Nanoemulsion preparation base on palm fiber mesocarp residue’s oil and its application on dry noodle

H Manurung¹, J Silalahi², D Siahaan³ and E Julianti⁴

¹Department of Agricultural Crop Technology Faculty of Agriculture, University of HKBP Nommen, Indonesia
²Department of Pharmaceutical Chemistry, Faculty of Pharmacy, Universitas Sumatera Utara, Indonesia
³Indonesian Oil Palm Research Institute, Indonesia
⁴Department of Food Science, Faculty of Agriculture, Universitas Sumatera Utara, Indonesia

E-mail: hotman.manurung@uhn.ac.id

Abstract. The research about nanoemulsion preparation base on palm fiber mesocarp residue’s oil and its application on dry noodle was carried out. The purposes of this research are to know the characterization of Palm Fiber Mesocarp Residue’s Oil (PFMRO), to generate nanoemulsion product and to apply nanoemulsion as well as colorness agent and carotenoid source on noodle. The method research consists of three steps: i) extraction of PFMRO with hexane solvent; ii) to generate nanoemulsion under condition: a. ratio PFMRO: water (15:82 and 20:80); b. concentration of tween 80 (2.5% and 5%) and c. homogenezier pressure (300 and 500 bar), respectively; and iii) application of nanoemulsion as colorness agent and carotenoid source on noodle. The results show that PFMRO contains oil 7.67 % (w/w), carotenoid (2549.5 ppm) and Deterioration of bleaching index (DOBI) 2.39. The nanoemulsion which was produced has diameter (150.80 – 202.35 nm) and average of Polidispercity index (PDI) (0.106 – 0.186). The conditions of best formula of nanoemulsion are ratio of PFMRO: water (20:80), amount of tween 80 (5%) and pressure of homogenizer (P) (500 bar). It is interestingly due is stable until storing for 16 days. Nanoemulsion may affect favorite color those are disfavor color (score 2.5) to be favor color (score 4.0 and 4.12). In addition, the concentration of carotenoid also increases on dry noodle namely undetected on dry noodle for without emulsion convert to 33.53 ppm (crude emulsion) and 81.27 (nano emulsion). It may be concluded that crude and nanoemulsion may apply to improve the quality of dry noodle.

Key words: PFMRO, nanoemulsion, carotenoid, drynoodle.

1. Introduction
Palm oil mills (POMs) as a producer of palm oil from palm fruit bunches (PFB) is loaded with residue or waste. One ton of Fresh Fruit Bunches (FFB) produces 12-15% residues of palm fiber mesocarp (PFM) [1]. Total residue of PFM in 2016 reached 17.89 million tons, and increased to 21.56 million tons in 2020. Currently in POMs, residue of palm fiber mesocarp is used as a fuel to generate steam in the boiler and to generate electrical energy [2-3].

In the case of, residue of palm fiber mesocarp still contains oil 3.47%, and Palm Fiber Mesocarp Residue’s Oil (PFMRO) contains 2305 ppm carotenoids with a DOBI value of 3.49 [4]. Exceeds carotenoid’s crude palm oil (CPO) (500-700 ppm) [5]. Carotenoid content and high DOBI (Deterioration of bleaching index) value of PFMRO indicates that the oil is potentially used as a source of cheap and sustainable carotenoids. This potentiality is very useful because today the global...
industry faces problems to meet the increasing need for natural and friendly carotenoids [6] and pigments for natural food dyes [7].

However, although PFMRO contains high carotenoids and DOBI, its use in food such as natural dyes still faces constraints, because the oil and carotenoids are not soluble in water [8]. In the case of one important aspect when carotenoid is used in the field of food is dispersed in water [9]. One way to increase the dispersion of oil or carotenoids in water is to form emulsions and reduce the size of emulsion particles to nano size. Nanoemulsion technology can increase oil solubility in water, increase color brightness, make emulsion more stable, and make particles more easily absorbed by the body [10]. Nanoemulsion as a carrier can speed up drug uptake in mouse skin from over 12 hours to 2.7-4 hours [11]. Nanoemulsion can maintain stability of β-carotene against aggregation, separation due to gravity, oxidation, increased solubility, bioaccessibility and bioavailability of β-carotene [12]. The purpose of this research is to know the characteristics of PFMRO and to utilize PFMRO for nanoemulsion product prepared with high pressure homogenizer and apply nanoemulsion as dye and carotenoid source in dry noodle.

2. Materials and Methods
PFM was taken from POMs KebunRambutanTebingTinggi and technical hexane for oil extraction from PFMRO, distilled water, tween 80, wheat Flour, Eggs, and Carboxymethy cellulose (CMC) were obtained from a chemicals store in Medan-Indonesia.

The research method consisted of 3 stages: oil extraction from PFM to produce PFMRO, making nanoemulsion from PFMRO, nanoemulsion application as dye and carotenoid source in dry noodle.

Oil extraction from PFMRO: Oil extraction from PFMRO was done by maceration method using technical hexane as solvent. PFMRO is inserted into a bag-shaped filter cloth. Note that, the weight fiber and bags is around 10-20 kg. Then, the bag containing the pressuring fiber was inserted into a container bucket or barrel. Then, hexane was added in to fiber with ratio between hexane and fiber: 1: 6 (v/w). After the hexane was inserted into the container, the container where the maceration was sealed so that the hexane did not evaporate. After the maceration time was complete (after 24 hours) the bag of fiber (which functions like a filter so that the fibers were easily separated from hexane) was removed from the container and drained until hexane no longer drips. The hexane was then distilled to remove the soluble oil in the hexane. The distillation process was carried out at 70-80oC. The distillation product was then vacuum distilled to minimize the amount of residual hexane in the PFMRO. Then the oil of vacuum distillation was analyzed its quality characteristics include: oil content, DOBI [13], free fatty acids [14], and carotenoids [15].

Nanoemulsion Preparation: The treatment of nanoemulsion preparation comprises: 1) PFMRO ratio: water consists of 2 levels ie 15:85 and 20:80; 2) The concentration of tween 80 consists of 2 levels ie 2.5% and 5%; and 3) Homogenizer pressure consists of 2 levels of 300 and 500 bar, so the number of treatment combinations is 8 units. The production of nanoemulsion was modified using PFMRO [16]. The preparation of PFMRO nanoemulsion began with the manufacture of crude emulsions. First, a coarse emulsion was weight 300g, then it was labeled as a basis weight. Based on base weight, we determined the weight of each ingredient ie PFMRO and water in accordance with the treatment. Then the number of tween 80 was determined by percentage (2.5% and 5%) of weight of oil. The amount of PFMRO, distilled water and tween 80 can be seen in Table 1. By using ultra turraxat 11.000 rpm for 5 minutes to produce solution. At the end of 5 minutes, PFMRO was added into solution, gradually and homogenized for 5 minutes to produce emultion. It was labeled as a raw emulsion.

A raw emulsion then was converted tobenanoemulsion with High Pressure Homogenizer (HPH) at 300, dan 500 bar under condition 5 cycles. Finally, nanoemulsion was generated and analyzed as well as a standard of nanoemulsion. The nanoemulsion was tested by using Freeze-Thaw Stability Method (Stability test) [16]; Dynamic Light Scatter (DLS) Method (Polydispersion test); Particle diameter (Z_{ave}) (Particle Size Analysis (PSA) [17] and colornessanalyzer:Chromameter CR-300 [18]. The Duncan test was used to test the effect of treatment to quality of nanoemulsion.
Table 1. Amount of PFMRO, water and tween 80 of the manufacture of nanoemulsion

| Ratio of oil: water | PFMRO (g) | Water (g) | Tween 80 (g) | 2.5% | 5% |
|-------------------|-----------|-----------|-------------|------|----|
| 15:85             | 45        | 225       | 1,12        | 2.25 |
| 20:80             | 60        | 240       | 1.3         | 3.0  |

Nanoemulsion Application for Dry Noodle: In order to production of dry noodle, we used crude emulsion and nanoemulsion as a dyeness. The amount of dyeness is 10% by weight of the material. The type and amount of materials show in Table 2.

Table 2. Type and amount of dry noodle materials

| Material type   | Emulsions as dyes |
|-----------------|-------------------|
| Material type   | Crude emulsion    | Nanoemulsion     |
| Wheat (g)       | 300               | 300              |
| Egg (g)         | 50                | 50               |
| CMC (g)         | 10                | 10               |
| Amount of materials (g) | 360               | 360              |
| Emulsion dye (g) | 36,0              | 36,0             |

Flour, egg, CMC, and dye were mixed, stirred and made into dough until smooth. The dough was called dull when it was not sticky in hand or on a dough making container. The dough was left to stand for 10 minutes. Then the dough was made into thin sheet and so on the thin sheet was molded into noodle by using ampia. Then, the noodles were steamed for ±10 minutes, then dried in oven for 3 hours at 70°C. Furthermore, the color preferences test and analysis of carotenoid content in dry noodles were carried out, respectively.

3. Results and Discussion

The analysis results of PFMRO can be seen in Table 3.

Table 3. Characteristics of PFMRO

| Characteristics of PFMRO | Average and standard deviation of PFMRO |
|--------------------------|----------------------------------------|
| Carotenoid(ppm)          | 2549.5±308.09                           |
| DOBI                     | 3.39±0.05                               |
| Oil content (%)          | 4.67±0.67                               |

Table 3. shows PFMRO containing carotenoid 2549.5 ppm and DOBI 3.39. Based on the content of carotenoids and DOBI, PFMRO is better than CPO. Because carotenoid content and DOBI in PFMRO are higher than CPO’s carotenoid (500-700ppm) and DOBI (2.3) [5]. Carotenoid content and high DOBI value of PFMRO indicate that the oil is very potential to be used as a source of carotenoids and raw materials of the natural food coloring industry or as a nutraceutical.

High DOBI indicates that carotenoids have not been damaged, which can lead to a decrease in color intensity and antioxidant power. The carotenoid damage through isomerization, oxidation, and molecular fragmentation results in pro-vitamin A activity and decreased DOBI values [19]. Oxidation and isomerization of carotenoids do not only decrease the DOBI but decrease the functional nature of carotenoids as antioxidants and the colors become faded. The carotene isomerization of the trans form...
into cis-forms causes a decrease in the intensity of the color so it can not be used as a dye [20]. If the PFMRO level is 4.67% (see Table 2) and that the number of PFMRO produced by POMs in Indonesia 2016 reached 17.89 million tons, the oil potential that could be obtained from PFMRO reached 1.37 million tons and potentially produced 3,472.8 tons of carotenoids. Currently, the global industry was facing problems to meet the needs of natural and environmentally friendly carotenoids [6].

The ratio of oil to water, concentration of tween 80, and homogenizer pressure gave a real effect on the particle diameter (Zave), PDI (Poly Dispersity Index), and Zeta potential as shown in Table 4.

**Table 4.** Effect ratio of PFMRO to water, tween 80 and pressure on nanoemulsion properties

| Ratio of PFMRO : Water/Tween 80 (%) | Pressure (bar) | Zave (nm) | PDI | Zeta (mV) |
|------------------------------------|----------------|-----------|-----|----------|
| 15 : 85                             | 2.5            | 300       | 195.00±8.06d | 0.185±0.009c | -31.65±4.48b |
| 15 : 85                             | 5.0            | 300       | 174.75±3.32c | 0.169±0.000c | 25.50±0.57b  |
| 20 : 80                             | 2.5            | 300       | 202.35±3.18d | 0.186±0.004c | 26.60±0.85b  |
| 20 : 80                             | 5.0            | 300       | 173.00±1.41c | 0.179±0.002c | -32.36±0.65c |
| 15 : 85                             | 2.5            | 500       | 160.90±0.14b | 0.106±0.004a | -20.60±1.27a |
| 15 : 85                             | 5.0            | 500       | 150.80±1.13a | 0.114±0.004a | -19.70±1.41a |
| 20 : 80                             | 2.5            | 500       | 161.75±1.12b | 0.141±0.01b  | 23.69±1.09ab |
| 20 : 80                             | 5.0            | 500       | 156.60±0.14ab| 0.150±0.004b | -31.30±1.14c |

**Note:** Different notations on the same column show significantly different (p = 0.05). Zave (nm) = average of particle diameter; PDI = polydispersity index (if it is smaller than 0.3, meaning already uniform); Zeta = zeta potential (if the value is > -35 or > +35 means relative more stable).

The average diameter of the nanoemulsion particles was 150.80 - 202.35 nm and the PDI mean (0.106-0.186), and the Zeta value (19.70-32.36). Based on particle diameter and PDI, the emulsion which was produced already fulfilled the requirements material to be nanoemulsion. Nanoemulsion is an emulsion having a particle diameter ranging from 30-300 nm), and the polydispersity index ranging from 0.09-0.40 [21-22].

The best formula was selected from 8 formulas in Table 3, those are particle diameter (Zave), the smallest PDI and the largest loading capacity. In Table 3, 500 bar homogenizer pressure yielded particle diameter (Zave) (150.80-161.75 nm) and PDI (0.106-0.150). Its smaller than at 300 bar pressure is Zave (173-202.3 nm) and PDI (0.179-0.186). This is due to on the pressure of 500 bar, nanoemulsion particles is much more thrown into homogenizer wall compare to when the pressure is 300 bar. The collision of nanoemulsion particles into the homogeneous wall causes the particles to break into smaller particles. At the ratio of PFMRO: water and similar pressure, the usage of higher tween 80 concentrations (5%) resulted nanoemulsion with an average size of smaller particle diameters when compared to the use of tween 80 (2.5%). Meanwhile, at tween 80 concentration and similar pressure, both ratio of PFMRO: water (15: 85 and 20: 80) yielded nanoemulsion with an average size of relatively small particle diameters.

Based on average particle diameter and its loading capacity, the best treatment to generate nanoemulsion uses ratio of PFMRO: water (20: 80), 80% tween 80 (5% concentration) and pressure (500 bar). The treatment can produce nanoemulsion with an average particle diameter of 156.60 nm. In this case the loading capacity of PFMRO waste is 20%, it is better because this resulting nanoemulsion will deliver more active ingredients and potentially give greater positive impact. Nanoemulsions were generated from all generally tested formulas have a good degree of uniformity of particle size. This is indicated by the value of the polydispersity index (PDI) of less than 0.2 for all nanoemulsion formulas. Polydispersity index is a measurement parameter that describes the level of uniformity of particle size in a system. In general, the PDI value <0.20 shows a narrow particle size distribution (relatively small particle size variation) [24].
In Table 3, it appears that zeta potential of nanoemulsion (19.70-31.65 mV). Theoretically potential zeta values indicate the potential stability of an emulsion system. The more negative or positive of potential zeta value causes particles will increasingly refuse and avoid flocculation so that emulsion is more stable [25]. Stable nanoemulsion has a potential zeta of ± 30 mV [26].

In the emulsion system including nanoemulsion, emulsion stability during storage over a period of time is an important factor for determining nanoemulsion quality. Figure 1 shows an increasing in diameter of the nanoemulsion particles due to storage for 16 days at room temperature. Increasing in particle diameter during storage is due to granular aggregation and the nature of the oil which tends to form large particle size in the water phase [27]. However, until the 16th day of storage all nanoemulsion formulations have relatively small size.

Figure 1. shows that the formula ratio of PFMRO: water (15: 85) and (20: 80), concentration of tween 80 (5%) and pressure (500 bar) produce the best nanoemulsion with smallest and stable average particle size from scratch (zero days) to the end of storage (16 days).

![Figure 1](image)

**Figure 1.** Stability of nanoemulsion particle size from various treatments up to day 16

Based on these results, the ratio of PFMRO: water (20: 80) is preferable and selected for subsequent applications because the resulting nanoemulsion has a higher capacity loading of palm oil waste than nanoemulsion with a ratio of PFMRO: water (15: 85) as described previously. The effect of ratio of PFMRO: water, concentration of tween 80 and homogenizer pressure can be seen in Table 5.

**Table 5.** Effect of ratio of PFMRO : water, concentration of tween 80 and homogenizer pressure to emulsion color.

| PFMRO:Water (%) | Tween 80 (%) | Pressure(300 bar) | Pressure(500 bar) |
|-----------------|--------------|-------------------|-------------------|
| 15:85           | 2.5          | 66.47             | 25.38             | 85.55             | 83.18             | 10.11             | 82.99             |
| 15:85           | 5.0          | 66.65             | 25.50             | 85.18             | 80.92             | 11.37             | 81.85             |
| 20:80           | 2.5          | 64.77             | 29.09             | 81.95             | 85.31             | 20.12             | 83.45             |
| 20:80           | 5.0          | 65.70             | 27.80             | 82.17             | 82.51             | 21.68             | 85.16             |
| Averages        |              | 65.86             | 26.94             | 83.91             | 82.98             | 15.82             | 83.36             |
Table 5. shows that increasing in homogenizer pressure from 300 bar to 500 bar can increase the emulsion brightness value (L) from 65.86 to 82.98. An increasing in the emulsion color brightness is due to an increasing in the surface area of the nanoemulsion particles. So that the amount of light reflected of particles increases. In Table 5, the homogenizer 500 bar pressure produces Zave is 150.80-161.75 nm. It is smaller than at 300 bar pressure i.e Zave 173-202.3 nm. One of the goals of making nanoemulsion is to increase the intensity of the desired color brightness ([28]).

The results of favorness test and concentration of karotenoid of dry noodle are shown in Table 6.

### Table 6. Favorness test and karotenoid concentration of dry noodle

| Materials                                | Favorness dye test | Karotenoid concentration (ppm) |
|------------------------------------------|--------------------|---------------------------------|
| Dry noodle without emulsion (control)    | 2.5 ± 0.51         | Undetection                     |
| Dry noodle with crude emulsion           | 4.0 ± 0.32         | 33.53 ± 2.55                   |
| Dry noodle with nanoemulsion             | 4.1 ± 0.52         | 81.27 ± 0.86                   |

Table 6. shows that both type of emulsion (crude and nano) may enhance favorness dye of dry noodle. The dye of dry noodle without emulsion (no colorness) is pale. While dry noodles used dye base on crude emulsion and nanoemulsion, they resulted dry noodle’s bright yellow and light yellow, respectively. The briefly dye of dry noodle is shown in Figure 2.

![Figure 2. Dry noodle’s dye: without emulsion (left side), crude emulsion (center side) and nanoemulsion (right side).](image)

Carotenoid concentration of dry noodle without emulsion as a dye source can not detect. While, dry noodle containing crude emulsion and nanoemulsion have karotenoid concentration 33.53 and 81.27 ppm, respectively. Indicating, SPMS as a dye agent containing crude and nanoemulsion may be used as a karotenoid source on dry noodle. Base on Table 6, 1 g dry noodle containing crude emulsion and nanoemulsion as a dye have karotenoid concentration 0.033 and 0.081 mg, respectively. Commonly, people in Indonesian suggest to concumt 6 mg karotenoid or 500 retinol equivalen per day [29]. Therefore, if a man concumts 70 g dry noodle containing crude and nanoemulsion, he has karotenoid 2.1 mg or equivalent to 35% and 5.68 mg or equivalent to 94.8% toward suggestion need, respectively. All data indicate that SPMS containing crude oil and nanoemulsion may be used as dye and karotenoid source.
4. Conclusions
Base on all of data, we may conclude: PFMRO waste contains crude oil (7.67 %) and carotenoid (2549.5 ppm) and DOBI (2.39). Nanoemulsion may produce under the best condition: i) ratio between SIMS: water (80:20); amount of tween 80 (5%) and homogenizer pressure (500 bar). Physical properties of nanoemulsion are: particle diameter (150.80-161.75 nm), PDI (0.106-0.150), and zeta potential (-31.30). Crude emulsion and nanoemulsion may be applied to enhance favoring dye of dry noodle from 2.5 (favor less of dye) to be 4.0-4.12 (most favor of dye). Karotenoid concentrations of dry noodle are 33.53 ppm (crude emulsion application) and 8.31 ppm (nanoemulsion application).

References
[1] Nasution, M. A., Herawan, T., and Rivan, M. 2014. Analyasis of palm biomass as electricity from palm oil mills in North Sumatera. Energy Procedia, 47:166-172.
[2] Hassan, S., Kee, L. S., and Al-Kayiem, H. H. 2013. Experimental study of palm oil mill effluent and oil palm frond waste mixture as an alternative biomass fuel. J Engr Sci Technol, 8:703-712.
[3] Olisa, Y. P and Kotingo, K. W. 2014. Utilization of palm oil empty fruit bunch (PEFB) as solid fuel for steam boiler. European Journal of Engineering and Technology, Vol 2 No.2: 1-7.
[4] Manurung, H., Silalahi, J., Siahaan, D., and Julianti, E. 2017. The re-extraction of oil from palm empty fruit bunch residues and palm mesokarp fibers and measures in reducing greenhouse gas emission. Asian J Agri. And Biol (5):337-345.
[5] Subramaniam, V., N. R. Menon, H. Sin, and C. Y. May. 2013. The development of residual oil recovery system increase the revenue of palm oil mill. Journal of oil palm research. 25:116-122.
[6] Kupan, S., Kulkarni, A. D., Hamid, H., and Yusoff, M. M. 2015. Extraction of palm carotenoids and effect of oxidative degradation on β-carotene. International Journal of Engineering Research & Technology (IJERT), 4: 662-667.
[7] Downham, A and Collins, P. 2000. Colouring our foods in the last and next millennium. Int. J. Food Sci. Technol, 35:5-22.
[8] Liang R., Xu, S., Shoemaker, C.F., Li Y., Zhong F., and Huang Q. 2012. Physical and antimicrobial properties of peppermint oil nanoemulsions. Journal of Agricultural and food chemistry, 60:7548-7555.
[9] Foo, V and Thiele, 2013. How to color food products naturally. Food Review Indonesia, 8: 42-43.
[10] Hoang, L. C., Fougere, P., and Wache, Y. 2011. Increase in stability and change in supramolecular structure of beta carotene through encapsulation into poly lactic acid nanoparticle. Food chemistry (124): 42-49.
[11] Tsai, M. J., Fu, Y. S., Lin, Y. H, Huang, Y. B, Wu, P. C. 2014. The Effect of Nanoemulsion as a Carrier of Hydrophilic Compound for Transdermal Delivery. PLoS ONE. 9:1-8.
[12] Qian, Ng. W. P., Lam, H.L., Yuen, Ng. F., Kamal, M., Lim, J.H. 2012. Waste-to-welth: green potential from palm biomass in Malaysia. Journal of Cleaner Production, 3:57-65.
[13] Azeman, N. H., Yusof, N. A., and Othman, A. I. 2015. Detection of free fattyacid in crude palm oil. Asian Journal of Chemistry, Vol 27, No.5:1569-1573.
[14] AOCS. 1987. Official Methods and Recommended Practices of the AOCS. 5th edition. Champaign, Ill.
[15] PORIM. 1995. PORIM test methods. Palm Oil Research Institute of Malaysia. Ministry of Primary Industries, Malaysia.
[16] Yulisari, S., Fardiaz, D., Andarwulan, N., and Yuliani, S. 2014. Characteristics of red beta nanomulsion enriched beta carotene. Journal of Litri, 20:111-121.
[17] Tan C. P., and Nakajima, M. 2005. B-caroten nanodispersion: Preparation, characterization and evaluation. Food Chemistry, 92: 66171.
[18] Hutching, J. B. 1999. *Food color and appearance* 2nd edition. A Chapman and Hall Food Science Book. Aspen Publication, Maryland.

[19] Levin, G., and Mokady, S. 1994. Antioxidant activity of 9-cis compared to all-trans-β-carotene in vitro. *Free Radical Biology and Medicine*, 17:77-82.

[20] Nurcahyono, I.D dan Zubaidah, E. 2015. Effect of carboxymethyl cellulose concentration as edible coating and drying temperature on physical and chemical properties of instant dried carrot. *Journal of Food and Agro-industry*. 3: 1192-1202.

[21] Sekhon, B. S. 2010. Food nanotechnology—an overview. *Nanotechnology, Science, dan Application*. 3: 1-15.

[22] Mao, L., Duoxia, X., Jia, Y., Fang, Y., Yanxiang, G., and Jian, Z. 2009. Effects of small and large molecule emulsifiers on the characteristics of β-carotene nanoemulsions prepared by high pressure homogenization. *Food technology Biotechnology*. 47: 336–342.

[23] Ahmed, K., Li, Y., McClements, D. J. and Xiao, H. 2012. Nanoemulsion and emulsion-based delivery systems for curcumin: Encapsulation and release properties. *Food Chemistry*, 32: 799-807.

[24] Amirtharajah, A., C.R. O'Melia. 1990. *Water Quality and Treatment*, A Handbook of Community Water Supplies; 4th Ed. Ch.6 Coagulation Processes, Destabilization, Mixing and Flocculation, F.W. Pontius, Ed. McGraw Hill, Inc. NY. p269-365.

[25] Thongchai, W., and Liawruangrath, B. 2016. Development of HPLC analysis for the determination of retinol and alpha tocopherol in corn oil nanoemulsion lotion. *International Food Research Journal*. 23: 1367-1371.

[26] Fingas, M. 2008. Oil spilldispertion stability and surfacing. [http://www.iosc.org/paper/2008/20111.pdf](http://www.iosc.org/paper/2008/20111.pdf) [10 Pebruari 2017]

[27] Silva, H. D., Cerqueira, M. A., and Vincente, A. A. 2012. Nanoemulsion for food application: Development and characterization. *Food Bioproces Technol*5:854-867

[28] Kiokias, S., Proestos, C. and Varzakas, T. 2016. A Review of the Structure, Biosynthesis, Absorption of Carotenoids—Analysis and Properties of their Common Natural Extracts. *Curr Res Nutr Food Sci*, doi :http://dx.doi.org/10.12944/CRNFSJ4.Special-Issue1.03

[29] Jaswir, I., D. Noviendri, R. FitriHasrini, and FitriOctavianti. 2011. Carotenoids: source, medicinal properties and their application in food and nutraceutical industry. *Journal of Medicinal Plants Research*. Vol.5 (33):7119-7131

**Acknowledgement**
The authors are grateful to Dr. Hoerudin which provides an opportunity for authors to use the Nanotechnology Laboratory facility for nanoemulsion research and to Dr. Rikson Siburian who has translated this paper into English.