Food Research 7 (1) : 236 - 243 (February 2023)
Journal homepage: https://www.myfoodresearch.com

FULL PAPER

Evaluation of the effect of sesame lecithin emulsifier generated from sesame oil water degumming process on margarine production

Berdiansyah, S. and *Arifan, F.

Industrial Chemical Engineering, Vocational School, Diponegoro University, Semarang, 50275, Indonesia

Article history:
Received: 10 January 2021
Received in revised form: 11 September 2021
Accepted: 7 January 2022
Available Online: 21 February 2023

Keywords:
Sesame Lecithin,
Water Degumming,
Margarine

DOI:
https://doi.org/10.26656/fr.2017.7(1).553

Abstract

Lecithin or phosphatidylcholine is an important natural emulsifier and is found widely in various food fields in the manufacture of emulsions. However, commercial lecithin comes from soybean oil. This suggests that there is a need to study lecithin production from other vegetable oils, such as sesame oil. This study aimed to determine the production and characteristics of vegetable lecithin from sesame oil through a water degumming process, and then applied it to the production of margarine to determine the effect on physical, chemical, and organoleptic properties. The lecithin produced was used in the manufacture of margarine using a two factorial randomized block design method consisting of 3 levels. The results of this study indicated that the lecithin characteristic of sesame oil has the largest content, namely oleic acid (9-Octadecenoic, C19) of 46.58% and the strongest vibration band is CH2 vibration with stretching mode of symmetry and asymmetry at 2920 and 2850 cm^{-1}. The L3C3 treatment was the best result with 27% water content, 70% fat content, 98% emulsion stability, 8.25 cm spreadability and organoleptic showed a preference value, namely colour 3.40 (good), taste 2.50 (looking good), smell 2.50 (looking good) and texture 3.40 (good).

1. Introduction

Food is anything that comes from biological sources and water, whether it is processed or not, which is intended as food or drinks for human consumers, including food additives and other materials used in preparing, processing, and making food or drink (Nissa *et al.*, 2019). Phosphatidylcholine (PC), phosphatidylethanolamine (PE), and phosphatidylinositol (PI) are acetone-insoluble phosphatides that are mixed with other substances such as triglycerides, fatty acids, and other minor compounds to form lecithin (Reckziegel, 2015). Lecithin or phosphatidylcholine is an important natural emulsifier and is found widely in many food fields (Robert *et al.*, 2020). Commercial lecithin used in nutritional supplements is generally a mixture of phosphatidylcholine and other phospholipids extracted from animal fats and vegetable oils. Although lecithin and choline can be found in various foodstuffs, usually foods rich in lecithin or choline are also high in cholesterol and fat such as eggs, meat, organs/offal (Hamad *et al.*, 2017).

Therefore, the production of lecithin from other vegetable oils can be a solution to the availability of halal vegetable lecithin such as sesame oil (Fatmawati *et al.*, 2012). Sesame seed contains lecithin which has antioxidant and hepatoprotective activity and ranges from 58 ppm to 395 ppm (United States Department of Agriculture, 2021). Sesame belongs to the *Pedaliaceae* family and of its nutrients with antioxidant function, vitamin E (alpha-tocopherol), and lignans, such as sesamin, sesamolin, and sesamol, stand out (Gouveia *et al.*, 2016). Sesame oil can be used as an emulsifier by producing lecithin. An emulsifier is a material used to reduce the interface tension between two phases which normally do not mix to be emulsified. Whereas a surfactant is a substance that can reduce the surface tension of a medium and reduce the interface tension between two phases with different polarities. Surfactants used in the food sector are called emulsifiers. There are 2 types of emulsifiers based on their origin, either natural or synthetic (Nawangsasi *et al.*, 2018).

One way of producing lecithin from vegetable oil is through the degumming process with the addition of water (Hamad *et al.*, 2017). Separation of gum or degumming is a process of separating sap or mucus which consists of phospholipids, proteins, residues, carbohydrates, water, and resins, without reducing the amount of free fatty acids in the oil. Degumming

*Corresponding author.
Email: *fahmiarifan@live.undip.ac.id*

eISSN: 2550-2166 / © 2023 The Authors.
Published by Rynnye Lyan Resources

converts phospholipids into hydrated gum which is insoluble in oil and is further separated by filtration or centrifugation. This process will make it easier to remove gum in the next filtering process. The word lecithin was originally used for pure phosphatidylcholine, but now other phosphatides have been discovered (Balcaen *et al.*, 2021). The lecithin obtained is expected to be applied as an emulsifier, one of which is margarine. Margarine is a food product in the form of an emulsion (water in oil), either solid or semi-solid made from vegetable fat and water, with or without chemical changes including hydrogenation, interesterification, and has gone through a refining process as the main ingredient8. The basic formulation of margarine is 80% fat/oil, 2-4% salt, 16% water, 0.2% antioxidant, 0.3% emulsifier, coloring and flavoring to taste (Li *et al.*, 2018).

This study aimed to determine the production of vegetable lecithin from sesame oil through a water degumming process and as an effort to find an alternative source of new lecithin derived from sesame oil by knowing the characteristics of lecithin and applied to margarine to determine its effect on physical, chemical and organoleptic properties.

2. Materials and methods

2.1 Materials

The ingredients used are sesame oil, aquadest, cooking oil, carboxymethyl cellulose (CMC), full cream milk, H_2SO_4 98%, and glycerin. The equipment used is a magnetic stirrer and centrifuge used to extract gum (crude corn lecithin) by following the previously reported procedure (Hamad *et al.*, 2017). Gas Chromatography-Mass Spectrometry (GC-MS) and Fourier Transform Infra-Red (FT-IR) were applied for analysis and corn lecithin characterization.

2.2 Methods

The study took place during the period of October to November 2020. The study included the process of making sesame lecithin followed by the analysis of the characteristics of the lecithin sesame with GCMS and FTIR. Furthermore, the process of making margarine for application to fellow lecithin and physicochemical analysis includes moisture content, fat content, emulsion stability, and spreadability as well as organoleptic analysis.

2.3 Gum production process (crude sesame lecithin)

Extraction of gum from sesame oil was done by mixing 250 mL of corn oil with distilled water (15 mL) then heated at a temperature of 80°C which was kept constant and stirred for 2 hrs. In this process, a clear colour layer will be obtained which will be taken and dried, the result of this drying is called gum. The clear layer obtained from heating is separated using a centrifuge at an acceleration of 500 rpm for 20 mins. The thin layer obtained after the centrifuge process is then dried using an oven with a temperature of 90.5°C for 5 days (Hamad *et al.,* 2017).

2.4 FTIR and GCMS analysis procedures

FTIR and GCMS testing was carried out at the Diponegoro University Integrated Laboratory. FTIR testing was carried out to determine the functional groups formed in the same lecithin emulsifier that had gone through the water degumming process, while the analysis by GC-MS was carried out to determine the acyl chain structure of lecithin.

2.5 Margarine making process

In making margarine with the 2 factorial randomized block design (RBD) method consisting of 3 levels. Factorial 1 was the addition of lecithin emulsifier with a weight of 0 g, 20 g, and 30 g, while factorial 2 was with the addition of CMC with a weight of 0 g, 20 g, and 30 g so that 9 treatment combinations were obtained with 3 replications.

2.6 Margarine analysis procedure with the addition of sesame lecithin and carboxymethyl cellulose

Margarine with the addition of sesame lecithin and CMC was tested for physical, and chemical properties such as moisture content, fat content, emulsion stability, spreadability, and also organoleptic tests. Data analysis was performed using ANOVA with a 5% confidence interval. If there is an interaction between factors, it is continued into the DMRT (Duncan Multiple Range Test) tests. Selection of the best treatment using multiple attributes.

3. Results and discussion

3.1 Characteristics of sesame lecithin emulsifier

The resulting sesame lecithin preliminary testing was carried out using GC-MS to determine the content in sesame lecithin. Using GC-MS to determine the acyl chain structure of sesame lecithin is considered effective because it does not require a longer retention time and the results can be accurately proven (Paradissis *et al.*, 2005). The data from the GC-MS test results are presented in tabular form and can be seen in Table 1.

The results of the mass spectroscopic analysis of each peak showed a fragmentation pattern of myristic acid (Tetradecanoic, C_{15}) 0.69%, palmitic acid

Table 1. The components in the same lecithin emulsifier were GC-MS test results

No	R. Time	Composition (%)	Component Name	Structural Formulas
1	34.05	0.69	Tetradecanoic acid, methyl ester (CAS)	$C_{15}H_{30}O_2$
2	39.36	41.39	Hexadecanoic acid, methyl ester (CAS)	$C_{17}H_{34}O_2$
3	43.41	46.58	9-Octadecenoic acid (Z)-, methyl ester (CAS)	$C_{19}H_{36}O_2$
4	44.07	5.95	Octadecanoic acid, methyl ester (CAS)	$C_{19}H_{38}O_2$
5	47.23	1.21	Oxiraneoctanoic acid, 3-octyl-, methyl ester, cis- (CAS)	$C_{19}H_{36}O_3$

(Hexadecanoic, C_{17}) 41.39%, oleic acid (9-Octadecenoic, C_{19}) 46, 58%, stearic acid (Octadecanoic, C_{18}) 5.95%, and oxalic acid (Oxiraneoctanoic, C_{19}) 1.21%. stearic acid (Octadecanoic, C_{18}) 5.95%, and oxalic acid (Oxiraneoctanoic, C_{19}) 1.21%. From these results, it can be seen that the fatty acid residues of the phospholipids, Ri and R2, the results of the isolation correspond to the fatty acid components found in sesame oil. Thus, the isolated phospholipids from sesame oil have a polar part as well as a non-polar part. A polar part is an amine group that can form hydrogen bonds with water because of the lone pair on the N atom (Hudiyanti *et al.*, 2012). While the non-polar parts have components that match the constituent components of sesame oil for this part to dissolve in the oil. It can also be seen that the largest content of lecithin oil produced is oleic acid (9-Octadecenoic, C_{19}) at 46.58%. This can cause the phospholipids to easily interface between sesame oil and water, this ensures the emulsion formed is relatively stable.

Furthermore, sesame lecithin was tested using FTIR to determine its functional groups from the same lecithin emulsifier. The FTIR spectra of the lecithin extract from sesame oil are given in Figure 1. Sesame oil lecithin has a gel-like appearance with a yellowish-white colour at first but over time the colour becomes browner due to the oxidation reaction (Li *et al.*, 2018). Fourier transforms infrared (FTIR) spectroscopy is widely used for the authentication of certain food products. FTIR instruments have many advantages over conventional dispersive instruments, with more energy yield, excellent wave number reproducibility and accuracy, broad and precise spectral manipulation capabilities, and advanced chemometric software to handle calibration development (Nzai *et al*., 1999).

FTIR results (Figure 1) show that sesame oil lecithin has almost the same absorbance pattern in the specific absorption regions for lecithin. The infrared spectra for lecithin can be divided into spectral regions arising from the vibrations of the lipophilic tail molecule, the interface region, and the head group. The strongest visible bands are for CH_2 vibration, stretching mode of symmetry, and asymmetry at 2920 and 2850 cm^{-1}. These wavenumbers are usually 'conformational sensitive'. they are affected by changes in the trans/gauche conformational ratio in the acyl chain (Hudiyanti et al., 2012). There is also an absorption band for the terminal CH_3 groups in the region of 2922 cm^{-1}. Vibration for the ester groups in particular for the C = O stretch appears in the region 1743-1700 cm^1. PO2 - at 1100-1000 cm^{-1}. According to previous research conducted by Hudiyanti *et al* (2012) which used commercial soy lecithin as a comparison for coconut lecithin and sesame lecithin. The results of FTIR analysis on commercial soy lecithin had an absorbance pattern that was not much different from the produced sesame oil lecithin. It was found that soy lecithin was the strongest band for CH_2 vibrations, stretching mode at 2920 and 2851 cm^{-1}. For the CH_3 group, the absorption band is known in the region of 2923.9 cm^{-1}, and the C = O stretching appears in the region 1735-1700 cm^{-1}, N-H at 3394 cm^{-1}, and PO2 - at

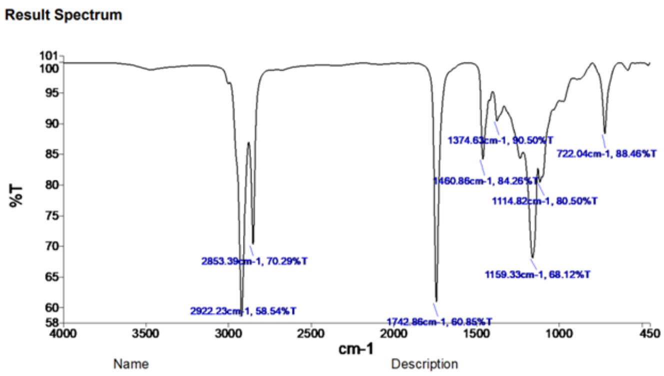

Figure 1. FTIR Spectra of sesame lecithin emulsifier

1200-1000 cm^{-1}.

3.2 Analysis of average physical chemistry margarine

This variation analysis aims to determine the differences in the average physical chemistry of margarine with the given factors between the addition of sesame lecithin and CMC. The average physical chemistry that was carried out was water content, fat content, emulsion stability, and spreadability to the resulting margarine with the addition of two predetermined factors. The resulting physical-chemical mean will be tested with the Analysis of Variance Two Factor without replication test to find out whether there is a real difference or not a significant effect on the two factors that have been given.

Table 2 shows the results of Duncan's continued test on the addition of CMC and sesame oil lecithin to the average physical chemistry of margarine. The mean

https://doi.org/10.26656/fr.2017.7(1).553

value which is marked with the same letter shows no significant difference at the 5% level between the treatments given. It can be seen that the addition of CMC and sesame oil lecithin greatly affects the average physical chemistry of margarine. Where the best treatment is known on run 9 using sesame oil lecithin and CMC of 30 g. This is because lecithin has a higher hydrophilic group than the hydrophobic group. Lecithin is an emulsifier that tends to be nonpolar and has a hydrophobic group as a fat-binding group and a hydrophilic one as a water-binding group. The higher the concentration of the added lecithin emulsifier, the higher the hydrophilic and hydrophobic groups, that the water content decreases, and the fat content will increase (Fitriyaningtyas *et al.*, 2015). According to Susilawati *et al.* (2016), the addition of an emulsifier causes the emulsion to become more stable, which is indicated by the less oil that is separated when it is in the centrifuge.

Table 2. Results of Duncan's Multiple Range Test (DMRT)

Run	Average Physical Chemical Analysis	DMRT 5%
1	39.3125ab	44.86
2	37.072a	42.47
3	37.729ab	43.27
4	37.458ab	42.98
5	39.916ab	45.46
6	42.803bc	48.35
7	42.291ab	47.84
8	48.333c	53.88
9	50.8125d	56.36

Lecithin as an emulsifier can stabilize oil and water which is clear from its structure.

The best treatment is at the highest number, 56.36 with the notation "d" and the same treatment followed by the notation "d" is at number 53.88. So, from the DMRT test analysis regarding the effect of the addition of sesame lecithin and CMC factors on the average physical chemistry of margarine, the best treatment was at run 9 with the next best being at run 8 of course this is not yet a valid reference because it still has to be discussed in more detail about the influence generated by these factors and due to this research on food, market factors and also SNI must also be considered further.

3.3 Analysis of moisture content of margarine

In Figure 2 it can be seen that the more the addition of sesame lecithin emulsifier and CMC from Run 1 to Run 9, the resulting water content will decrease. This is because the higher the bounded water, the lower the evaporation rate, and with the increasing concentration of the emulsifier lecithin, the water content of the product will decrease. Water molecules in margarine can attract hydrophilic groups from other emulsifier materials such as CMC and push hydrophobic groups to the surface. That the polar part will surround the water and the water molecules are bound in a continuous phase which will inhibit the evaporation of water from the system. According to Prabandari (2011), the CMC can bind with water, therefore, water molecules are trapped in the gel texture formed by CMC.

The results of the moisture content obtained in this study amounted to 48-27% while the quality requirements for margarine (SNI 3541-2014) were at least 18%. This high water content is due to the non-hydrogenation process of making this margarine. The hydrogenation process in particular is practical because this process is also widely used in petroleum processing refineries to reduce aromatic content. The principle of the hydrogenation process is to add hydrogen atoms to unsaturated fatty acids to increase the saturation amount and reduce the double bonds (Heizal and Anwar, 2015).

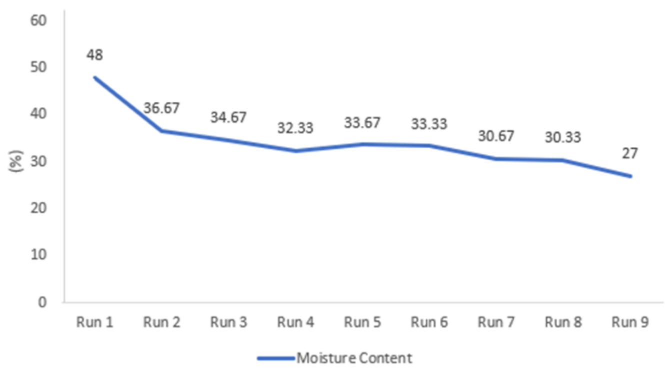

Figure 2. Graph of analysis of moisture content on margarine

3.4 Analysis of fat content in margarine

In Figure 3 it can also be seen that there is an increase between Run 1 to Run 9 in the fat content obtained. The increase in fat content at each Run was due to the increasing addition of the lecithin emulsifier concentration, making the hydrophobic group also higher which affected increasing margarine fat content. The correlation between water content and fat content is negative. The higher the fat content, the lower the water content. This is consistent with the results of observations on water content where the water content

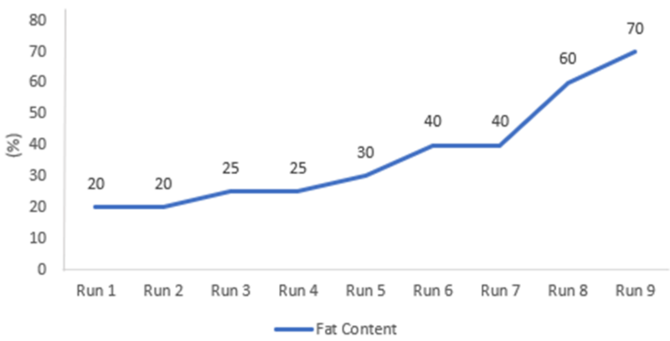

Figure 3. Graph of analysis of fat content in margarine

https://doi.org/10.26656/fr.2017.7(1).553

with the addition of emulsifier lecithin and CMC has decreased while the fat content has increased (Fitriyanintyas *et al.*, 2015).

Based on previous research by Ulfa (2017), the results obtained were 80.88-82.74% fat content, while in the research conducted in this research, the highest fat content obtained is 70% which means it is still far below the standard to be marketed. This is because the minimum fat content limit in margarine allowed by the Ministry of Health of the Republic of Indonesia in SNI 3541: 2014 is 80% (Ulfa *et al.*, 2017).

3.5 Analysis of emulsion stability of margarine

Lecithin as an emulsifier can stabilize oil and water which is clear from its structure. Emulsion stability is also influenced by the particle size, type, and amount of emulsifier, density difference between the two phases, the movement of the particles, and the viscosity of the external phase (Susilawati *et al.*, 2016).

In Figure 4, it can also be seen that there is an increase between Run 1 and Run 9 in the stability of the emulsion obtained. This is filled with lecithin which functions as an emulsifier and can stabilize oil and water that is clear from its structure. The two fatty acid radicals form the lipophilic part and show a strong affinity for fat, whereas the phosphocholine radical shows a strong

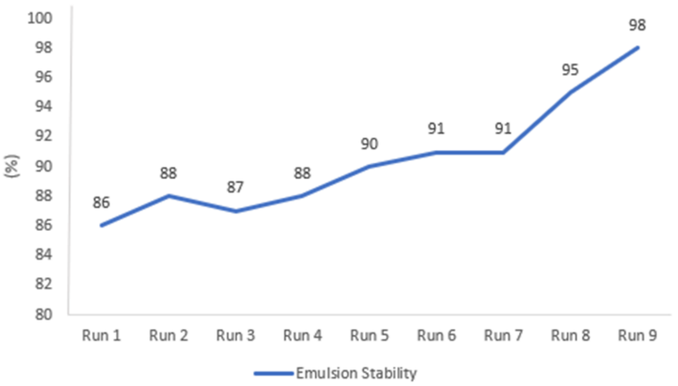

Figure 4. Graph of analysis of emulsion stability on margarine

affinity for water. In the mixture of oil and water, lecithin will form an emulsion by reducing the interfacial surface tension between the oil and water phases (Susilawati *et al.*, 2016).

Emulsion stability is defined as an emulsion separation process that runs slowly and the process is not observed during the desired time interval. A good emulsion does not form layers, does not change colour, and has a fixed consistency. Emulsion stability is one of the most important characteristics and has a major influence on the quality of the emulsion product when it is marketed. The stability of this emulsion will affect the shelf life of the emulsion system (Todingbua *et al.*, 2017).

3.6 Analysis of the spreadability of margarine

Spreadability is one of the important quality attributes of margarine and butter and instruments for measuring spreadability was first developed about 50 years ago (Board *et al.*, 1980). Spreadability, one of the most important attributes of margarine, butter, and shortening, is the ease with which a sample spreads out over a surface in a thin even layer. Furthermore, it is generally related to both firmness and consistency

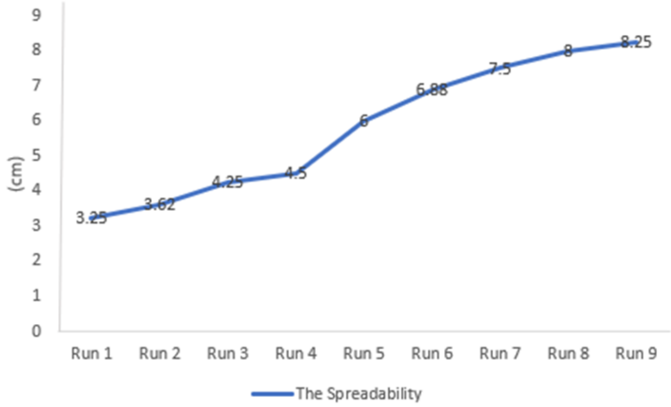

Figure 5. Graph of analysis of the spreadability of margarine

(smoothness, evenness, and plasticity) (Kangchai *et al.*, 2018). The spreadability is calculated from the length (cm) of the distance travelled by margarine when applied to a glass sheet. The value of the rubbing power (cm) of margarine can be seen in Figure 5.

In Figure 5 it can be seen that there is an increase in the spreadability of the use of lecithin emulsifiers. The higher the concentration of emulsifier lecithin and CMC added, the longer the spreadability. This is because lecithin has hydrophobic and hydrophilic groups that bind fat and water so the higher the concentration of lecithin emulsifier added will form a gel structure that can improve the level of smearing power. Whereas CMC has ionic properties of Na + carboxyl methylcellulose (CMC) which can attract sediment particles so that the sediment particles can be tightened and form a gel structure that can increase smear power. This makes CMC able to increase the spreadability of the resulting margarine.

3.7 Organoleptic test

The organoleptic test was carried out on the panellists on mayonnaise with the addition of sesame lecithin. The tests carried out included the colour, taste, smell, and texture of margarine.

3.7.1 Colour

The results of the organoleptic test on colour can be seen in Table 3. Consumer preferences for food products

https://doi.org/10.26656/fr.2017.7(1).553

are also determined by colour because product colour is the first attribute seen by consumers (Susilawati *et al.*, 2016).

Table 3 shows that in terms of colour, Run 8 and Run 9 received the highest average rating among the others, 3.40 followed by the notation "c" which means that in these two treatments the panellists preferred the treatment on run 8 and run 9. This is because the higher the concentration of lecithin emulsifier added, the lower the brightness level. Meanwhile, the addition of a CMC emulsifier also affects the increase in colour brightness (Fitriyaningtyas *et al.*, 2015). The addition of the lecithin emulsifier has a yellow colour which affects the colour of the final margarine product.

Table 3. Panelists' preferred level of margarine color

Run	Average of Color	Notation
1	1.00	a
2	2.20	b
3	2.10	b
4	2.20	b
5	3.30	c
6	2.50	b
7	2.40	b
8	3.40	c
9	3.40	c

3.7.2 Taste

Table 4. Panelists' preferred level of margarine taste

Run	Average of Taste	Notation
1	1.00	a
2	1.40	ab
3	1.40	ab
4	1.60	b
5	1.60	bc
6	1.60	bc
7	2.40	c
8	2.60	c
9	2.50	c

Organoleptic test results on taste can be seen in Table 4. Taste is the most decisive consideration for consumers in choosing or rejecting a margarine product in general. Taste is influenced by several factors chemical compounds, temperature, solution concentration, and interactions with other taste components (Winarno *et al.*, 2018).

Table 4 shows that in terms of taste run 8 gets the highest score among the others, 2.60 with the following notation "c", which means that the panellists prefer the treatment on run 8. This is because the margarine with the addition of lecithin emulsifier has an unpleasant taste. Which is derived from sesame oil extract, thus reducing the taste preferences of the panellists, while the addition of CMC emulsifier has an increasing tendency. CMC is a cellulose derivative that has a sweetness level of 69% so with the addition of the CMC emulsifier, the panellist's preference for taste increases. But in terms of taste, the highest value obtained was not the maximum value, this is because the resulting taste is not as strong as the typical taste of margarine in the market and the level of preference for neutral consumers leads to a bit like it (Winarno *et al.*, 2018).

Table 5. Panelists' preferred level of margarine smell

Run	Average of Smell	Notation
1	1.00	a
2	2.20	bc
3	1.90	b
4	2.20	bc
5	2.10	bc
6	2.20	bc
7	2.20	bc
8	2.60	c
9	2.50	c

3.7.3 Smell

The results of the organoleptic test on taste can be seen in Table 5. The distinctive aroma that arises can be felt by the sense of smell depending on the constituent food ingredients, for example, with different processing factors, the resulting aroma will be different.

Table 5 shows that in terms of smell or aroma, run 8 gets the highest score among the others, which is 2.60 with the following notation "c", which means that the panellists prefer the treatment on run 8. This is because the CMC is in powder form white, odourless, and tasteless which does not affect the aroma of the product, while the lecithin emulsifier has a slightly unpleasant aroma that can affect the aroma of food (Fitriyaningtyas *et al.*, 2015).

3.7.4 Texture

Table 6. Panelists' preferred level of margarine texture

Run	Average of Texture	Notation
1	1.00	a
2	2.00	bc
3	2.10	c
4	1.60	b
5	2.20	c
6	1.80	bc
7	1.90	bc
8	3.40	d
9	3.40	d

https://doi.org/10.26656/fr.2017.7(1).553

The results of the organoleptic test on taste can be seen in Table 6. The preferred texture of the panellists is the one that is easier to smear (Herizal and Anwar, 2015). The assessment of consumers who rather like the texture is likely that the resulting texture is closer to the typical texture of margarine, semi-solid (Kartikasari *et al.*, 2019).

Table 6 shows that in terms of smell or aroma on run 8 and run 9, it gets the highest score among the others, which is 3.40 with the following notation "d", which means that the panellists prefer the treatment on run 8 and run 9. The addition of CMC has a higher value compared to the addition of lecithin emulsifier although it is not too significant.

4. Conclusion

The result of the research aims to determine the production of vegetable lecithin from sesame oil through the water degumming process and as an effort to find new alternative sources of lecithin derived from sesame oil by knowing the characteristics of lecithin and applying it to margarine to determine the effect on physical, chemical and organoleptic properties. Sesame lecithin was produced, and initial testing was carried out using GC-MS to determine the content and the acyl chain structure of sesame lecithin. Furthermore, sesame lecithin was tested using FTIR to determine the functional groups of the Sesame Lecithin emulsifier. From the results of the study, it can be seen that the sesame lecithin produced can be used as an emulsifier in the manufacture of margarine which is then carried out by physical-chemical analysis. This analysis of variation aims to determine the differences that occur in the average physical chemistry of margarine with the given factor between the addition of sesame lecithin and CMC. The average physical chemistry was carried out, namely water content, fat content, emulsion stability, and spreadability of margarine produced by adding two predetermined factors.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

The author would like to thank all parties in the Nutrition Laboratory and Food Technology Laboratory of Diponegoro University.

References

Balcaen, M., Steyls, J., Schoeppe, A., Nelis, V. and Meeren, P.V.D. (2021). Phosphatidylcholine-depleted lecithin: A clean-label low-HLB emulsifier to replace PGPR in w/o and w/o/w emulsions. *Journal of Colloid and Interface Science*, 581, 836–846. https://doi.org/10.1016/j.jcis.2020.07.149

Board, P.W., Aicken, K. and Kuskiss, A. (1980). Measurement of the spreadability of margarine and butter using a single pin maturometer. *Journal Food Technology*, 15(3), 277–283. https://doi.org/10.1111/j.1365-2621.1980.tb00940.x

Fatmawati, N.K., Ali, M. and Widjajanto, E. (2012). Efek Proteksi Kombinasi Minyak Wijen (Sesame Oil) dengan α-Tocopherol terhadap Steatosis melalui Penghambatan Stres Oksidatif pada Tikus Hiperkolesterolemia. *Journal of Experimental Life Sciences*, 2(2), 56–64. https://doi.org/10.21776/ub.jels.2012.002.02.01 [In Bahasa Indonesia].

Fitriyaningtyas, S.I. and Widyaningsih, T.D. (2015). The Effect of Lecithin and CMC Against Physical, Chemical and Organoleptic Apple Manalagi Margarine (*Malus sylfertris Mill*) which Supplemented with Peanut Oil. *Jurnal Pangan dan Agroindustri*, 3(1), 226–236.

Gouveia, L.D.A.V., Carolina, A.C., Glaucia, M.M.D.O., Glorimar, R. and Annie, S.B. (2016). Effect of The Intake of Sesame Seeds (*Sesamun indicum L.*) and Derivates on Oxidative Stress: A Systematic Review. *Journal of Medicinal Food*, 19(4), 337–345. https://doi.org/10.1089/jmf.2015.0075

Hamad, A., Heru, S. and Ma'ruf, A. (2017). Optimasi produksi *lecthin* dari proses water degumming minyak wijen menggunakan response surface methodology. *Jurnal Momentum,* 13(1), 39–45. [In Bahasa Indonesia].

Herizal and Anwar, C. (2015). Making Biodiesel from *Reutealis Trisperma* (*Blanco*) Airy Shaw Via Catalytic Hydrogenation of Raw Material with Ni γ Al_2O_3 Catalyst. *Journal Lemigas ESDM*, 02, 53–60.

Hudiyanti, D., Raharjo, T.J. and Noegrohati, S. (2012). Isolasi dan karakterisasi lesitin kelapa dan wijen isolation and characterization of plant lecithin. *Journal of Agritech*, 32, 23-26. https://doi.org/10.22146/agritech.9652 [In Bahasa Indonesia].

Kangchai, W., Ratsamee, S. and Pawadee, M. (2018) Feasibility Study of Margarine Substitute Based on Gelatin-oil Emulsion Gel. *Chiang Mai Journal of Science,* 45(1), 505-514.

Kartikasari, L.R., Hertanto, B.S. and Nuhriawangsa, A.M.P. (2019). Evaluasi Kualitas Organoleptik Mayonnaise Berbahan Dasar Kuning Telur yang Mendapatkan Suplementasi Tepung Purslane (*Portulaca oleracea*). *Jurnal Ilmu Produksi Dan*

FULL PAPER

Teknologi Hasil Peternakan, 7(2), 81–87. https://doi.org/10.29244/jipthp.7.2.81-87 [In Bahasa Indonesia].

Li, Y., Zhao, J., Xie, X., Zhang, Z., Zhang, N. and Wang, Y. (2018). A low trans margarine fat analog to beef tallow for healthier formulations: Optimization of enzymatic interesterification using soybean oil and fully hydrogenated palm oil. *Journal Food Chemistry*, 255(1), 405–413. https://doi.org/10.1016/j.foodchem.2018.02.086

Nawangsasi, I.R., Hintono, A. and Pramono, Y.B. (2017). Karakteristik Fisikokimia Emulsi Ganda W/O/W Sodium Klorida (NaCl) pada Bumbu Mi Instan. *Journal Foreign Affairs*, 91(5), 1689–1699. https://doi.org/10.1017/CBO9781107415324.004 [In Bahasa Indonesia].

Nissa, C., Arifan, F., Febrianto, R., Aditya, W., Hayu Dwimawanti, I. and Pramudyono Widyasmara, R., 2019, Effect of sugar on nutrient composition and shelf life of red guava jams. *IOP Conference Series: Earth and Environmental Science*, 406, 012027. https://doi.org/10.1088/1755-1315/406/1/012027

Nzai, J.M. and Proctor, A. (1999). Soy lecithin phospholipid determination by fourier transform infrared spectroscopy and the acid digest/arseno-molybdate method: A comparative study. *Journal of the American Oil Chemists' Society*, 76(1), 61–66. https://doi.org/10.1007/s11746-999-0048-9

Pande, G., Akoh, C.C. and Shewfelt, R.L. (2013). Utilization of enzymatically interesterified cottonseed oil and palm stearin-based structured lipid in the production of trans-free margarine. *Journal of Biocatalysis and Agricultural Biotechnology*, 2(1), 76–84. https://doi.org/10.1016/j.bcab.2012.08.005

Paradissis, A., Hatziantoniou, S., Georgopoulos, A. and Demetzos, C. (2005). Lipid analysis of Greek broad bean oil: Preparation of liposomes and physicochemical characterization. *European Journal of Lipid Science and Technology,* 107(11), 799–804. https://doi.org/10.1002/ejlt.200501148

Reckziegel, Y. (2015). Characterization and comparison of the functionality of fractionated lecithin from different sources. Belgium: Ghent University, MSc. Thesis.

Robert, C., Couëdelo, L., Vaysse, C. and Michalski, M.C. (2020). Vegetable lecithins: A review of their compositional diversity, impact on lipid metabolism and potential in cardiometabolic disease prevention. *Biochimie*, 169, 121–132. https://doi.org/10.1016/j.biochi.2019.11.017

Susilawati, Sugiharto, R. and Damaiyanti, S.M. (2016). Formulasi virgin coconut oil (VCO) dan pengemulsi lesitin kedelai terhadap stabilitas emulsi dan sifat organoleptik pasta kacang merah. *Jurnal Teknologi Industri dan Hasil Pertanian*, 21, 42-50. [In Bahasa Indonesia].

Todingbua, A., Masud, I. and Indriati, S. (2017). Produksi Margarin dari Minyak Biji Mangga Serta Analsis Sifat Fisiko Kimianya. *Prosiding Seminar Hasil Penelitian*, 2017, 127–132. [In Bahasa Indonesia].

Ulfa, A.M. Winahyu, D.A. and M.J. (2017). Penetapan kadar lemak margarin merk x dengan kemasan dan tanpa kemasan dengan metode sokletasi determination. *Jurnal Analisis Farmasi*, 32(2), 117–123. [In Bahasa Indonesia].

United States Department of Agriculture (USDA) (2021). Dr Duke's Phytochemical and Ethnobotanical Databases. Retrieved from USDA website: https://phytochem.nal.usda.gov/phytochem/search

Winarno, F.G. (2018). Kimia Pangan dan Gizi. Jakarta, Indonesia: PT. Gramedia Pustaka [In Bahasa Indonesia].

https://doi.org/10.26656/fr.2017.7(1).553