Effect of Candlenut Oil Addition to Physicochemical Properties of Ice Cream

[1]Maria O. Lukmanto, S.T., BEng., [1*]Dr. rer.-nat. Filiana Santoso, [1*]Hery Sutanto, M.Si.
[1]Department of Food Technology, Faculty of Life Sciences, Swiss German University, 15339
BSD City, Indonesia

Keywords: Candlenut oil, unsaturated fatty acid, ice cream, physicochemical properties

Abstract

The objective of this research is to increase the unsaturated fatty acid content (omega-3, omega-6 and omega-9) in ice cream by the substitution of whipping cream with candlenut oil and to study the effect of the candlenut oil addition to physicochemical properties of the ice cream. The oil from the candlenut extract was found to have high unsaturated fatty acid content. The amount of omega-3, omega-6 and omega-9 in candlenut oil was 26.50%, 39.86% and 24.36% respectively. The candlenut oil was added in three different timing during ice cream production; before pasteurisation, after pasteurisation and after aging. Various amount of candlenut oil (2%, 4% and 6%) were added to ice cream to replace the whipping cream. Sensory analysis using hedonic test with 30 untrained panellists was conducted to select the most preferred composition of candlenut oil in ice cream. Ice cream with addition of 6% candlenut oil before pasteurisation was chosen by the panellists as having the best formulation. During the ice cream production, there were losses in unsaturated fatty acid content in the ice cream with 6% candlenut oil. Omega-9 has the least amount of losses (1.65%), followed by significant losses of omega-6 (41.38%) and omega-3 (97.34%). The overrun, meltdown rate, total soluble solid and pH of each formulated ice cream remained stable. Other nutritional values of formulated ice cream (ash content, fat content and protein content) did not change significantly as well. Candlenut oil did not contribute to any additional protein value and mineral content in ice cream.

INTRODUCTION

Ice cream is becoming one of the most popular desserts worldwide nowadays Ice cream has some disadvantages impact for human health. Ice cream has a large amount of sugar and fat content and is very calorific. The fat contained in ice cream is higher in saturated fatty acid (SFA) than unsaturated fatty acid (UFA). Saturated fatty acid is believed to be responsible for the most common deadly diseases in the world such as cardiovascular disease and cancer, while unsaturated fatty acid has many health benefits such as for cognitive function and behaviour, arthritis, and asthma (Ehrlich, 2011).

There is also a problem with the source of oil that contains UFA. Fish oil is widely known as the source of Omega-3 fatty acid. However, it is costly; hence not many people can afford it. Candlenut is a native Indonesian plant and its oil has a very high content of essential fatty acids. Rahayu (2010) stated that from the high unsaturated fatty acid content in candlenut oil, it approximately contains 15% oleic acid, less than 30% linolenic acid and 40% linoleic acid. Because of its benefits and economical value, candlenut oil can replace the usage of fish oil. Thus, it has potential to substitute the unsaturated fatty acid in ice cream using candlenut oil so that the ice cream contains additional nutritional value of

essential fatty acid (omega-3, omega-6 and omega-9). Furthermore, ice cream is stored in low temperature storage condition which is suitable for candlenut oil to keep its essential fatty acid content in good and stable condition (Goh et al., 2006). The stability of the physicochemical properties of formulated ice cream was analyzed during storage day 21 and 42.

MATERIALS AND METHODS

Candlenut oil extraction

The candlenut oil was obtained by extracting candlenut kernels with expeller press machine. The principle of an expeller press machine is using mechanical friction force and continuous pressure from the main screw to break the kernel's cell wall and compressed it to extract the oil. The extraction was done under cold condition to preserve the essential fatty acid content in the candlenut oil. In the expeller press machine, cold water was circulated around the end of the head of the expeller press. Extraction was conducted at low temperature of 4°C. Candlenut extract that was obtained from the extraction still contained impurities. Thus, centrifugation was conducted twice at 10,000 RPM at 4°C for 20 minutes to purify the oil. The supernatant obtained from the centrifugation was collected as the candlenut oil.

Ice cream processing

The ice cream mixture consist of 12% (w/w) fat (milk fat from Bongrain SA, France and candlenut oil), 11.5% (w/w) skim milk powder (TATURA, Australia), 13% (w/w) sucrose (Sugar Group Companies, Indonesia), 0.3% (w/w) Carboxymethyl Cellulose (PT. Brataco Chemical, Indonesia), 0.1% (w/w) vanilla flavour (PT. Essence Indonesia - IFF) and 63.1% (w/w) water. The ice cream mixture was prepared according to the formulations in Table 1. The combination of different portions of milk fat and candlenut oil was given as% milk fat:% candlenut oil with the following order; 12:0 (B), 10:2 (F1), 8:4 (F2) and 6:6 (F3), 10:2 (F4),

8:4 (F5) and 6:6 (F6), 10:2 (F7), 8:4 (F8) and 6:6 (F9). There are three different treatments that were applied to the formulated ice cream. In F1, F2 and F3, the candlenut oil was added from the beginning of formulation, while in F4, F5 and F6 the candlenut oil was added after pasteurization, before the ice cream mix was homogenised using homogeniser. In formulated ice cream F7, F8 and F9, the candlenut oil was added after ageing, before freezing process in ice cream maker. All ingredients were mixed and subjected to pasteurisation at 80°C for 15 seconds. Homogenisation was done using IKA RW 20 digital (Staufen, Germany) homogeniser. The ice cream mixture was cooled and stored overnight at ±4°C. Vanilla flavour was then added into the cold mixture. The mixtures were whipped into ice cream using Kenwood IM 280 ice cream maker (Hampshire, England). The formulated ice creams were stored in the freezer at -18°C for 24 h before undergo further analysis.

Sensory analysis

Ice cream samples were analysed for their sensory attributes by 30 untrained panellists through hedonic test method. Four samples of ice cream were given to the panellists. Each panellist was asked to fill the questionnaire for each sample. In the questionnaire, panellist should give score to the overall acceptability of the samples. The result was analysed using ANOVA: Two-Factor without Replication. The first set of

sensory analysis was held to determine the best timing of candlenut oil addition (before pasteurisation, after pasteurisation or after aging) while the second set of sensory analysis was held to determine one best sample among 3 samples that was chosen from the first sensory analysis result. The one best sample was chosen for further analysis for the stability of its unsaturated fatty acid content (day 21 and 42).

Physicochemical properties

Physicochemical properties of ice cream samples were analysed in triplicate. Overrun of the ice cream was analysed by measuring the increase percentage in the volume of whipped ice cream compared to the initial volume of ice cream mixture before whipping process (Egan et al., 1987). The meltdown percentage analysis was carried out based on method from Govin and Leeder (1971). A hardened ice cream sample of approximately 50 g was placed at room temperature (25°) on a small sieve.

The melted ice cream was hold in the beaker glass and weighed every 5 minutes interval using a digital balance for 60 minutes. pH of the ice cream sample was measured using a pH meter (SCHOTT Instrument Lab 850, Germany) while the total soluble solid of the melted ice cream mixture was measured using pocket refractometer (ATAGO PAL-1, Japan). The moisture content of ice cream was determined based on the method from SNI Official Standard Method 01-2354.2 (SNI, 2006). Ash content of ice cream was determined using SNI Official Standard Method 01-2354.1 (SNI, 2006). Protein content and fat content of ice cream was determined through SNI Official Standard Method 01-2891-1992, Kjeldahl method (SNI, 1992) and SNI Official Standard Method 01-01-2891-1992 soxhletation (SNI, 1992).

Unsaturated fatty acid analysis

Candlenut oil obtained from the extraction process and the ice cream samples were analysed for its unsaturated fatty acid content (omega-3, omega-6 and omega-9) in by using gas chromatography at PT. Saraswanti Indo Genetech, Bogor. The samples were analysed in duplicate. The fat from the samples were extracted by Weibull hydrolysis method for liquid and semi-liquid sample. Then the samples were extracted using perforator. Fatty Acid Methyl Esters (FAME) standard solutions were prepared. The gas chromatography (GC) with a Flame Ionisation Detector (FID) was used to analyse the unsaturated fatty acid in the samples. The GC analysis was carried out using capillary column polyethylene glycol, equivalent variants CP-Wax 52 CB (30m x 0.25mm x 0.25µm film thickness) and nitrogen as carrier gas. The flow rate was 1 ml/min. The initial oven temperature was 120°C with an increase of 4°C per minute until reached 240°C. The injector and detector temperatures were set at 260°C.

Saponin analysis

Saponin content in ice cream samples were measured using modified extraction method from Edeoga et al. (2005). The samples (candlenut oil and formulated ice cream) were prepared and 20 g of each sample was put into Erlenmeyer flask. Aqueous ethanol 20% 100 ml were added into both flasks. The samples were heated over hot water bath at 55°C for 4 hours with continuous stirring. The mixture was filtered and the residue was extracted again with another 200 ml of aqueous ethanol 20% for another 4 hours. Then the combined extract obtained from both extractions was reduced to 40 ml over water bath at about 90°C. The concentrated extract was transferred into 250 ml separatory funnel. 20 ml of diethyl ether was added into the funnel and it was shaken vigorously. The ether layer was

recovered while the aqueous layer was discarded. The purification with diethyl ether was repeated. Then, 60 ml of n-butanol was added into the separatory funnel. The combined n-butanol extract were washed twice with 10 ml of 5% aqueous sodium chloride. The remaining solution was transferred into a porcelain crucible and heated in a water bath. After evaporation, the samples were dried in the oven to constant weight. The residue of the dried samples were weighed and recorded as the saponin content.

Total plate count (TPC) analysis

The microbe assays used in this research was TPC in PCA media. First, saline solution was prepared by diluting 4.25 g of sodium chloride with 500 ml distilled water. The solution was sterilised in autoclave at 121°C for 30 minutes. Then dilution of 1:10, 1:100 and 1:1000 were made by diluting the ice cream sample with sterilised saline solution in each dilution ratio. Then, 1 ml sample of each dilution was pipette into 3 different petri dishes (triplicate). Approximately 20 ml of sterilised PCA agar was poured into each petri dish. The samples were incubated at 37°C for 28 hours inside incubator. After 48 hours, the samples were analysed.

RESULTS AND DISCUSSION

Sensory analysis

The sensory analysis was done for 10 samples as listed in Table 1. Four sessions of sensory test was conducted to find the acceptable formulation of ice cream. Hedonic test was used to evaluate each attributes of the formulated ice cream. 30 untrained panellists were participated in each sensory test. The result of the sensory is based from the overall acceptability of the panellists.

At the first session, 4 samples of ice cream (B, F1, F4, F7) were given to the panellists. The blank sample was used as control. The formulated ice creams contained 2% candlenut oil but with different treatments (the candlenut oil was added before pasteurisation, after pasteurization and before freezing in ice cream maker). The sensory analysis result in Table 2 showed that the F1 sample (2% candlenut oil added before pasteurization) was the most accepted by the panellists beside the blank sample.

At the second session, similar sensory test was conducted with different samples (B, F2, F5, F8). The result of the second session of sensory test showed that the F2 sample was the most accepted by the panellists beside the blank sample.

At the third session, four samples of B, F3, F6 and F9 was given to the panellists. The most accepted sample was F3. From the sensory test evaluation, it could be concluded that the panellists preferred the formulated ice cream that was added with candlenut oil before pasteurisation (F1, F2, F3). The panellist reported that in that samples, the candlenut oil bitter taste and smell was more acceptable than the other sample with different treatments. This might be due to pasteurisation, the candlenut oil was heated, thus reduced the bitter taste and smell of the oil. Thus the F1, F2 and F3 sample was chosen for further analysis for its physicochemical properties.

At the fourth session, each sample selected from the three previous sensory tests was given to the panellist to determine the most accepted sample. However, the sensory result from the test showed no significant difference ($p>0.05$) among the sample (Table 5). The result was analysed using ANOVA: Two-Factor without Replication. Since there was no significant difference between the F1 (2% oil), F2 (4% oil) and F3 (6% oil), the F3 sample with the highest candlenut oil content was chosen to be analysed during storage (day

1, day 21 and day 42). The physicochemical properties of other formulations (B, F1 and F2) were analysed at day 1.

Unsaturated fatty acid analysis

After the extraction of candlenut kernel using cold expeller press method, candlenut oil was obtained. Wijaya (2004) discovered that the total amount of unsaturated fatty acid in candlenut oil was 79.64% while Stefanus (2011) founded that the total amount of unsaturated fatty acid in candlenut oil was 76.49%. The result in Table 6 showed that the omega-3, omega-6 and omega-9 content in candlenut oil were 26495.46 mg, 39863.67 mg and 24360.35 mg per 100 g oil respectively. From the result obtained, it can be calculated that the total amount of unsaturated fatty acids (omega-3, omega-6 and omega-9) in candlenut oil is 90.72%. The higher value of unsaturated fatty acid content compared to that studied in Wijaya (2004) and Stefanus (2011) is caused by different source of the raw material, storage time and condition before extraction process. The candlenut kernel used in the experiment was obtained from candlenut farm in Rangkasbitung, Lebak, Banten. It was obtained in relatively fresh condition, thus the oil resulted in higher unsaturated fatty acid content (omega-3, omega-6, omega-9) than the candlenut kernels used by Wijaya (2004) and Stefanus (2011) that were obtained from traditional market or candlenut distributor. There was possibility that the candlenut kernels have be stored for some period and different storage condition before it was sold, thus may affect the fatty acid content. After extraction, the candlenut oil was stored in refrigerator (4°C) to maintain the stability of its unsaturated fatty acid content.

Based on result in the sensory analysis, F3 sample was chosen as the best sample. It was then analysed for its unsaturated fatty acid content. The result from the unsaturated fatty acid analysis of F3 was showed in Table 7 and Figure 1. There were some losses between the expected value and actual value of the omega-3, omega-6 and omega-9 content of the sample. Omega-3 and omega-6 are prone to auto-oxidation process (Hamilton and Rossel,1986). Rudnik et al. (2001) also stated that oil with high unsaturated acid content lead to reduced oxidative stability.

Omega-9 has the least amount of losses (1.65%), followed by omega-6 (41.38%) and omega-3 (97.34%). This was occurred because of the difference between the omega-3, omega-6 and omega-9 structure as shown in Fig. 2. There are CH_2 with low activation energy (50 kcal/mol) located between the double bond in omega-3 and omega-6 long chain as seen in Fig. 13. The CH_2 only requires low energy to break its bond (C-H bond), thus heat during the pasteurisation of ice cream broke those bonds in omega-3 and omega-6. When the C-H bond was broken, the structure was not recognized as omega-3 or omega-6 anymore. CH2 with low activation energy is not found in omega-9. Thus, omega-9 is more stable to heat and has the least amount of losses when it was heated.

According to Lim et al. (2010), the formulated ice cream mix was subjected to pasteurisation with High Temperature Short Time (HTST) pasteurisation technique at 80°C for 15 seconds. The unsaturated fatty acid was sensitive to heat (Swern, 1979), hence the temperature of pasteurisation was too high for the ice cream and caused great loss in omega-3 content. There is possibility to reduce the loss of omega-3 in ice cream by using another technique of pasteurisation with lower temperature, such as LTLT technique (Low Temperature Longer Time).

Physicochemical properties analysis

Overrun measurement of the formulated ice creams were calculated based on the different volume of ice cream before and after whipping process in ice cream maker. The result of overrun measurement in Table 8 was analysed using ANOVA single factor. The statistical analysis showed that there were no significant differences ($p>0.05$) between the formulated ice creams (F1, F2, F3) and the control (B) sample. It means that addition of candlenut oil does not affect the overrun.

Goh et al. (2006) reported in their study that ice cream made with higher concentration of flaxseed oil has higher meltdown rate. The ice cream could not stabilise air cells efficiently due to minimal fat flocculation. According to Fig. 3, there was no significant difference ($p>0.05$) between the meltdown rates of F1, F2 and F3 samples compared to control (B) sample. However in the F3 sample, it can be seen that the meltdown rate was slightly higher than the other samples but not significant.The total soluble solid content between the ice cream samples (Table 8) showed no significant difference ($p>0.05$). Thus, candlenut oil did not contribute additional value to the total soluble solid content in the ice cream. In terms of pH value, candlenut oil substitution had no significant effect to the formulated ice cream pH value. Marshall et al. (2003) stated that the pH of regular fat ice cream was about 6.3, while Lim et al. (2010) reported that ice cream with addition of flaxseed oil has pH around 6.42. The result obtained showed that the pH values of the ice cream samples used in this study were slightly higher, around 6.7. Ash content, fat content and protein content in the formulated ice cream also did not change significantly (Table 8).

However, moisture content of the formulated ice cream decreased with the increasing amount of candlenut oil in the samples. The addition of candlenut oil decreased the moisture content because the whipping cream was substituted by candlenut oil. Whipping cream contains higher moisture content than candlenut oil, thus substitution of higher concentration of candlenut oil decrease the concentration of whipping cream hence decreased the moisture content.

During storage (day 21 and day 42), there were significant changes in total soluble solid and moisture content of formulated ice cream F3 (Table 9). The total soluble solid at day 1 and day 21 shows similar value which means it is stable during storage. However at day 42, the total soluble solid of the sample was significantly increased. According to Hartolo (2011), the increase of total soluble solid during storage may caused by the stabiliser that was not able to bind with the water and fat very well. Since stabiliser is a carbohydrate that is soluble in the water, it can increase the total soluble solid.

The moisture content of F3 sample during storage at day 1 and 21 was analysed and found to be similar. However, at day 42 the moisture content increased significantly. This might be caused by the packaging and storage condition. The ice cream was put in plastic cup and stored in freezer. The plastic cup for ice cream packaging was not an air-tight packaging, so it was suspected that the formulated ice cream absorbed the moisture from the freezer.

Saponin analysis

The candlenut kernel is reported to have saponin compound, which is mildly toxic (Scott and Thomas, 2000). However according to Knight and Walter (2001), saponin is found in highest concentration in the tung nuts and leaves but not in the oil. Although candlenut and tung trees are close relatives, candlenut is not considered as toxic as tung nut. Saponin analysis was conducted for the ice cream sample F3 which has the highest concentration of candlenut oil to check if the sample still contained saponin. The candlenut oil was also checked for its saponin content.

The result of saponin content in the candlenut oil and F3 sample was shown in Table 10. Saponin was found in both candlenut oil and formulated ice cream F3. However, according to US Environmental Protection Agency (2000), the saponin content in the ice cream sample was way below the lethal dose and still considered as safe for consumption.

Total Plate Count (TPC) analysis

Microbiological analysis that was done to the sample is Total Plate Count (TPC). According to SNI Official Standard, the maximum TPC is 2.0 x 10^5 CFU/ml. From the Table 11, the result of TPC analysis was between 5.0 x 10^1 and 5.8 x 10^1. Thus, it already fulfilled the microbiological standard TPC of ice cream.

CONCLUSIONS

Based on hedonic test result, different time of candlenut oil addition gave significant effect to the sensory properties of ice cream. Addition of candlenut oil from the beginning was chosen by the panellists as the most acceptable samples. However the concentration of candlenut oil did not give significant effect to the sensory properties of ice cream, thus F3 with the highest concentration of candlenut oil was chosen for further analysis. In formulated ice cream with 6% candlenut oil (F3), omega-9 has the least amount of losses (1.65%), followed by omega-6 (41.38%) and omega-3 (97.34%). The omega-3, omega-6 and omega-9 contents in every 100g of ice cream sample with 6% candlenut oil (F3) were found to be 43.31mg, 1398.77mg and 2930.71mg. Substitution of candlenut oil in ice cream gave slight changes in physicochemical properties of ice cream. During 42 days of storage, there was significant increase in the total soluble solid and moisture content of formulated ice cream with 6% candlenut oil.

Literature Cited

Arbuckle, W. S. 1986. *Ice Cream.* 4th ed. s.l.:Van Nostrand Reinhold.

Arnelia. 2002. *Fito-kimia komponen ajaib cegah PJK, DM dan kanker.* http://www.kimianet.lipi.go.id/utama.cgi?artikel&1100397943&2, Accessed on June 22, 2013.

Bailey, A. E., and Shahidi, F. 2005. *Bailey's Industrial Oil and Fat Products*. Hoboken, NJ: John Wiley & Sons.

Balsom, T., and Lynch, G. 2008. *Monitoring pasture quality using brix measurements.*http://www.novel.co.nz/uploads/76545/files/136209/Brix_Measurements.pdf, Accessed on June 15, 2013.

Christie, W. 2013. *Fatty acids: straight-chain saturated.* http://lipidlibrary.aocs.org/lipids/fa_sat/index.htm, Accessed on June 23, 2013.

Clarke, C. 2004. *The Science of Ice Cream.* Cambridge, UK: RSC Paperbacks.

Connor, W.E. 1999. *α-linolenic acid in health and disease.* http://ajcn.nutrition.org/content/69/5/827.full, Accessed on June 21, 2013.

Duke, J. A. 1983. *Aleurites moluccana (L.) Willd.*. s.l.:Handbook of Energy Crops.

Ehrlich, S. D., 2011. *Omega-3 fatty acids.* http://umm.edu/health/medical/altmed/supplement/omega3-fatty-acids, Accessed on June 24, 2013.

El Owni, O. A., and Zeinab, K. O. 2009. *Chemical Composition of Ice Cream Produced in Khartoum State, Sudan*. *Pakistan Journal of Nutritio,* 8(2):158-160.

Elevitch, C. R., and Manner, H. I. 2006. Aleurites moluccana (kukui). April, p. 7.

Eliott, K. 2013. *Food & Nutrition.* http://extension.missouri.edu/extensioninfonet/article.asp?id=3150, Accessed June 28, 2013.
FAO. 2013. *Review of methods of analysis.* http://www.fao.org/docrep/008/y4705e/y4705e12.htm, Accessed on June 23, 2013.
Fitrahdini., U. Sumarwan, and R. Nurmalina. 2010. *Analisis persepsi konsumen terhadap ekuitas merek produk es krim*. *Jur. Ilm. Kel. & Kons.* 3(1) : 74-81.
Food and Enviromental Hygiene Department HKSAR. 2001. http://www.cfs.gov.hk/english/programme/programme_rafs/files/ice_e.pdf, Accessed on June 17, 2013. Franklin, B. 2009. *Omega-6 fatty acids in the hierarchy of cardiovascular protection*. http://pt01.wkhealth.com/pt/re/chf/addcontent.11085486.htm;jsessionid=RNyX4D1JN hdpJJVmp5hT1SyrSJYV4pLGcl5hnv2Lwpmy2xmTXhwm!-261918151!181195628!8091!-1, Accessed on June 25, 2013.
Goff, D. 1955. *Finding science in ice cream.* Ontario: University of Guelph.
Goff, H. D. 1997. *Review colloidal aspects of ice cream - a review*. *International Dairy Journal* 7(6-7) : 363-373.
Goh, K. T., A. Ye, and N. Dale. 2006. *Characterisation of ice cream containing flaxseed oil. International Journal of Food Science & Technology* 41(8) : 946-953.
Hamilton, R. J., and J. B. Rossell. 1986. *Analysis of Oils and Fats.* London: Elsevier Applied Science.
Hartono, T., 2009. *Saponin*. http://www.farmasi.asia/saponin/, Accessed on June 17, 2013. Hartolo, L. 2011. *Effect of Stabilizer to Physicochemical and Sensory Properties od Non-Dairy Ice Cream*. BS Thesis. Department of Food Technology. Swiss German University, Tangerang, Indonesia.
Hendriani, Y. 2005. *Stabilitas Es Krim Yang Diberi Khitosan Sebagai Bahan Penstabil Pada Konsentrasi Yang Berbeda.* s.l.:Institut Pertanian Bogor.
Hibbeln, J. R. et al., 2006. *Healthy intakes of n−3 and n−6 fatty acids: estimations considering worldwide diversity*. *The American Journal of Clinical Nutrition.*
Hilditch, T. P. 1944. *The Chemical Constitution of Natural Fats.* Hoboken, NJ: John Wiley & Sons.
Hooper, L., 2006. *BMJ.* http://www.bmj.com/specialties/drugs-cardiovascular-system, Accessed on June 21, 2013.
Hostettmann, K., and A. Marston. 2005. *Saponins.* Cambridge, UK: Cambridge University Press.
Hui, H., R. C. Chandan, and S. Clark. 2007. *Handbook of Food Products Manufacturing, 2 Volume Set.* 1st ed. Hoboken, New Jersey: Wiley Interscience.
IDFA, 2009. *Pasteurization: Definition and Methods.* http://www.idfa.org/files/249_ Pasteurization%20Definition%20and%20Methods.pdf, Accessed on May 1, 2013.
IDFA. 2013. *Ice cream labelling*. http://www.idfa.org/news--views/media-kits/ice-cream/ice- cream-labeling/, Accessed on June 22, 2013.
Jamieson, G. S. 1943. *Vegetable fats and oils.* s.l.:Reinhold Pub. Corp.
Knight, A. P., and R. G. Walter. 2001. *A Guide to Plant Poisoning of Animals in North America.* Jackson, WY: Teton New Media.
Korsten, L. et al. 2008. *Holticultural Chain Management for Eastern and Southern Africa: A Theoretical Manual.* London, UK: Commonwealth Secretariat.
Lawn, R., and E. Prichard. 2003. *Laboratory Skills Training Guides: Measurement of pH.* UK: RSC.

Lim, C. W., M. H. Norziah, and H. F. S. Lu. 2010. *Effect of flaxseed oil towards physicochemical and sensory characteristic of reduced fat ice creams and its stability in ice creams upon storage. International Food Research Journal,* Volume 17 : 393-403.

Lin, T. -J. et al. 1996. *Two outbreaks of acute tung nut (Aleurites fordii) poisoning. Journal of Clinical Toxicology,* Volume 34 : 887-892.

Lowe, B. 1997. *Experimental Cookery from the Chemical and Physical Standpoint.* Iowa: John Wiley & Sons.

Marshall, R. T., H. D. Goff, and R. W. Hartel. 2003. *Ice Cream.* 6th ed. New York, US: Springer.

Morris, D. H. 2003. *Flax a Health and Nutrition Primer.* 3 ed. Canada: Flax Council of Canada.

Nakayama, F. S., and W. L. Osbrink. 2010. *Evaluation of kukui oil (Aleurites moluccana) for controlling termites. Industrial Crops and Products,* 31(2) : 312-315.

Naresh, L., and U. Shailaja. 2006. *Stabilizer Blends and their importance in Ice Cream Industry - A Review.* Jodhpur, Rajasthan, India: Lucid Colloids Limited.

National Cancer Institute, 2012. *Obesity and cancer risk.* http://www.cancer.gov/cancertopics/factsheet/Risk/obesity, Accessed on June 22, 2013.

Nik Norulaini, N. A. et al. 2004. *Major Chemical Constituents of Candlenut Oil Extract Using Supercritical Carbon Dioxide. Journal of Pharmaceutical Sciences,* Volume 2 : 61-72.

Okuyama, H. et al. 2007. *3 fatty acids effectively prevent coronary heart disease and other late-onset diseases: the excessive linoleic acid syndrome. World Review of Nutritional Dietetics 96 :* 83-103.

Onning, G., M. A. Juillerat, L. Fay, and N. –G. Asp. 1994. *Degradation of Oat Saponins during Heat Processing - Effect of pH, Stainless Steel, and Iron at Different Temperatures. J. Agric. Food. Chem,* Volume 42 : 2578-2582.

Penn State University, 2010. *FDA recommended pasteurization time/temperature.* http://extension.psu.edu/food/safety/course-follow-up-information/juice-haccp-resources/food-safety-juice-haccp-regulations/FDA%20Recommended%20Pasteurization%20Time.pdf/view, Accessed on May 22, 2013.

Purwadaria, H. K., S. Pertiwi, A. M. Syarief, and M. Putiati. 1995. *Processing and Marketing of Candle Nut (Kemiri) in Indonesia,* Padang: Institut Pertanian Bogor.

Reusch, W., 2013. *Lipids.* http://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/lipids.htm, Accessed on June 23, 2013.

Rudnik, E. et al. 2001. *Comparative studies of oxidative stability of linseed oil. Thermochimica Acta,* Volume 370 : 135-140.

Rustan, A. C., and C. A. Drevon. 2005. *Fatty Acids: Structures and Properties.* Hoboken, NJ: John Wiley & Sons.

Saati, E. A., and T. Sundari. 2009. *Pembuatan Es Krim Lidah Buaya (Aloe Chinensis) dengan Penambahan Gelling Agents.* s.l.:Kimia Pangan dan Gizi: Gramedia.

Schramm, L. L. 2005. *Emulsions, Foams, and Suspensions.* Weinheim: Wiley-VCH Verlag GmbH & Co. KGsA.

Scott, S., and C. Thomas. 2000. *Poisonous Plants od Paradise L First Aid and Medical Treatments and Injuries from Hawaii's Plants.* Honolulu, HI: University of Hawai'i Press.

Siddique, B. M., A. Ahmad, A. F. Alkarkhi, and M. H. Ibrahim. 2011. *Chemical composition and antioxidant properties of candlenut oil extracted by supercritical CO2. Journal of Food Science,* 76(4) : 535-542.

Sinclair, A. J., D. Begg, M. Mathai, and R. S. Weisinger. 2007. *Omega-3 fatty acids and the brain: review of studies in depression*. *Asia Pac J Clin Nutr,* 16(1) : 391-397.

Stefanus, M. 2011. *Formulation of Chocolate Bar Enriched with Omega-3 From Candlenut Oil Extract*. BS Thesis. Department of Food Technology. Swiss German University, Tangerang, Indonesia.

Sunanto, H. 1994. *Budidaya Kemiri: Komoditas Ekspor*. Jakarta: Penerbit Kanisius.

Taufik, M. 1991. *Pengaruh Suhu dan Lama Pemasakan Biji Kemiri (Aleurites moluccana) Terhadap Rendemen dan Sifat Fisiko-Kimia Minyak Kemiri*. s.l.:Institut Pertanian Bogor.

U. S. Food and Drug Administration. 2012. *CFR–Code of federal regulations title 21*. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=135. 110, Accessed on June 22, 2013.

West, A. P., and A. I. De Leon. 1924. *Oxidation od lumbang and linseed oils, and of the principal compounds in lumbang oil. Philippine Journal of Science,* 24(1):123.

Wijaya, T. 2004. *Extraction of Candlenut Oil using Cold Press Method*. BS Thesis. Department of Food Technology. Swiss German University, Tangerang, Indonesia.

Wilcox, E. V., and A. R. Thompson. 1913. *The Extraction and Use of Kukui Oil. Hawaii Agricultural Experiment Station Honolulu,* Volume 39:1-8.

Tables :

Table 1. Various composition of ice cream formulations.

Formulations	Ingredients in percentage(%), w/w							
	Candlenut oil addition	whipping cream	Candlenut oil	Skim Milk	Sugar	CMC	Vanilla Flavour	Water
Blank	-	12	0	11.5	13	0.3	0.1	63.1
F1	Before	10	2	11.5	13	0.3	0.1	63.1
F2		8	4	11.5	13	0.3	0.1	63.1
F3	Pasteurisation	6	6	11.5	13	0.3	0.1	63.1
F4		10	2	11.5	13	0.3	0.1	63.1
F5	After	8	4	11.5	13	0.3	0.1	63.1
F6	Pasteurisation	6	6	11.5	13	0.3	0.1	63.1
F7		10	2	11.5	13	0.3	0.1	63.1
F8	After Aging	8	4	11.5	13	0.3	0.1	63.1
F9		6	6	11.5	13	0.3	0.1	63.1

Table 2. Sensory analysis result of B, F1, F4, F7.

Ice Cream Formulation	Candlenut Oil addition	Ratio of milk fat and candlenut oil	Overall acceptability
B	-	12 : 0	7.38^{a}
F1	Before Pasteurisation	10 : 2	7.24^{a}
F4	After Pasteurisation	10 : 2	5.76^{b}
F7	After Aging	10 : 2	5.55^{b}

Mean values ± standard deviation within column with different superscripts are significantly different at $p<0.05$.

Table 3. Sensory analysis result of B, F2, F5, F8.

Ice Cream Formulation	Candlenut Oil addition	Ratio of milk fat and candlenut oil	Overall acceptability
B	-	12 : 0	7.93^{a}
F2	Before Pasteurisation	8 : 4	6.73^{b}
F5	After Pasteurisation	8 : 4	5.90^{c}
F8	After Aging	8 : 4	5.13^{d}

Mean values ± standard deviation within column with different superscripts are significantly different at $p<0.05$.

Table 4. Sensory analysis result of B, F3, F6, F9.

Ice Cream Formulation	Candlenut Oil addition	Ratio of milk fat and candlenut oil	Overall acceptability
B	-	12 : 0	7.83^{a}
F3	Before Pasteurisation	6 : 6	6.20^{b}
F6	After Pasteurisation	6 : 6	5.50^{c}
F9	After Aging	6 : 6	5.00^{c}

Mean values ± standard deviation within column with different superscripts are significantly different at $p<0.05$.

Table 5. Sensory analysis result of B, F1, F2, F3.

Ice Cream Formulation	Candlenut Oil addition	Ratio of milk fat and candlenut oil	Overall acceptability
B	-	12 : 0	7.10^{a}
F1	Before Pasteurisation	10 : 2	6.83^{b}
F2	Before Pasteurisation	8 : 4	6.60^{b}
F3	Before Pasteurisation	6 : 6	6.50^{b}

Mean values ± standard deviation within column with different superscripts are significantly different at $p<0.05$.

Table 6. Unsaturated fatty acid composition in candlenut oil.

Type of Unsaturated Fatty Acid	Concentration (%)
Omega-3 (mg/100g)	26.50 ± 0.51
Omega-6 (mg/100g)	39.86 ± 0.63
Omega-9 (mg/100g)	24.36 ± 0.17

Table 7. Unsaturated fatty acid composition in F3.

Type of Unsaturated Fatty Acid	Actual Value	Expected Value
Omega-3 (mg/100g)	43.31	1624.27
Omega-6 (mg/100g)	1398.77	2386.28
Omega-9 (mg/100g)	2930.71	2979.8

Table 8. Physicochemical properties of formulated ice cream.

Physicochemical Attributes	Samples		
	F3 (day 1)	F3 (day 21)	F3 (day 42)
Meltdown half-life (min)	52.45 ± 5.06[a]	56.02 ± 3.74[a]	52.49 ± 0.08[a]
Total Soluble solid (^{o}Brix)	28.5 ± 1.11[b]	28.2 ± 1.08[b]	30.9 ± 2.76[a]
pH value	6.72 ± 0.17[a]	6.70 ± 0.06[a]	6.69 ± 0.23[a]
Moisture content (%)	62.76 ± 0.65[b]	63.38 ± 1.05[b]	64.89 ± 0.43[a]
Ash Content (%)	0.86 ± 4.19[a]	0.84 ± 1.19[a]	0.85 ± 1.36[a]
Fat Content (%)	10.15 ± 1.56[a]	10.83 ± 0.59[a]	11.53 ± 9.53[a]
Protein content (%)	3.37 ± 2.72[a]	3.47 ± 6.53[a]	3.19 ± 2.12[a]

Mean values ± standard deviation within column with same letter superscripts indicate that there is no significant difference ($p>0.05$).

Table 9. Physicochemical properties of formulated ice cream F3 during storage.

Physicochemical Attributes	Samples			
	Blank	F1	F2	F3
Overrun (%)	34.81 ± 1.95[a]	33.59 ± 3.14[a]	34.07 ± 5.09[a]	33.82 ± 6.15[a]
Meltdown half-life (min)	57.31 ± 4.35[a]	56.20 ± 1.56[a]	54.70 ± 1.34[a]	52.45 ± 5.06[a]
Total Soluble solid (^{o}Brix)	27.8 ± 3.40[a]	28.9 ± 1.56[a]	28.8 ± 2.28[a]	28.3 ± 1.95[a]
pH value	6.74 ± 0.09[a]	6.73 ± 0.17[a]	6.73 ± 0.16[a]	6.70 ± 0.45[a]
Moisture content (%)	63.72 ± 0.31[a]	63.17 ± 0.40[ab]	63.13 ± 0.18[ab]	62.58 ± 0.36[ab]
Ash Content (%)	0.89 ± 3.18[a]	0.94 ± 3.01[a]	0.94 ± 0.76[a]	0.88 ± 0.79[a]
Fat Content (%)	10.51 ± 3.97[a]	10.59 ± 1.80[a]	10.52 ± 0.94[a]	10.29 ± 2.61[a]
Protein content (%)	3.80 ± 1.49[a]	3.76 ± 2.26[a]	3.86 ± 2.20[a]	3.59 ± 2.56[a]

Mean values ± standard deviation within column with same letter superscripts indicate that there is no significant difference ($p>0.05$).

Table 10. Saponin content in candlenut oil and F3.

Sample	Saponin Content (mg/g)
Candlenut Oil	6.83
Ice cream with 6% candlenut oil (F3)	1.93

Table 11. TPC analysis of formulated ice cream.

Ice Cream Formulation	Total Plate Count (CFU/ml)
Blank	5.0×10^{1}
F3 at day 1	5.8×10^{1}
F3 at day 42	5.8×10^{1}

Figures :

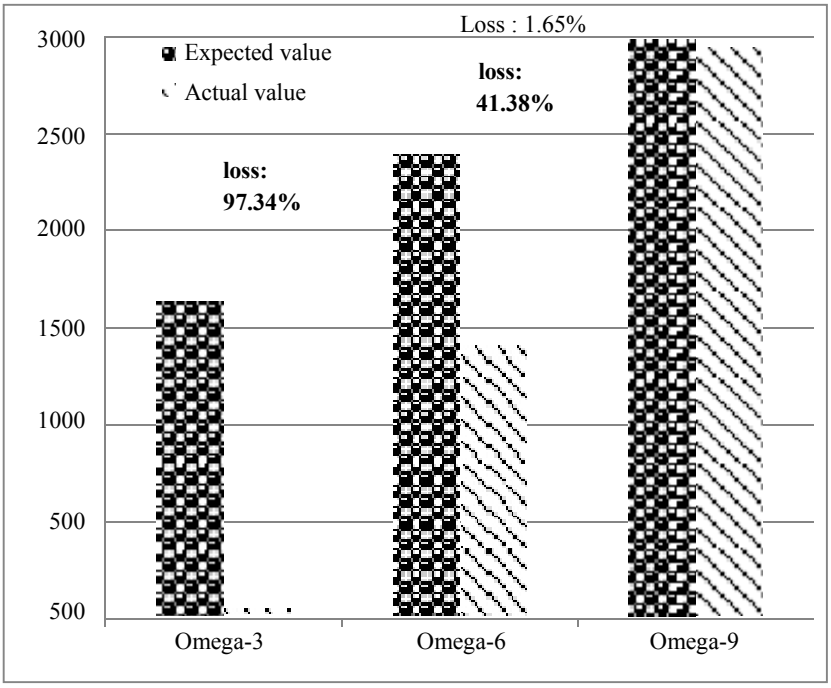

Figure 1. Comparison of expected value and actual value of Omega-3, Omega-6 and Omega-9 in F3

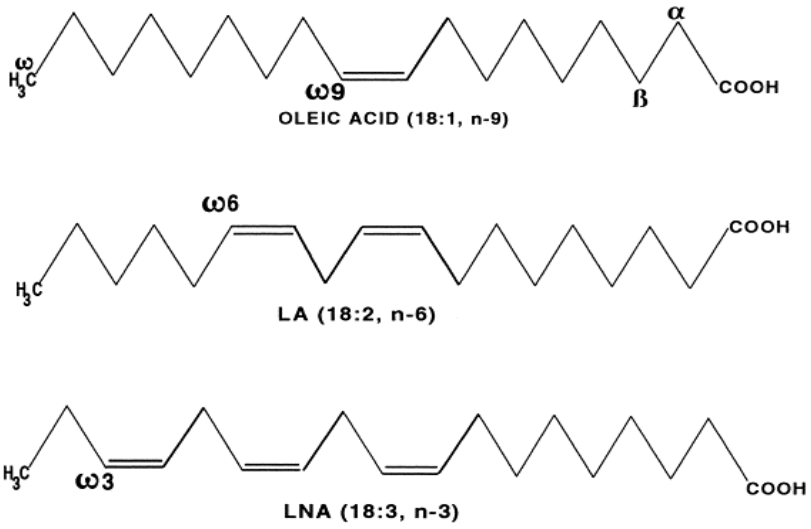

Figure 2. Chemical Structure of Omega-3, Omega-6 and Omega-9 Fatty Acid.

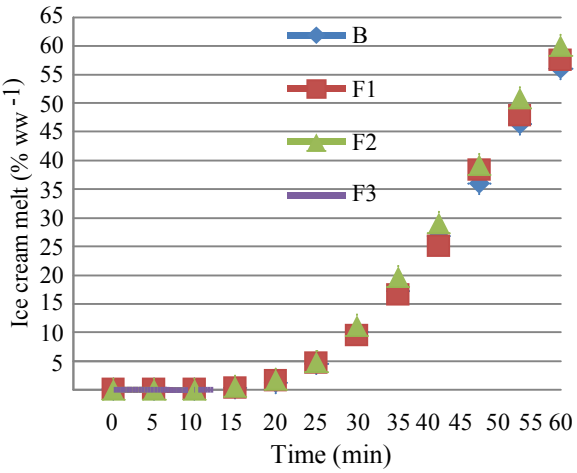

Figure 3. Meltdown characteristics of ice cream over 60 minutes at 25°C.

O07

Effects of Candlenut Oil Addition on Physicochemical Properties of Ice Cream

Maria O. Lukmanto, Filiana Santoso, Hery Sutanto

Department of Food Technology, Faculty of Life Science, Swiss German University
BSD Edutown, Serpong, Tangerang 15339, Indonesia

Abstract

The objective of this research was to increase the unsaturated fatty acid content (omega-3, omega-6 and omega-9) in ice cream by the substitution of whipping cream with candlenut oil and to study the effect of the candlenut oil addition on physicochemical properties of the ice cream. The candlenut oil was extracted using expeller pressing method. Low temperature was applied during extraction to prevent degradation of colour, flavour and unsaturated fatty acid content of the candlenut oil. The oil from the candlenut extract was found to have high unsaturated fatty acid content. The amount of omega-3, omega-6 and omega-9 in candlenut oil was 26.50%, 39.86% and 24.36% respectively. The candlenut oil was added in three different timing during ice cream production; before pasteurisation, after pasteurisation and after aging. Various amount of candlenut oil (2%, 4% and 6%) were added to ice cream to replace the whipping cream. Sensory analysis using hedonic test with 30 untrained panellists was conducted to select the most preferred composition of candlenut oil in ice cream. Ice cream with addition of 6% candlenut oil before pasteurisation was chosen by the panellists as having the best formulation. During the ice cream production, there were losses in unsaturated fatty acid content in the ice cream with 6% candlenut oil. Omega-9 has the least amount of losses (1.65%), followed by significant losses of omega-6 (41.38%) and omega-3 (97.34%). In overall, total soluble solid and pH of each ice cream formula remained stable. Other nutritional values of ice cream formulas (ash content, fat content and protein content) did not change significantly as well. Candlenut oil did not contribute to any additional protein value and mineral content in ice cream. However, higher concentration of candlenut oil in ice cream resulted in a slight increase in the rate of melting down. This was attributed to the low melting temperature of candlenut oil. The rate of melting down of ice cream increased gradually with higher concentration of candlenut oil added to the ice cream. The higher concentration of candlenut oil added to the ice cream resulted in the decrease of the moisture content. This was due to the fact that the whipping cream had high moisture content while candlenut oil had very low moisture content.

Keywords: Candlenut oil, unsaturated fatty acid, ice cream, physicochemical properties

ICAPHP

INTERNATIONAL CONFERENCE
ON AGRICULTURAL POSTHARVEST
HANDLING AND PROCESSING

CERTIFICATE OF APPRECIATION **PRESENT** TO :

Maria Olivia Lukmanto, S.T., B. Eng

As

PARTICIPANT

In

ICAPHP

INTERNATIONAL CONFERENCE ON AGRICULTURAL
POSTHARVEST HANDLING AND PROCESSING

November 19 - 21, 2013, Jakarta - Indonesia

Dr. Haryono

Directorat General of IAARD

ABSTRACT AND PROGRAM BOOK

ICAPHP

INTERNATIONAL CONFERENCE ON AGRICULTURAL POSTHARVEST HANDLING AND PROCESSING

Breakthrough in Postharvest and Processing Technology as The Backbone of Tomorrow's Green Economy

NOVEMBER 19 - 21, 2013

JAKARTA - INDONESIA