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Effect of different treatments for the destabilization of coconut milk emulsion

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ABSTRACT

Coconut milk is an emulsion which is stabilized by naturally occurring proteins. The main objective of the present work is to explore different methods employing thermal, pH, chilling, enzyme treatments and combination of enzyme treatments followed by chilling and thawing for effective destabilization of the coconut milk emulsion. Stability of emulsion is evaluated by measuring the creaming index and observed for the changes in structure of oil droplets, using phase contrast microscope. Combination of treatments (enzyme treatment at 37 °C followed by chilling and thawing) of coconut milk emulsion has resulted in highest yield of 94.5%. Physico-chemical properties and fatty acid compositions are evaluated for coconut oil obtained by combination of treatments and compared with that of commercial coconut oil. It is found that the oil obtained by combination of treatments is low with respect to free fatty acids and peroxide value and high in lauric acid content.

1. Introduction

Coconut milk is the natural oil-in-water emulsion extracted from the endosperm of mature coconut (*Cocos nucifera* L.) (Seow and Gwee, 1997) and it plays an important role in many traditional foods of Asian and Pacific regions (Chiewchan et al., 2006). Coconut milk contains about 54% moisture, 35% fat and 11% solid non-fat (Simuang et al., 2004; Tansakul and Chaisawang, 2006). Freshly extracted coconut milk is a stable emulsion, which requires extra energy to destabilize this emulsion (McGlone et al., 1986). It is naturally stabilized by coconut proteins such as globulins and albumins as well as phospholipids (Tangsuphoom and Coupland, 2008). Some of the proteins present in the aqueous phase of the coconut milk interact with fat globules and act as emulsifier by surrounding its surface (Peamprasart and Chiewchan, 2006).

Conventionally, coconut oil is produced by expelling dry copra, followed by refining during which oil is exposed to high temperatures. Oil obtained from fresh and mature coconuts without any refining is known as virgin coconut oil (VCO) (Shilhavy and Shilhavy, 2004; Marina et al., 2009a). It is colourless with characteristic coconut flavour and finds several applications in medicinal, cosmetics and cooking purposes. VCO retains the fresh aroma and taste of coconuts whereas, the copra-based refined coconut oil will have a bland taste due to the refining process. It has more beneficial effects than copra pressed oil, since it retains most of the nutraceutical components (Nevin and Rajamohan, 2004). The natural antioxidants present in oil makes it very stable having long shelf life. The health benefits of coconut oil are mainly from the medium chain fatty acids (MCFAs). These MCFAs are similar to that of human milk and have corresponding nutraceutical benefits. The most predominant MCFA is lauric acid (45–53%). German and Dillard (2004) cited the virtues of lauric acid of having antiviral, antibacterial, and antifungal functions. Traditionally, virgin coconut oil is produced by fermentation method, where coconut milk expelled from freshly harvested coconuts is fermented for 24–36 h during this period, the oil phase gets separated from aqueous phase. Further, oil is slightly heated for a short time to remove the moisture and finally filtered (Madhavan et al., 2005). The main disadvantages of this process are low oil recovery and fermented odour, which masks the characteristic coconut flavour of the oil.

Systematic research has been in progress at CFTRI for the production of value added products from coconut (Raghavarao et al., 2008; Raghavendra et al., 2004, 2006, 2007, 2009; Rastogi and Raghavarao, 2006). The present work is one such attempt in that direction. The main objective of the present work is to explore different methods for effective destabilization of coconut milk emulsion based on thermal, pH, chilling, enzyme treatments and also combination of enzyme treatment followed by chilling and thawing.

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2. Materials and methods

2.1. Materials

Fresh and mature coconuts (10–12 months old) were procured from the local market. Commercial coconut oil sample is procured from the market (Departmental Store, Mysore). Enzyme aspartic protease [EC 3.4.23] (Activity: 2500 tyrosine units/g) of commercial grade was procured from Kaypeeyes Biotech Private Ltd., Mysore, India. All chemicals of analytical grade were procured from Merck Chemicals, Mumbai, India. For GC analysis, hexane (HPLC grade) was procured from Ranbaxy Fine Chemicals Ltd, Mumbai, India.

2.2. Extraction of coconut milk

The mature coconuts were subjected to deshelling, paring and removal of water. The white coconut kernel was disintegrated using rotary wedge cutter (Krauss Maffei, Germany). The grating was subjected to expelling in a screw press to extract coconut milk. The fat content of coconut milk (39 ± 1%) was determined by Rose–Gottlieb method (AOAC, 1990).

2.3. Destabilization of coconut milk emulsion

2.3.1. Thermal treatment

Freshly extracted coconut milk was heated in a constant temperature stirred water bath at different temperatures (40, 50, 60, 70, 80 and 90 °C) for 20 min to destabilize the coconut milk emulsion. Then each sample was subjected to centrifugation (Model: TC-4100 D, Eltectrocraft, India) at 3585*g* for 10 min to separate coconut cream and aqueous phases. Finally cream was centrifuged at 4880*g* for 15 min to obtain clear oil.

2.3.2. pH treatment

Freshly extracted coconut milk has a pH 6 (control). The pH of coconut milk emulsion was varied between 3 and 5 using 0.1 N HCl and pH 7 and 10 using 0.1 N NaOH. The samples were allowed to stand for 2 h at ambient temperature (29 ± 2 °C) to destabilize the coconut emulsion. Then they were subjected to centrifugation at 3585*g* for 10 min to separate coconut cream and aqueous phases. Finally, coconut cream was centrifuged at 4880*g* for 15 min to obtain oil.

2.3.3. Chilling treatment

The coconut milk emulsion were chilled at different temperatures (5, 10, 15 and 20 °C) for 6 h and thawed to ambient conditions (29 ± 2 °C). Further, thawed coconut milk emulsion was centrifuged at 3585*g* for 10 min to obtain coconut cream and aqueous phases. Coconut cream was subjected to centrifugation at 4880*g* for 15 min to obtain oil.

2.3.4. Enzyme treatment

The coconut milk emulsion was treated with aspartic protease (Activity: 2500 tyrosine units/g) of 0.1% concentration and incubated at 25 and 37 °C for 3 h. Then it was centrifuged at 3585*g* for 10 min to separate coconut cream and aqueous phases. Finally coconut cream was centrifuged at 4880*g* for 15 min to obtain oil.

2.3.5. Combination of enzyme and chilling treatments

The coconut milk emulsion was treated with enzyme protease of 0.1% concentration and incubated at 25 and 37 °C for 2 h. Enzyme treated emulsion was centrifuged at 3585*g* for 10 min to obtain coconut cream and aqueous phase. Then cream was chilled at 5 °C for 6 h and then thawed to ambient temperature (29 ± 2 °C). Finally, cream was centrifuged at 4880*g* for 15 min to obtain oil.

2.4. Emulsion stability measurements

Creaming index, an indicator of emulsion stability, was measured according to method reported by White et al. (2007) with a little modification. Coconut milk emulsion subjected to different treatments (thermal, pH, chilling, enzyme and combination of enzyme and chilling treatments) was allowed to stand for 6 h at ambient temperature (29 ± 2 °C). All samples were separated into the cream (top) and the transparent aqueous (bottom) phases. The total height of the emulsion in the test tube (H_E) and the height of the aqueous layer (H_S) were measured. The extent of creaming was characterized by a creaming index = $100 * (H_S/H_E)$.

2.5. Microstructure of oil droplets

Coconut milk emulsion destabilized by different treatments was observed under phase contrast microscope (Olympus BX-40, USA) equipped with camera. Emulsion samples were placed on a glass slide, covered with cover slip and observed at 45× magnification using a phase contrast microscope.

2.6. Fatty acid composition

Analysis of fatty acid composition was done by gas chromatography (GC) (Model: GC-15A, Shimadzu) as per the AOCS method Ce1-62 (AOCS, 1998). Fatty acids present in oil were first converted to fatty acid methyl esters (FAME) before injecting into GC column to obtain the fatty acid profile. The injector and detector temperatures were 230 and 240 °C, respectively. The column temperature was 220 °C and nitrogen was used as a carrier gas at a flow rate of 1 ml/min.

2.7. Physico-chemical properties

The coconut oil obtained by combination of treatments was evaluated for moisture, specific gravity, refractive index, iodine value, polenske value, acid value, saponification value, unsaponifiable matter, peroxide value according to standard methods (AOAC, 2000). A commercial oil sample was also evaluated for the purpose of comparison. Free fatty acids were analyzed according to AOCS method Ca 5a-40 (AOCS, 1998) and expressed as percentage FFA as lauric acid.

2.8. Statistical analysis

All the physico-chemical analysis and fatty acid composition was carried out in triplicates for oil obtained from combination of treatments and commercial sample. Significant differences between means were determined by *t* test (independent samples for mean) using statistical package for social science (SPSS). Significance of differences was defined at $p < 0.05$.

3. Results and discussion

3.1. Effect of thermal treatment

The effect of thermal treatment on the stability of the coconut milk emulsion (quantified by oil yield) is shown in Fig. 1. The coconut oil yield was found to increase with an increase in temperature. The maximum oil yield of 86% was observed at 90 °C. Destabilization of coconut milk emulsion is due to denaturation of heat labile proteins during heating, which results in the aggrega-

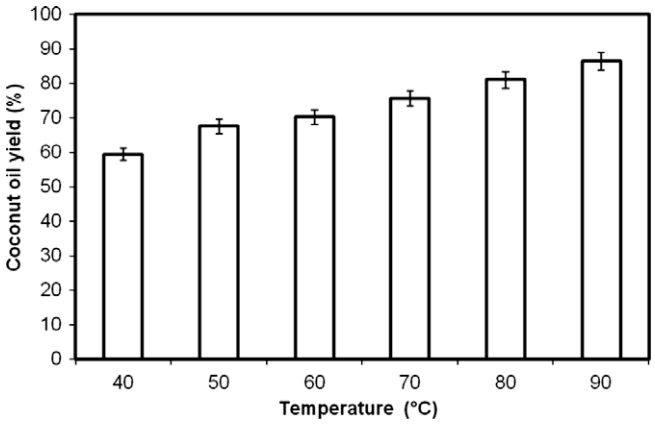

Fig. 1. Effect of thermal treatment on the stability of coconut milk emulsion quantified by oil yield.

tion of oil droplets. Proteins present in coconut milk play an important role on the stability of the emulsion and heating the coconut milk at higher temperature causes protein denaturation. Coconut proteins have been shown to denature and coagulate at 80 °C and higher (Kwon et al., 1996). Aggregation of oil droplets occur due to thermal denaturation of proteins stabilizing coconut milk emulsion which in turn affect the surface charge of oil droplets. Droplets with lower surface charge interact with each other and coalesce into larger ones. Finally, the close contact among large droplets (higher interaction time) and applied force during centrifugation lead to destabilization of emulsion, resulting in the phase separation and formation of oil and aqueous layers (Peamprasart and Chiewchan, 2006; Seow and Gwee, 1997). Hence, heating coconut milk above 80 °C is prone to denature most of the proteins, there by resulting in complete destabilization of coconut milk emulsion.

3.2. Effect of pH

The effect of pH on the stability of the coconut milk emulsion (quantified by oil yield) is presented in Fig. 2. Freshly extracted coconut milk has pH 6 and at this pH, the stability is high, resulting in coconut oil yield of only 62%. When pH was decreased from 6 to 3, destabilization of emulsion increased with corresponding increase in yield (89%). Tangsuphoom and Coupland (2008) reported that coconut milk proteins easily coagulated and precipitated at pH 4. Coconut milk emulsion can be separated by adjusting pH of the coconut milk emulsion between pH 3 and 5.6 (Marina et al., 2009a). An increase in pH from 6 to 10 also resulted in higher destabilization of emulsion and 83% yield was obtained. The coconut milk emulsions were highly unstable to creaming at pH 3–6, and also at pH 7 and 8, forming a highly turbid layer at the bottom and an opaque creamed layer at the top (Onsaard et al., 2006).

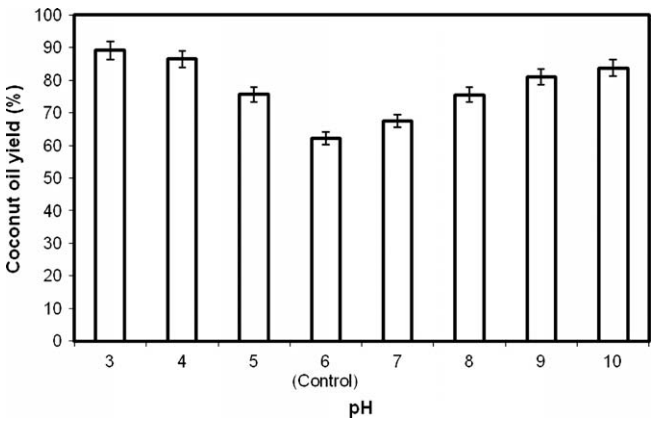

Fig. 2. Effect of pH on the stability of coconut milk emulsion quantified by oil yield.

3.3. Effect of chilling temperature

The effect of chilling temperature on the stability of the coconut milk emulsion (quantified by oil yield) is presented in Fig. 3. The coconut oil yield was found to increase with a decrease in chilling temperature from 20 to 5 °C. Gunetileke and Laurentius (1974) reported that 17 °C as the optimum temperature for the separation of oil from coconut milk emulsion. However, it was observed that complete separation of oil from cream was not possible at that temperature. The decrease in temperature up to 5 °C resulted in 92% recovery of oil upon thawing and centrifugation. Coconut milk chilled at 20 °C showed a yield of 65% and 74% at 15 °C. Much higher yield of 86% was observed in sample chilled at 10 °C while the highest yield of 92% was obtained at 5 °C. Even though the critical temperature for oil separation is 17 °C, complete separation of oil could be achieved only at 5 °C. As a result of lowering the temperature, the solidification of oil takes place and during thawing (29 ± 2 °C) oil globules loose their spherical structure and coalesce to form large droplets, resulting in the higher destabilization of the emulsion and in turn higher yield. Thus it can be observed that with a decrease in the chilling temperature from 20 to 5 °C, yield has increased from 65% to 92%.

3.4. Effect of enzyme treatment

It was observed that coconut milk treated with 0.1% concentration of enzyme at 25 °C has resulted in 76% yield, whereas at 37 °C, 83% yield was observed (at same enzyme concentration). Since, most of the enzymes show optimum activity at 37 °C, the yield was higher at that temperature. Aspartic protease (endoprotease) was selected to destabilize the coconut milk emulsion, which hydrolyzes peptide bonds in the interior of the polypeptide chain. Thereby these exposed shorter fragments of protein/peptides decrease the emulsifying property which leads to aggregation of oil droplets. Further, these proteins/peptide fragments move towards aqueous phase facilitating the phase separation.

3.5. Effect of combination of enzyme and chilling treatments

The effect of combination treatments (enzyme and chilling treatment) along with other treatments (quantified by oil yield) is shown in Fig. 4. In order to destabilize the coconut milk emulsion

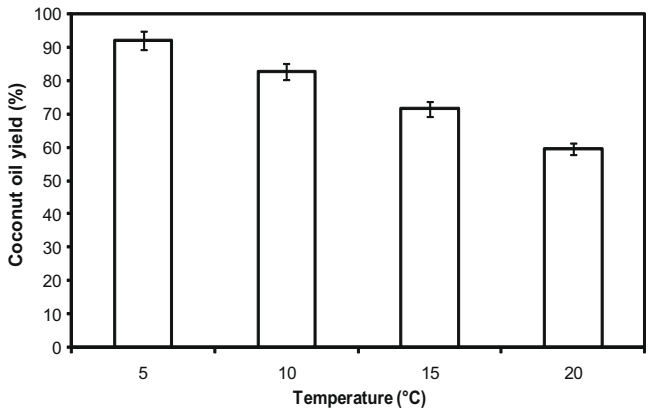

Fig. 3. Effect of chilling temperature on the stability of coconut milk emulsion quantified by oil yield.

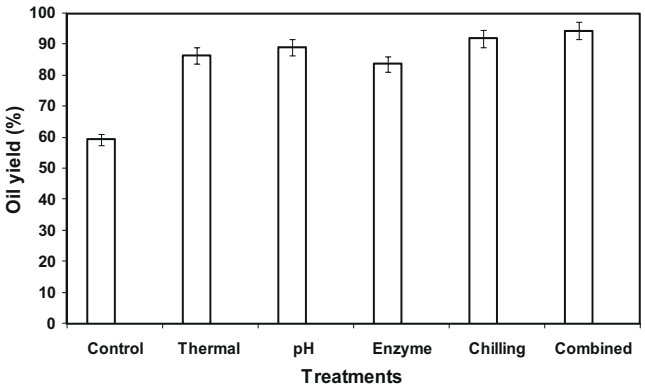

Fig. 4. Coconut oil yield of different treatments.

(to increase the coconut oil yield), combination of treatments (enzyme treatment followed by chilling at 5 °C and thawing to ambient temperature) was employed. It was observed that coconut milk treated with 0.1% of protease at 25 °C followed by chilling and thawing yielded 91%. Whereas, the highest yield of 94.5% was observed in the coconut milk sample treated with 0.1% of protease at 37 °C followed by chilling and thawing to ambient conditions. Optimum activity of enzyme was observed at 37 °C hence, complete destabilization of milk emulsion is occurred. Chilling and thawing is also important for complete destabilization of the enzyme treated emulsion, as packing of globules during chilling is necessary to facilitate oil separation (Gunetileke and Laurentius, 1974). Thus it may be noted that combination of treatments (enzyme followed by chilling and thawing) was more effective for the destabilization of coconut milk emulsion compared to all other treatments.

3.6. Emulsion stability

Emulsion stability, quantified by creaming index of coconut milk samples subjected to different treatments (thermal, pH, chilling, enzyme and combination of enzyme and chilling treatments) was studied and presented in Table 1. From the table, it can be observed that coconut milk treated at 90 °C shows 49% creaming index whereas, in control sample it was observed to be only 27%. This provides the evidence for oil droplets aggregation taking place to a higher extent during the thermal treatment. Peamprasart and Chiewchan (2006) reported that some proteins denature during heating at 80 °C resulting in the aggregation of oil droplets. Milk sample treated at pH 3 and 10 showed 55% and 54% creaming index, respectively. This clearly shows that pH can influence the oil droplet aggregation and helps in destabilization of stable coconut milk emulsion. Coconut milk treated with enzyme protease showed 52% creaming index. It indicates that enzymatic action plays an important role on destabilization of coconut milk emulsion. Chilling (5 °C) and thawing showed 53% creaming index. During chilling the structure of fat globules becomes crystal like formation, on thawing the structure breaks and forms bigger droplets (Gunetileke and Laurentius, 1974). Combination of treatments (enzyme assisted at 37 °C followed by chilling and thawing) showed creaming index of 58%, which is the highest among all the treatments. Creaming index provides the indirect information of droplet aggregation, more precisely of the flocculation while the destabilization (after centrifugation) indicates the degree of coalescence. Hence the differences in the former (creaming index) are relatively less when compared to the latter (oil yield) for different methods. Onsaard et al., (2006) reported that higher the creaming index, faster the droplets move and therefore more droplet aggregation occurs during combination of treatments.

Table 1
Emulsion stability of different treatments.

Treatments	Creaming index (%)
Control	27.7 ± 0.58
Thermal treatment at 90 °C	49.0 ± 1.00
pH 3	55.7 ± 1.15
pH 10	55.0 ± 1.00
Enzyme treatment at 25 °C	49.6 ± 0.58
Enzyme treatment at 37 °C	52.3 ± 0.58
Chilling at 5 °C	53.6 ± 0.59
Enzyme treatment at 25 °C followed by chilling	56.3 ± 0.52
Enzyme treatment at 37 °C followed by chilling	58.3 ± 0.60

Means of the same column of different treatments are significantly different at $p < 0.05$.

3.7. Microscopic structure of treated coconut milk

Microscopic structure of coconut milk emulsion subjected to different treatments is shown in Fig. 5. The microstructure of untreated coconut milk (control) is shown in Fig. 5A, where it can be observed that the oil droplets are in uniform shape as well as size and distributed evenly, indicating a stable emulsion. Fig. 5B shows the microstructure of coconut milk emulsion treated at 90 °C. It can be observed that milk heating to higher temperature promoted the aggregation of small oil droplets to form bigger droplets. During heating, protein denatures and undergoes conformational changes. These conformational changes increase the attractive forces between oil droplets which in turn lead to aggregation of oil droplets (Jirapeangtong et al., 2008). The microscopic structure of coconut milk emulsion adjusted to pH 3 (Fig. 5C) tended to move closer and formed stronger structure of aggregates. Fig. 5D shows the microstructure of coconut milk emulsion subjected to chilling (5 °C) and thawing to ambient conditions. It can be observed that the oil droplets coalesced and formed bigger droplets.

Microscopic structure of coconut milk emulsion treated by enzyme protease at 25 and 37 °C is shown in Fig. 5E and 5F, respectively. It can be observed that enzymatic treatment (37 °C) resulted in aggregation of big oil droplets compared to thermal and pH treatments. The microscopic structure of coconut milk emulsion treated with combination of enzyme treatment (25 and 37 °C) followed by chilling (5 °C) and thawing is shown in Fig. 5G and H, respectively. Here, it can be observed that aggregation of bigger droplets taking place when compared to other treatments. In Fig. 5H, the biggest size of oil droplets, which are non-uniformly dispersed, can be seen when compared to all other treatments. Here, emulsion was centrifuged before chilling which allowed better packing of the coconut oil globules. During thawing, the oil coalesced due to loss of spherical shape and formed large droplets of varying sizes (Marina et al., 2009a). Since, enzyme shows optimum activity at 37 °C, destabilization of coconut milk emulsion was highest at this temperature. Thus, combination of treatments (enzyme treated at 37 °C followed by chilling and thawing) was found to be most effective for destabilization of coconut milk emulsion when compared to all other treatments.

3.8. Fatty acid composition

The fatty acid composition for two oil samples (oil obtained from combination of treatments and commercial oil) is shown in Table 2. It can be observed that short chain fatty acids are higher in oil obtained by combination of treatments compared to commercial sample. Caprylic ($C_{8:0}$) and Capric ($C_{10:0}$) showed 9.4% and 6.3%, respectively, in the oil obtained from present work when

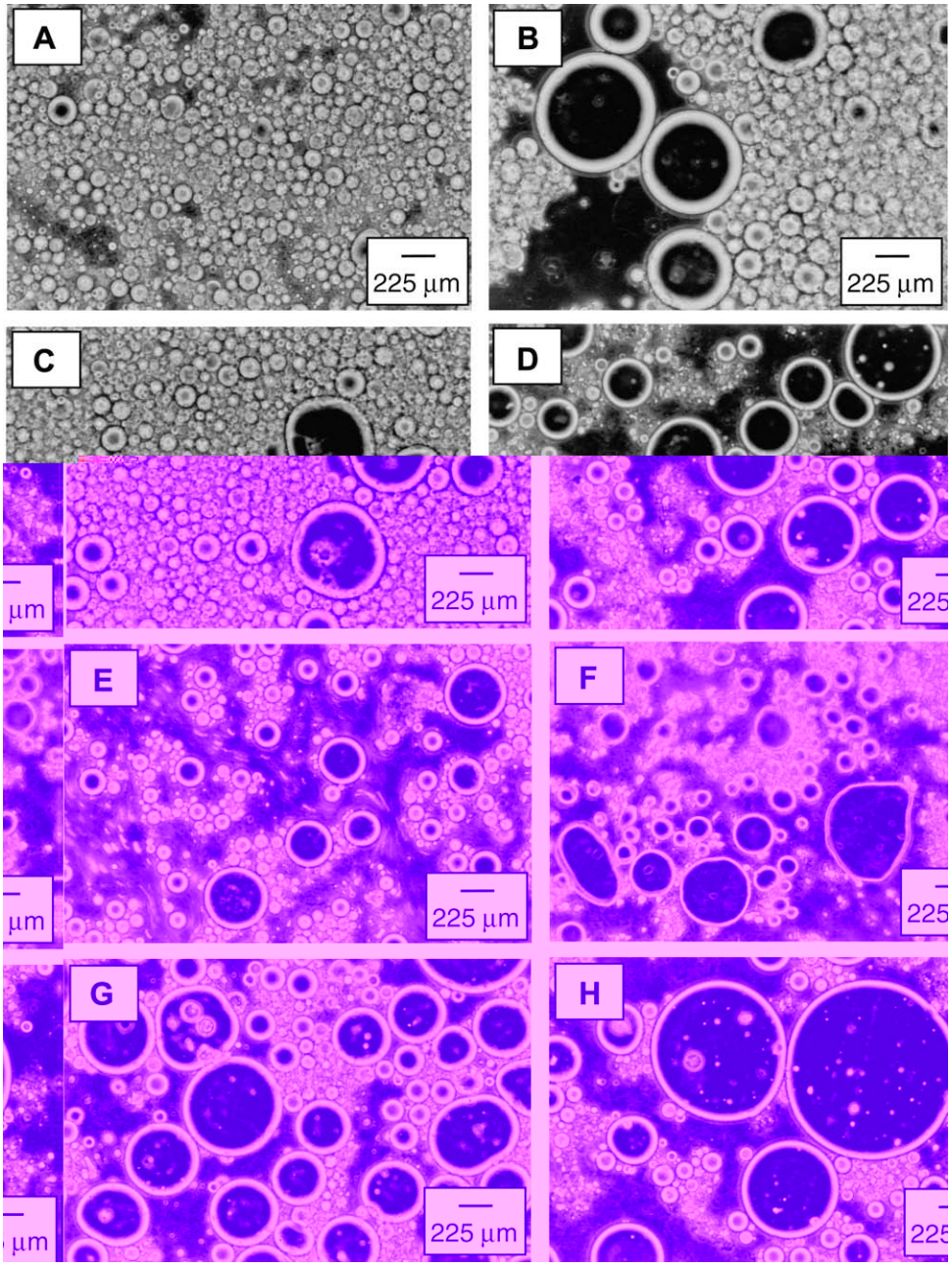

Fig. 5. Microscopic structure (magnification 45×) of coconut milk emulsion treated at different conditions: (A) control; (B) thermal treatment at 90 °C; (C) pH 3; (D) chilling and thawing; (E) and (F) enzyme assisted at 25 and 37 °C, respectively; (G) and (H) combination of treatments (enzyme assisted at 25 °C and 37 °C, respectively, followed by chilling and thawing).

Table 2
Fatty acids composition.

Fatty acids	Coconut oil (present work) (%)	Coconut oil (commercial sample) (%)	APCC standards (%)
$C_{8:0}$ (caprylic)	9.4 ± 0.85	4.5 ± 4.06	5.0–10
$C_{10:0}$ (capric)	6.3 ± 0.57	4.4 ± 1.2	4.5–5.8
$C_{12:0}$ (lauric)	50.7 ± 1.27	46.8 ± 1.9	43–53
$C_{14:0}$ (myristic)	18.9 ± 0.26	22.2 ± 2.2	16.0–21
$C_{16:0}$ (palmitic)	6.7 ± 0.35	9.7 ± 1.9	7.5–10
$C_{18:0}$ (stearic)	2.3 ± 0.21	3.5 ± 0.8	2.0–10
$C_{18:1}$ (oleic)	3.9 ± 1.55	7.0 ± 1.6	5.0–10
$C_{18:2}$ (linoleic)	0.5 ± 0.47	1.6 ± 0.6	1.0–2.5

Means between two columns of different fatty acid composition are not significantly different at $p < 0.05$.

compared to 4.5% and 4.4%, respectively, for commercial sample. The values obtained in the present work were comparable to those reported by Marina et al. (2009b). Higher amount of short chain fatty acids, corresponds to more health benefits. In combination of treatments, the oil was not subjected to heat treatment and any refining process (chemical) for purification. Whereas, in the production of commercial oil heat treatment and refining process are involved hence it contains lesser amount of short chain fatty acids. From the table it is observed that most predominant fatty acids are medium chain (69.7% and 68% in oil obtained by combination of treatments and commercial oil, respectively) which was slightly higher than reported by Marina et al. (2009b). Out of which, Lauric acid is about 50.7% in oil obtained by combination of treatments and 46.8% in commercial oil. As a result, the oil

Table 3
Comparison of physico-chemical properties of the coconut oil.

Sl. no.	Parameters	Coconut oil (present work)	Coconut oil (commercial sample)	APCC standards
1	Moisture (%)	0.27 ± 0.06^a	0.40 ± 0.02^a	0.1–0.5
2	Specific gravity @ (30 °C)	0.92 ± 0.01^b	0.93 ± 0.01^c	0.915–0.920
3	Refractive index (40 °C)	1.4489 ± 0.0^b	1.4499 ± 0.0^c	1.4480–1.4492
4	Iodine value (g of I 100 g of oil^{-1})	4.17 ± 0.50^b	4.72 ± 0.50^c	4.1–11.0
5	Polenske value	14.7 ± 0.53^b	13.93 ± 0.38^c	13 min
6	Acid value	0.27 ± 0.05^a	0.91 ± 0.02^a	6 max
7	Saponification value	265 ± 1.53^a	259 ± 1.53^a	250–260 min
8	Unsaponifiable matter (%)	0.4 ± 0.02^a	0.45 ± 0.03^a	0.2–0.5
9	Peroxide value	0.82 ± 0.02^a	1.46 ± 0.06^a	<3 meq O_2/kg
10	Free fatty acid (%)	0.14 ± 0.02^a	0.47 ± 0.03^a	0.5

Means between two columns of different parameters with same superscript are significantly different at $p < 0.05$.

obtained by combination of treatments will have higher oxidative stability in comparison with the commercial oil, due to the higher resistance of saturated fatty acids to oxidation (Maduko et al., 2008). Lauric acid is the major component of tropical oils such as coconut oil and palm kernel fat (Mensink et al., 2003). These fatty acids, unlike the long chain fatty acids are not deposited in adipose tissue and do not require to be transported by chylomicrons (Enig, 1990). The long chain fatty acids like $C_{16:0}$, $C_{18:0}$, $C_{18:1}$ and $C_{18:2}$ showed 6.4%, 2.3%, 3.9% and 0.5%, respectively, in the oil obtained in present work when compared to 9.7%, 3.5%, 7.0% and 1.6%, respectively, in the commercial sample. These values are comparable to the results reported by Marina et al. (2009b) for VCO sample obtained by different processes. The fatty acid compositions of both the samples (present work and commercial) are within the limits of Asian and Pacific Coconut Community (APCC) standards for VCO.

3.9. Physico-chemical properties

Physico-chemical properties of coconut oil obtained by combination of treatments was compared with commercial coconut oil is shown in Table 3. The quality of oil is very much determined by its physico-chemical properties. Moisture content in the oil obtained from our work was found to be 0.27% whereas, in commercial sample it was 0.40%. Moisture content of the oil is one of the parameter which affects the shelf life. Higher the moisture content adversely influences the oxidation process promoting rancidity. Che Man et al., (1997) reported that free fatty acids were higher in coconut oil having higher moisture content. Specific gravity and refractive index values of both coconut oil samples were not significantly different. Iodine value of oil obtained from present work was found to be 4.17 and 4.72 in commercial sample. Similar range of values for VCO samples obtained from different processes was reported by Marina et al. (2009b). The low content of Iodine value indicated high degree of saturation. The low degree of unsaturation leads to high resistance to oxidative rancidity (Onyeike and Acheru, 2002). Polenske values of both samples were not significantly different. Acid value of oil obtained from our work was found to be 0.27% whereas, in commercial sample it was 0.91%. Saponification values were found to be 265 and 259 mg KOH/g oil, respectively, for oil obtained in present work and in commercial sample. These values are comparable to the results reported by Marina et al. (2009b). Unsaponifiable matter in both samples was significantly different. Free fatty acids in oil obtained from our work were found to be 0.14%, which is 3 times lower (Indicating good quality of oil) when compared to the commercial sample (0.47%). Similar results for FFA of VCO produced by different methods were reported by Marina et al. (2009b). FFA is responsible for undesirable flavour in oils and fats. FFA is formed during hydrolytic rancidity, which is the hydrolysis of an ester by lipase or moisture (Osawa et al., 2007). According to Lawson (1985), hydrolysis gets accelerated by high temperatures and excessive amount of moisture. Hence FFA is high in commercial oil sample when compared to the oil obtained in the present work. Peroxide value was found to be 0.82 and 1.46 meq O_2/kg in oil obtained in present work and in commercial oil samples, respectively, and are within the limits of APCC (1994) standards for VCO. The peroxide value of both sample were relatively low, indicating their higher stability against oxidation. The peroxide values reported by Marina et al. (2009b) were in the range 0.2–0.63 meq O_2/kg.

4. Conclusions

Destabilization of coconut milk emulsion was achieved by employing different treatments like thermal, pH, enzyme, chilling and combination of enzyme and chilling. Out of these the most effective method for destabilization of milk emulsion was found to be combination treatments. The observed results were supported by micrographs and creaming index values. Very high yield of 94.5% oil was obtained in the present work when compared to other methods reported in literature. Short and medium chain fatty acids are found to be in the higher range which gives more stability to the oil obtained in the present method when compared to commercial sample.

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