amounts of protein and fat remaining in coconut milk. The results would be useful in establishing fouling mechanisms of coconut milk, which in turns could improve fouling mitigation and cleaning.

MATERIALS AND METHODS

Preparation of coconut milk

Coconut milk was prepared by squeezing fresh grated coconut pulp in distilled water. The ratio of coconut pulp to distilled water used was 500 g coconut pulp to 200 ml distilled water.

Fouling formation

This work studied coconut milk foulant found in batch pasteurization which was formed using an apparatus shown in Figure 1 (Saikhwan *et al.,* 2015). The apparatus was designed to simulate batch pasteurization where coconut milk is heated from the bottom and stainless steel sample plates (Figure 1(b)) can be placed at the bottom of the apparatus. Rotational speed of 100 rpm was chosen as this was reported to prevent film formation at the surface of coconut milk (Saikhwan *et al.*, 2011). The studied pasteurization involved heating the coconut milk to 70°C (heating rate of ~ 13°C/min) and then this temperature was maintained. The time at which coconut milk reached 70°C was considered as a start of the pasteurization. In order to study effects of pasteurization on fat and protein contents of coconut milk and coconut milk foulant, heating was stopped at various times (5, 10, 15, 20, 25, 30 min) after the start of the pasteurization. Then samples of coconut milk in the apparatus and sample plates at the bottom of the apparatus were then removed for further testing. It should be noted that usually pasteurization time of 20 min is used to prevent spoilage of coconut milk by micro-organisms (Seow and Gwee, 1997). This is why the pasteurization times studied were up to 30 min.

Fat and protein contents of coconut milk and coconut milk

The fat contents of coconut milk and coconut milk foulants were determined using solvent extraction method. The solvent used was chloroform as this was used to extract fat in milk by the literature (Assawanuwat and Sripramote, 2009). Protein contents of coconut milk and the foulants were determined using the Bradford method (Redmile-Gordon *et al.,* 2013). For each experimental condition, fat and protein contents determination was repeated to give three reproducible runs.

Fat globule sizes

Fat globule sizes were imaged using a phase contrast light microscope (Eclipse Ni-U, Nikon, USA) at magnification of 10x.

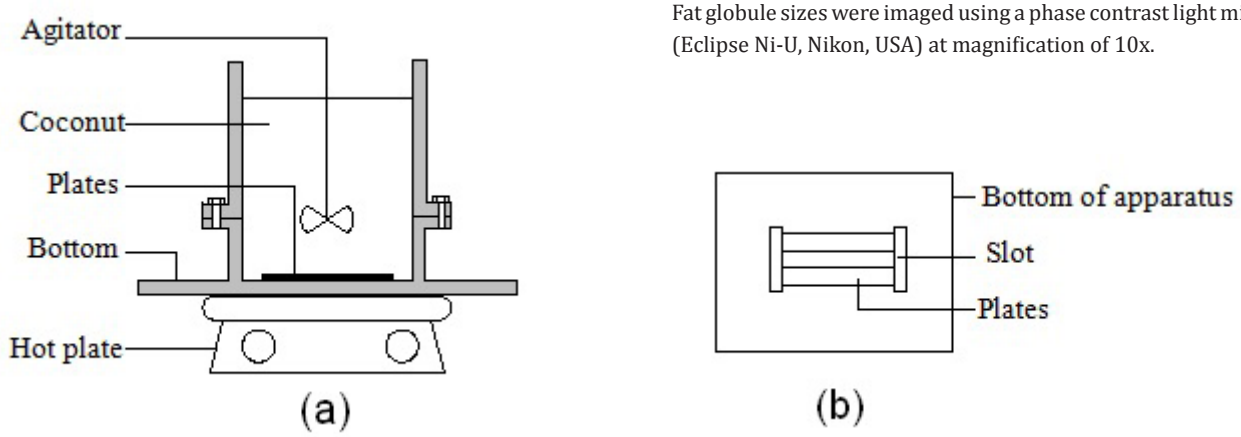

Figure 1 (a) The designed apparatus for simulating batch pasteurization process. (b) Top view of the bottom of the apparatus.

RESULTS AND DISCUSSION

As compositions of coconut milk used varied between batches, data presented in Figures 2 to 5 were normalized by the compositions of coconut milk before pasteurization. For example, mass of protein found in pasteurized coconut milk was divided by mass of protein presenting in the coconut milk before pasteurization. According to Figure 2, protein content of coconut milk decreases with increasing pasteurization time whereas Figure 3 depicts that protein content of coconut milk foulant increases with time. These results are consistent and suggest that coconut milk fouling formation may involve denaturation of protein in coconut milk and deposition of the denatured protein onto a heat transfer surface. Denaturation and deposition of protein have been reported to cause milk fouling as well

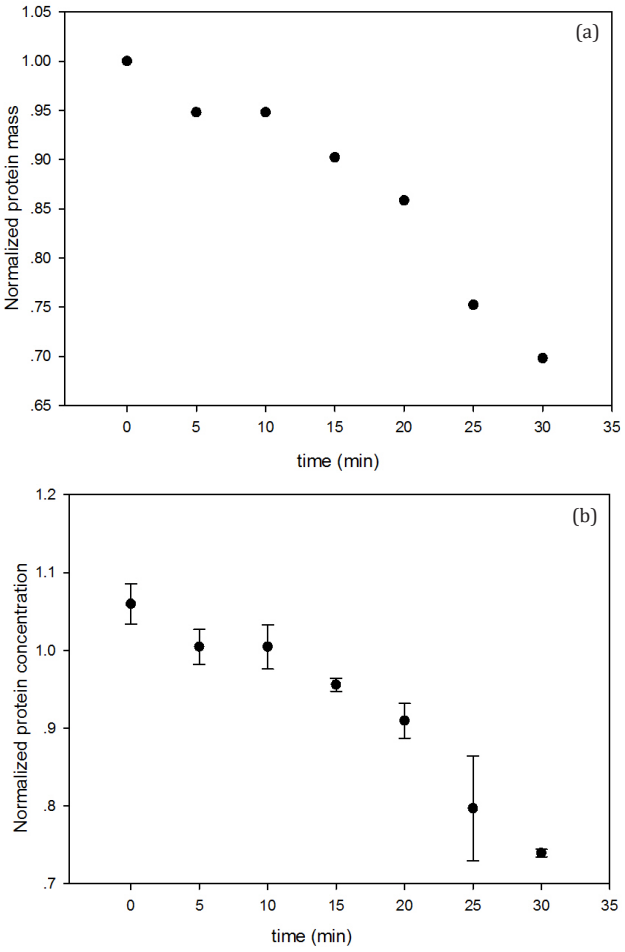

Figure 2 Protein content in coconut milk pasteurized for different times: (a) normalized protein mass and (b) normalized protein concentration (data is normalized by dividing by mass or concentration of protein in coconut milk before pasteurization).

(Bensal and Chen, 2005). However, coconut milk contains other components such as fat which was reported as the major component found in coconut milk founlants (Thongchan, 2012). Hence, fat contents in coconut milk and the foulant obtained at various pasteurization times were measured. Figure 4(a) shows that weight of fat extracted from pasteurized coconut milk increases with the pasteurization time. Since the batch pasteurization is a close system, the increase in mass of fat is not possible.

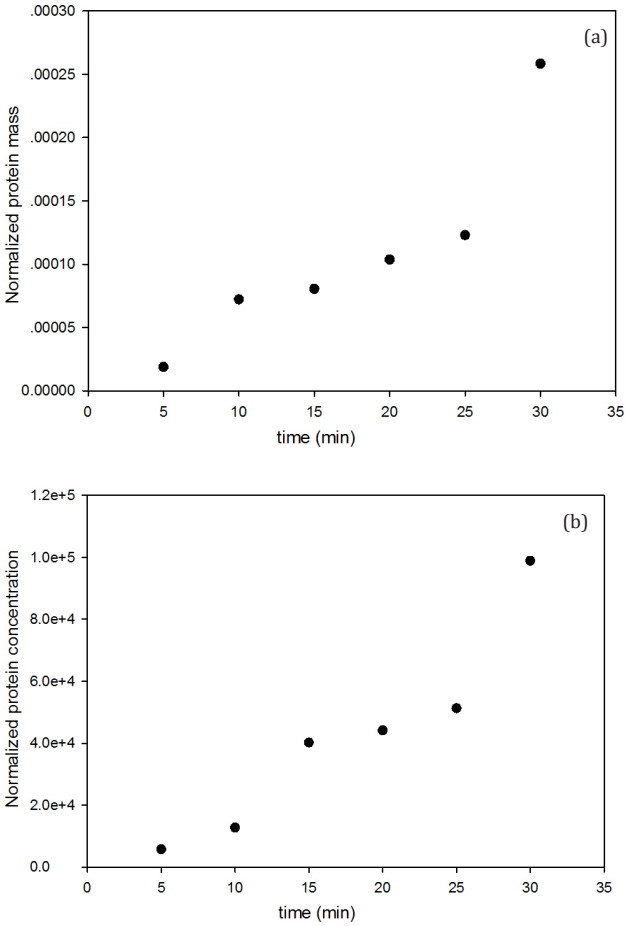

Figure 3 Protein content in coconut milk fouling pasteurized for different times: (a) normalized protein mass and (b) normalized protein concentration (data is normalized by dividing by mass or concentration of protein in coconut milk before pasteurization).

Figure 4(c) illustrates that weight concentration of fat in coconut milk increases initially and then decreases. The initial increase of the concentration was also inconsistent with the fact that a close system was studied. Although, the increase in fat concentration could be easily explained by water evaporation during the pasteurization, the evaporation does not explain the increase in fat mass. Hence, further investigation was conducted. It was found that more fat could be extracted from coconut milk heated in a water bath (to avoid fouling formation) at 70°C for longer times (Results are not shown here).

This suggests that the pasteurization time may affect extraction efficiency. Therefore, the results in Figure 4(a) were adjusted to account for the water evaporation and the change in extraction efficiency. The adjusted results are shown in Figure 4(b). According to Figure 4(b), mass of fat found in pasteurized coconut milk decreases with pasteurization time. This is consistent with Figure 6 where fat content in coconut milk foulant fluctuates with an increasing trend. The fluctuation could be due to experimental errors from using small amounts of foulants in the analysis. The use of small samples was hard to avoid because thin layer of foulant was formed in each batch particularly when pasteurization times were 5 and 10 mins.

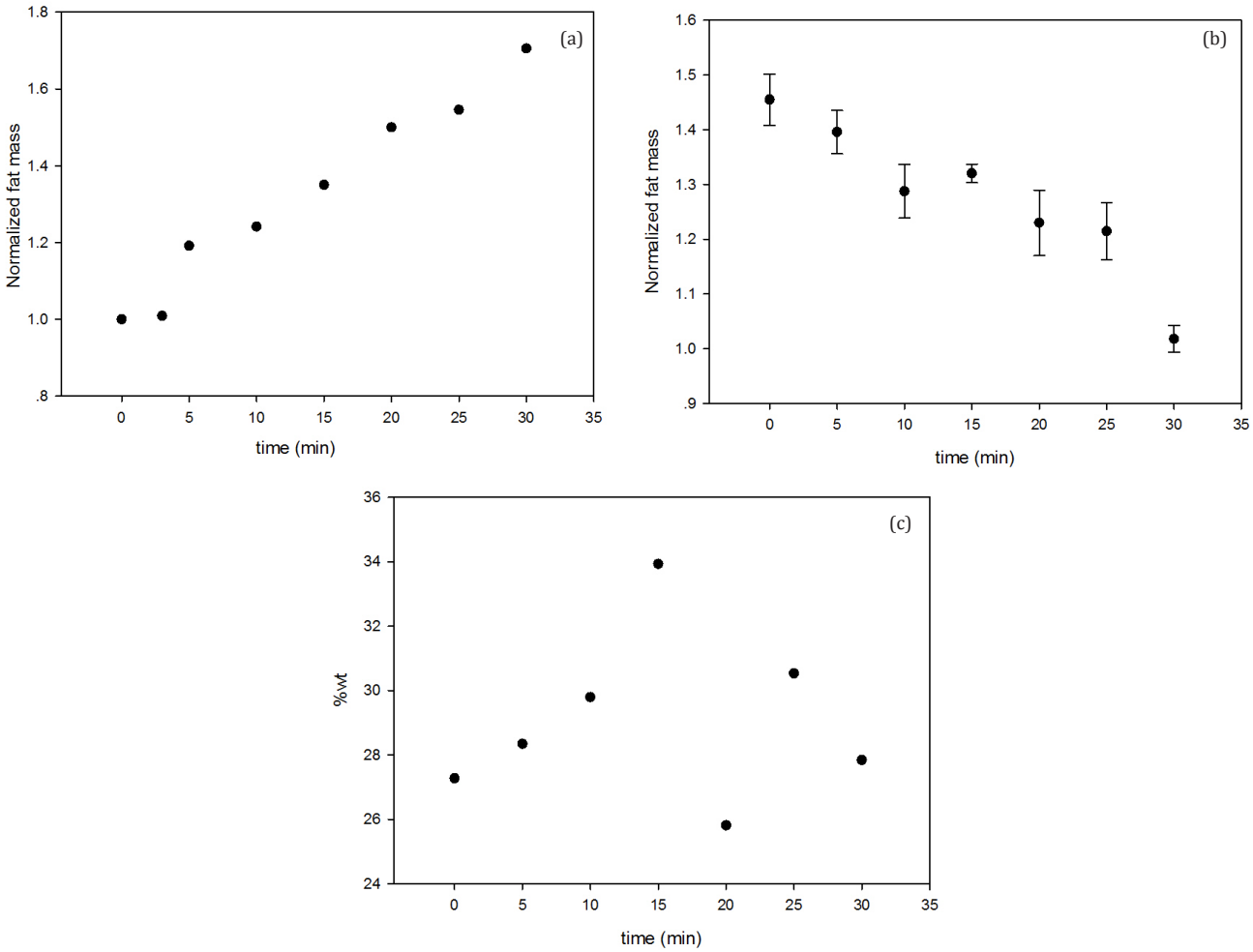

Figure 4 Fat content in coconut milk pasteurized for different times: (a) normalized fat mass (b) fat mass adjusted for water evaporation and change in extraction efficiency with heating time and (c) percent fat (data is normalized by dividing by mass of fat in coconut milk before pasteurization).

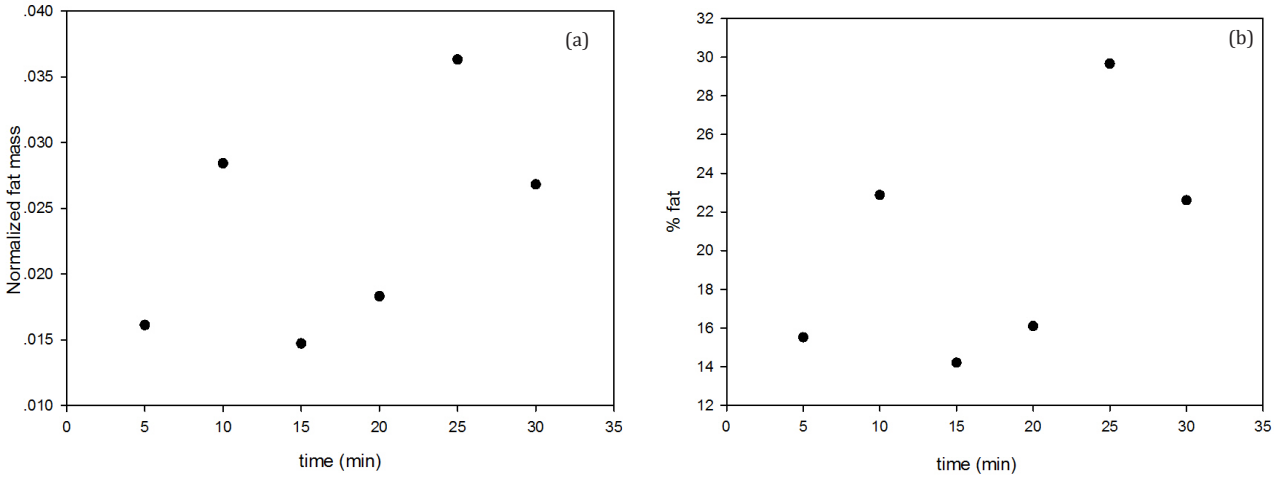

Figure 5 Fat content in coconut milk fouling pasteurized for different times: (a) normalized fat mass and (b) percent fat (data is normalized by dividing by mass of fat in coconut milk before pasteurization).

According to Figure 6, fat globules in coconut milk being pasteurized tended to agglomerate and form bigger globules. Since fat globules in coconut milk is surrounded by a film of proteins (Law *et al,*. 2009), the agglomeration could be due to protein denaturation. The agglomeration of fat globules could also be the reason why efficiency of fat extraction from pasteurized coconut milk increased with increasing pasteurization time, i.e., bigger and less stable fat globules are more readilable to separate from aqueous phase of coconut milk.

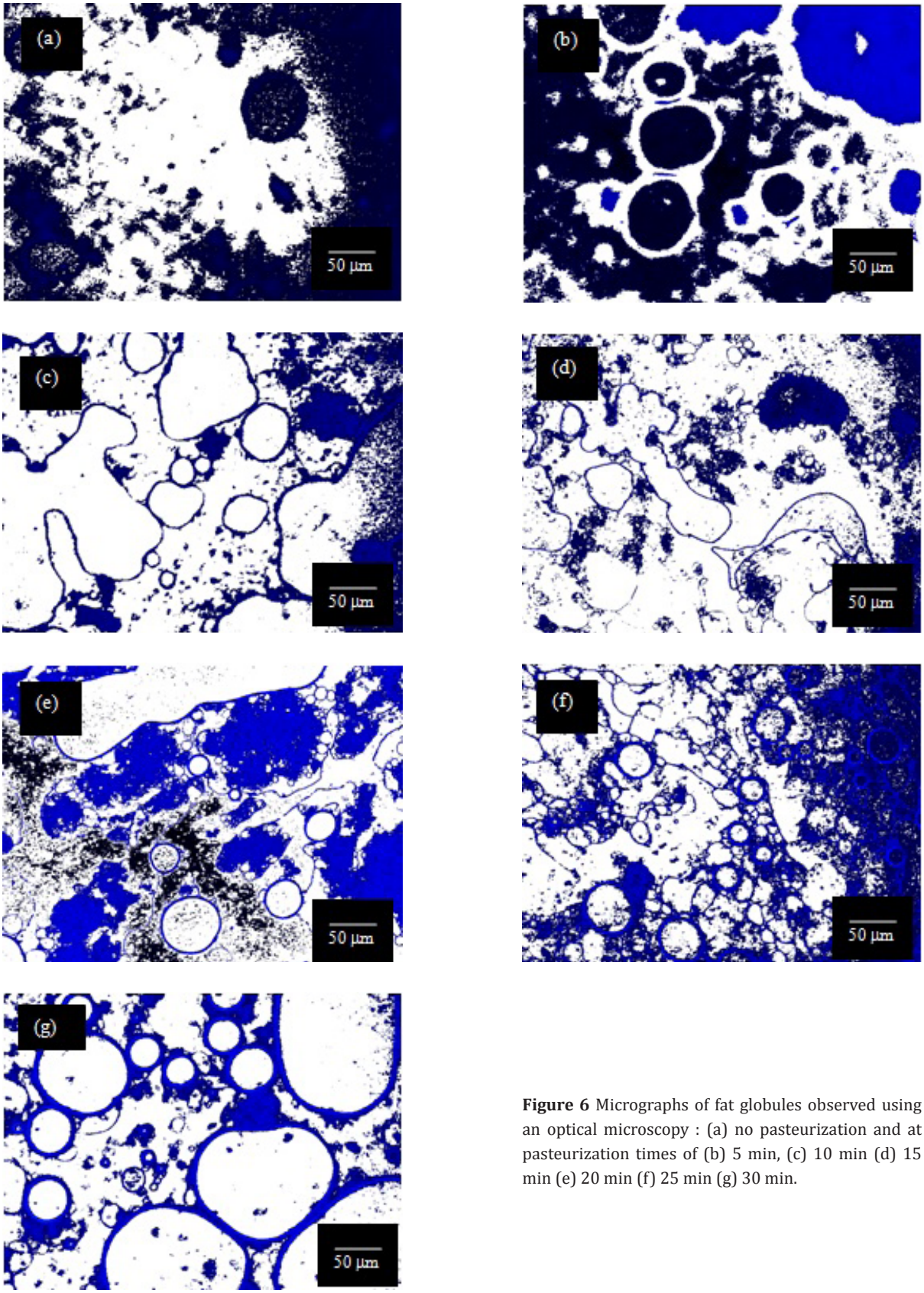

Figure 6 Micrographs of fat globules observed using an optical microscopy : (a) no pasteurization and at pasteurization times of (b) 5 min, (c) 10 min (d) 15 min (e) 20 min (f) 25 min (g) 30 min.

CONCLUSION

In this study, the protein content remaining in pasteurized coconut milk decreased with increasing pasteurization time whereas the protein content in coconut milk foulant increased with increasing pasteurization time. These results suggest that fouling formation may involve denaturation and deposition of protein. The investigation of fat contents in both pasteurized coconut milk and foulants suggests that fat deposition also occurred. It may be explained that while protein denatured, fat globules that were initially surrounded by protein combined to form bigger globules. Some of the fat then separated from the aqueous phase and deposited. However, it could not be concluded whether the protein deposition or fat deposition occurred at the same time or not. Hence, an investigation of compositions at different layers of foulants should be conducted in order to establish a complete coconut milk fouling mechanisms.

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