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Emulsifying Properties of Interfacial Components of Coconut Oil Bodies

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Abstract

Oil bodies are organelles in plant that store triacylglycerol (TAG) in plants. Some oil bodies exhibit remarkable physical and chemical stability to against coalescence and lipid oxidation due to their unique interfacial layer. These interfacial biomaterials present themselves as ideal materials for encapsulation and have potential applications in food, pharmaceutical and cosmetic formulations. This study compared the emulsifying properties of biomaterials obtained from coconut oil body membrane (COBM) and coconut skimmed milk extracts (CSME) and investigated the structure of resulting COBM and CSME emulsions.

Coconut oil body membrane (COBM) and coconut skimmed milk extracts (CSME) were extracted from freshly prepared coconut milk (around 20%, w/w, fat). The properties of CSME and COBM such as solubility, isoelectric pH and their ability to reduce the interfacial tension between water and soybean oil was characterized by tensionmeter. The CSME and COBM (0.2, 0.4, 0.6 and 0.8%, w/w, final protein concentration) were used for preparing soybean oil-in-water emulsions (20%, w/w) by microfluidizer. The physicochemical characteristics of the CSME and COBM emulsions at different pH (2-8) and NaCl (0-500 mM) conditions were investigated by using dynamic light scattering techniques and confocal laser scanning microscopy. Sodium dodecyl sulphate polyacrylamide electrophoresis (SDS-PAGE) was used to characterize the proteins composition of the 2 extracts (CSME and COBM) and the proteins composition of droplet interfacial proteins of CSME and COBM emulsions. To investigate the surface composition of CSME and COBM emulsions, the surface of the droplet of CSME and COBM emulsions was perturbed by the enzymes pepsin, trypsin and phospholipase A₂ (PLA₂), separately.

The SDS-PAGE analysis of two extracts showed distinct differences in the protein composition of CSME and COBM. The isoelectric points of CSME and COBM solutions were between pH 4 and 5. Both extracts lowered the interfacial tension between water and oil but the extent of decrease in surface tension was greater for COBM than that for CSME, indicating that COBM was more surface active than CSME.

The particle size of CSME emulsion decreased with an increase in protein concentration, while the effect of protein concentration on particle size was less pronounced in COBM emulsions. Compared with CSME emulsion, COBM emulsion had a smaller particle size with less degree of flocculation and was more stable during storage. These results suggest that COBM had the better emulsifying capacity than CSME. The CLSM images revealed that the droplet surface of CSME and COBM emulsions consisted of both protein and phospholipids. Both pepsin and phospholipase A₂ treatment of CSME and COBM emulsions lead to the coalescence, which indicates the possible droplet interfacial layer structures of CSME and COBM emulsions are similar, that both phospholipids and protein sequences with aromatic and hydrophobic residues present at the interface. The SDS-PAGE analysis of the droplet surface proteins of CSME and COBM emulsions revealed that not all proteins in CSME and COBM were adsorbed on the droplet surface of CSME and COBM emulsions. The surface protein composition of COBM emulsion was similar to that of natural coconut oil body.

The effect of pH on CSME and COBM emulsions revealed that the isoelectric points of both emulsions were close to each other (around pH 4.7 and 4.5 for COBM and CSME respectively). In addition, both COBM and CSME emulsions were stable at high pH (pH > pI) but had different behaviour below pI. While the COBM emulsion flocculated at pH near pI and the CSME emulsion showed coalescence at pH ≤ pI.

In the presence of salt, CSME and COBM emulsions were still negatively charged, even at 500 mM NaCl, indicating that 500 mM NaCl was unable to screen all the charges on the droplet surface. Flocculation occurred in COBM emulsion with the increase in NaCl concentration. No coalescence was observed in CSME emulsion at all given salt concentrations. This work shows that COBM emulsion has better stability against changes in pH than CSME emulsion.

Both COBM and CSME were successfully stabilized emulsions, which indicates that COBM and CSME may be suitable for use as a food emulsifier. COBM seems to be a better emulsifier material, since it can form emulsions with smaller droplet size and the flocculation occurred at low pH and high salt conditions may not be a major problem in some food, such as sauces and yoghurts.

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Table of Contents

Abstract i

Acknowledgement iii

Table of Contents v

List of Abbreviations ix

List of Tables xi

List of Figures xiii

1. Introduction 1

 1.1 Introduction 1

 1.2 Outline of thesis 2

2. Literature review 3

 2.1 Food emulsions 3

 2.1.1 Emulsification 4

 2.1.2 Homogenization equipment 4

 2.1.3 Food emulsifiers 7

 2.1.4 Emulsion characterization 12

 2.1.5 Emulsion stability 13

 2.1.6 Factors affecting emulsion stability 16

 2.2 Oil bodies in plants 17

 2.2.1 Structure of oil bodies 17

 2.2.2 Oil bodies extract materials as food emulsifiers 19

 2.3 Coconuts 20

 2.3.1 Structure of coconut fruit 21

 2.3.2 Coconut milk 22

 2.3.3 Coconut milk composition and properties 23

2.3.4 Coconut oil body.....	27
2.3.4 Destabilization of coconut oil emulsion.....	28
2.3.5 Coconut oil body proteins as emulsifying materials.....	30
3. Materials and Methods.....	31
3.1 Materials.....	31
3.2 Methods.....	31
3.2.1 Preparation of coconut oil body membrane (COBM) material extracts and coconut skimmed milk material extracts (CSME).....	31
3.2.2 Preparation of emulsions stabilized by coconut oil body membrane (COBM) and coconut skimmed milk extracts (CSME).....	32
3.2.3 Analysis of fat content.....	33
3.2.4 Total phosphorus analysis.....	34
3.2.5 Protein analysis.....	36
3.2.6 Interfacial tension.....	41
3.2.7 Emulsion characterization.....	41
3.2.8 Enzymatic studies to investigate the surface composition of emulsions.....	43
4. Characterization of coconut skimmed milk extracts (CSME) and coconut oil body membrane (COBM).....	47
4.1 Introduction.....	47
4.2 Results.....	47
4.2.1 Composition of coconut skimmed milk extracts (CSME) and coconut oil body membrane (COBM).....	47
4.2.2 Protein solubility of CSME and COBM.....	48
4.2.3 Characterization of proteins in CSME and COBM.....	48
4.2.4 Effect of pH on CSME and COBM solutions.....	50
4.2.5 Interfacial tension.....	53
4.3 Discussion.....	54
4.4 Conclusions.....	58

5. Characterization of the emulsions stabilized by coconut skimmed milk extract (CSME) or coconut oil body membrane (COBM)	59
5.1 Introduction	59
5.2 Results	59
5.2.1 Emulsion protein analysis	59
5.2.2 ζ - potential.....	61
5.2.3 Particle size and distribution	62
5.2.4 Emulsion stability	65
5.2.5 Structure of CSME and COBM emulsion droplets membrane.....	67
5.3 Discussion	76
5.4 Conclusion	79
6. Effect of pH and ionic strength on the emulsions stabilized by coconut oil body membrane (COBM) or coconut skimmed milk extract (CSME)	81
6.1 Introduction	81
6.2 Results	81
6.2.1 Effect of pH on emulsions.....	81
6.2.2 Effect of ionic strength on emulsions.....	91
6.3 Discussion	97
6.4 Conclusion	99
7. Conclusions and avenues for future work	101
7.1 General discussion	101
7.2 Avenues for future work	106
References:	109
Appendix:	117

List of Abbreviations

CCP1	Coconut cream protein (isoelectric precipitation)
CCP2	Coconut cream protein (freeze-thaw)
CLSM	Confocal laser scanning microscopy
COBM	Coconut oil body membrane
CSME	Coconut skimmed milk extracts
CSPC	Coconut skimmed milk protein concentrate
CSPI	Coconut skimmed milk protein isolate
$d_{4,3}$	Average volume-weighted diameter
$d_{3,2}$	Average surface-weighted diameter
FG	Fast Green
HLB	Hydrophilic-lipophilic balance
MFGM	Milk fat globular membrane
NR	Nile Red
OB	Optical density
pI	Isoelectric point
PLA ₂	Phospholipase A2
POB	Protein of oil body
Rd-DHPE	Lissamine TM rhodamine B
SDS	Sodium dodecyl sulfate
SDS-PAGE	Sodium dodecyl sulfate polyacrylamide electrophoresis
SGF	Simulated gastric fluid
SIF	Simulated intestinal fluid
TAG	Triacylglycerol
w/w	Weight/weight
w/v	Weight/volume
v/v	Volume/volume

List of Tables

Table 2.1 Examples of emulsions in food systems	4
Table 2.2 Comparison of the attributes of high-pressure homogenizer and microfluidizer	7
Table 2.3 Studies of proteins as food emulsifiers	12
Table 2.4 The composition of coconut kernel and testa (Appaiah et al., 2014).....	22
Table 2.5 Proximate composition of the kernel from fresh mature coconut (Ohler, 1999; Seow & Gwee, 1997; Tangsuphoom & Coupland, 2008).....	23
Table 2.6 Fatty acid composition of coconut oil (Bhatnagar et al., 2009).....	24
Table 2.7 Different types of phospholipid in coconuts	25
Table 2.8 Amino acid composition of coconut protein.....	27
Table 2.9 The yield of coconut oil from coconut kernel using different treatments (Raghavendra & Raghavarao, 2010).	29
Table 3.1 Composition of CSME and COBM emulsions	32
Table 3.2 Concentrations of 10 mM KH ₂ PO ₄ used for the preparation of the standard curve	35
Table 3.3 Composition of SDS-PAGE sample buffer	40
Table 3.4 Composition of SDS-PAGE resolving and stacking gel solutions	40
Table 3.5 Compositions simulated gastric fluid (SGF) and simulated intestinal fluid (SIF) for enzyme studies	44
Table 4.1 Composition of coconut skimmed milk extracts (CSME) and coconut oil body membrane (COBM).....	48
Table 4.2 Protein content in extracts and their solubility after centrifugation.....	48
Table 4.3 Proximate compositions of coconut skimmed protein milk isolate (CSPI), coconut skimmed milk protein concentrate (CSPC) and coconut cream protein (CCP) (% , w/w) (Onsaard et al., 2005, 2006).....	56
Table 5.1 Distribution of protein concentrations in coconut skimmed milk extracts (CSME) and coconut oil body membrane (COBM) emulsions	59
Table 5.2 ζ- potential of freshly extracted coconut milk, coconut skimmed milk extracts (CSME) and coconut oil body membrane (COBM) emulsions	62

List of Figures

Figure 1.1 Overview of chapters in this thesis.....	2
Figure 2.1 Illustration of different types of emulsions.....	3
Figure 2.2 Schematic showing the flow of the product though the homogenizer.....	6
Figure 2.3 Single and double inlet model of microfluidizer	6
Figure 2.4 Most common types of phospholipids found in nature	10
Figure 2.5 Physical changes in O/W emulsion. The yellow circles represent oil droplets while the blue shaded area represents continuous phase.....	14
Figure 2.6 The model of seed oil body. Reproduced with permission from Tzen and Huang (1992).....	18
Figure 2.7 Parts of mature coconut	21
Figure 2.8 Steps involved in the manufacture of coconut milk	23
Figure 2.9 Confocal laser scanning microscopy of freshly extracted coconut oil bodies (Dave et al., 2019).....	28
Figure 3.1 Standard curve showing absorbance at 830 nm for solutions showing different concentrations of potassium-dihydrogen orthophosphate when measured as per method described above.	36
Figure 3.2 Standard curve for determination of protein concentration by Bradford assay	38
Figure 4.1 Protein composition of coconut skimmed milk extracts (CSME) and coconut oil body membrane (COBM). M ₁ , M ₂ and M ₃ are molecular mass markers. CSME was coconut skimmed milk extracts solution and COBM is coconut oil body membrane solution. COBP refers to freshly extracted coconut oil bodies, adapted from Dave et al. (2019). For the description of bands marked A to Q, see text.....	49
Figure 4.2 Effect of pH on the ζ - potential of coconut skimmed milk extracts (CSME) solution and coconut oil body membrane (COBM) solution	51
Figure 4.3 Effect of pH on the size of coconut skimmed milk extracts (CSME) solution and coconut oil body membrane (COBM) solution	52

Figure 4.4 Effect of pH on the optical density of coconut skimmed milk extracts (CSME) solution and coconut oil body membrane (COBM) solution	53
Figure 4.5 Interfacial tension of Milli-Q water, coconut skimmed milk extracts (CSME) solution and coconut oil body membrane (COBM) solution at 0.4% and 0.8% (w/w) protein concentrations	54
Figure 5.1 SDS-PAGE of interfacial proteins in (A): coconut skim milk extract (CSME); (B): coconut oil body membrane (COBM) emulsion droplets; and (C) freshly extracted coconut oil body protein (COBP). 1: Marker, 2: CSME or COBM solution (1mg/mL), 3: CSME or COBM emulsion, 4: Serum phase (after centrifugation at 13600 g for 20 min), 5: Interfacial proteins from emulsion droplets. Image in (C) adapted from Dave et al. (2019).....	60
Figure 5.2 Effect of protein concentrations on particle size ($d_{4,3}$) of emulsions stabilized by coconut skimmed milk extracts (CSME) and coconut oil body membrane (COBM) and their emulsions dispersed in 1% SDS solution	63
Figure 5.3 Particle size distributions of emulsions. (A) Coconut skimmed milk extract (CSME) 0.4% and 0.8% (w/w); and (B) Coconut oil body membrane (COBM) 0.4% and 0.8% (w/w). Samples were either diluted in buffer (corresponding pH values) or 1% (w/v) SDS solution.....	64
Figure 5.4 Creaming indices of coconut skimmed milk extracts (CSME) and coconut oil body membrane (COBM) formed emulsions at two protein concentrations (0.4 and 0.8%, w/w) respectively.....	65
Figure 5.5 Images showing stability of (A) coconut skim milk extracts (CSME), and (B) coconut oil body membrane (COBM) formed emulsions at two protein concentrations (0.4 and 0.8%, w/w) at time 0h and 36h	66
Figure 5.6 Effect of storage on the particle size ($d_{4,3}$) of coconut skim milk extracts (CSME) and coconut oil body membrane (COBM) formed emulsions (0.4 and 0.8%, w/w, protein)	67
Figure 5.7 Confocal laser scanning microscopy images of coconut skimmed milk extracts (CSME) formed at 0.2 to 0.8% (w/w) protein concentrations. Droplets in A-D stained using Nile Red (neutral lipids) and Fast Green (proteins). Those in D are stained by Lissamine TM rhodamine B (Rd-DHPE) showing phospholipids. F shows the separated green channels (showing protein) for CSME emulsions at (0.8% w/w). Scale bar = 25 μ m	69

- Figure 5.8 Confocal laser scanning microscopy images of coconut skimmed milk extracts (COBM) formed at 0.2 to 0.8% (w/w) protein concentrations. Droplets in A-D stained using Nile Red (neutral lipids) and Fast Green (proteins). Those in D are stained by LissamineTM rhodamine B (Rd-DHPE) showing phospholipids. F shows the separated green channels (showing protein) for COBM emulsions at (0.8% w/w). Scale bar = 10 μ m 70
- Figure 5.9 Particle size ($d_{4,3}$) of coconut skimmed milk extracts (CSME) formed emulsion and coconut oil body membrane (COBM) formed emulsion treated by pepsin, trypsin and phospholipase A₂, separately, dispersed in 1 % SDS solution. Different lower case letters represent significant differences ($p < 0.05$) between samples 71
- Figure 5.10 Confocal laser scanning microscopy images of (i): coconut skimmed milk extracts (CSME) formed emulsion (ii): coconut oil body membrane (COBM) formed emulsion treated by pepsin, trypsin and phospholipase A₂. The droplets were stained by Nile Red and Fast Green FCF (Scale bar = 25 μ m) 73
- Figure 5.11 SDS-PAGE of interfacial proteins in (i) CSME and (ii) COBM emulsions after treatments with proteases pepsin and trypsin. M refers to marker. The pepsin-treated CSME emulsion showed oil separation hence the aqueous phase was used for the SDS-PAGE analysis..... 75
- Figure 6.1 ζ - potential of coconut skimmed milk extracts (CSME) emulsions and coconut oil body membrane extracts (COBM) emulsions at two protein concentrations (0.4 and 0.8%, w/w) at different pH (2-8) 82
- Figure 6.2 Particle size ($d_{4,3}$) of coconut skimmed milk extracts (CSME) emulsions at two protein concentrations (0.4 and 0.8%, w/w) at different pH (2-8) and their emulsions in 1% SDS solution..... 83
- Figure 6.3 Particle size ($d_{4,3}$) of coconut oil body membrane extracts (COBM) emulsions at two protein concentrations (0.4 and 0.8%, w/w) at different pH (2-8) and their emulsions in 1% SDS solution..... 84
- Figure 6.4 CLSM images of coconut skimmed milk extracts formed emulsion (CSME1 at 0.4%, w/w, protein) stained by Nile Red and Fast Green at different pH conditions (pH 2 - 8) (Scale bar = 25 μ m) 86

Figure 6.5 CLSM images of coconut skimmed milk extracts formed emulsion (CSME2 at 0.8%, w/w, protein) stained by Nile Red and Fast Green at different pH conditions (pH 2 - 8) (Scale bar = 10 μ m)	87
Figure 6.6 CLSM images of coconut oil body membrane extracts formed emulsion (COBM1, 0.4%, w/w, protein) stained by Nile Red and Fast Green at different pH conditions (pH 2 - 8) (Scale bar = 20 μ m).....	89
Figure 6.7 CLSM images of coconut oil body membrane extracts formed emulsion (COBM2, 0.8%, w/w, protein) stained by Nile Red and Fast Green at different pH conditions (pH 2 - 8) (Scale bar = 15 μ m).....	90
Figure 6.8 ζ - potential of coconut skim milk extracts (CSME2) and coconut oil body membrane (COBM2) emulsions (0.8%, w/w, protein) at different NaCl concentrations (0 to 500 mM)	92
Figure 6.9 Particle size ($d_{4,3}$) of coconut skimmed milk extracts (CSME) formed emulsions at two protein concentrations (0.4 and 0.8%, w/w) at 0 to 500 mM NaCl concentrations and their emulsions in 1% SDS solution	93
Figure 6.10 Particle size ($d_{4,3}$) of coconut oil body membrane extracts formed emulsion (COBM) at two protein concentrations (0.4 and 0.8%, w/w) at 0 to 500 mM NaCl concentrations and their emulsions in 1% SDS solution	94
Figure 6.11 CLSM images of coconut skimmed milk extracts formed emulsion (CSME1, 0.4%, w/w, protein) stained by Nile Red and Fast Green at different NaCl conditions (0 to 500 mM) (Scale bar = 25 μ m).....	95
Figure 6.12 CLSM images of coconut skimmed milk extracts formed emulsion (CSME2, 0.8%, w/w, protein) stained by Nile Red and Fast Green at different NaCl conditions (0 to 500 mM) (Scale bar = 25 μ m).....	95
Figure 6.13 CLSM images of coconut oil body membrane extracts formed emulsion (COBM1, 0.4%, w/w, protein) stained by Nile Red and Fast Green at different NaCl conditions (0 – 500 mM) (Scale bar = 10 μ m).....	96
Figure 6.14 CLSM images of coconut oil body membrane extracts formed emulsion (COBM2, 0.8%, w/w, protein) stained by Nile Red and Fast Green at different NaCl conditions (0 – 500 mM) (Scale bar = 10 μ m).....	97
Figure 7.1 The droplet structures of coconut skim milk emulsion (CSME) and coconut oil body membrane (COBM) emulsions.	102