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Kernel Condition with Variations in Roasting Temperature on Yield and Quality of Candlenut Oil

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ABSTRACT

Background: Candlenut is one of the vegetable oil-producing plants as a source of biodiesel raw materials. One of the innovations is to increase the production and quality of candlenut oil by treating the kernels before roasting. Kernel condition (whole or fine powder) and roasting temperature affects and the oil production. This study aims to determine the condition of the kernel at various roasting temperatures on the production, yield and quality of the oil.

Methods: Using a one-factor completely randomized design, kernel conditions with variations in roasting temperature consists of 7 (seven) levels, such as T_0= Finely ground kernel, without roasting; T_1= Whole kernel, roasted at 80°C for one hour, then mashed; T_2= Whole kernel, roasted at 90°C for one hour, then mashed; T_3= Whole kernel, roasted at 100°C for one hour, then mashed; T_4= finely ground kernel, baked at 80°C for one hour; T_5= Finely ground kernel, baked at 90°C for one hour; T_6= Finely ground kernel, baked at 100°C for one hour. Each treatment was repeated 5 times and further tested with Duncan's multiple range test at 0.01 level.

Result: The results showed that the roasted fine powder kernels resulted in higher oil production, oil weight and oil yield compared to unroasted kernels and whole roasted kernels. The best results were found in finely ground kernels roasted at 90°C. The roasting temperature lowers the free fatty acid content of the oil, whole kernels produce lower free fatty acids than finely ground kernels. The lowest free fatty acids were found in whole kernels baked at 90°C.

Key words: Biodiesel, Candlenut, Fine powder, Free fatty acids, Oil yield, Viscosity, Whole kernel.

INTRODUCTION

The need for fuel oil increases along with the increase in the world's population and the fuel is obtained from fossils. The increasing demand for energy causes exploitation, higher consumption of energy from petroleum and depletion of petroleum reserves. One solution to overcome this problem is to look for renewable energy sources that can be produced continuously and sustainably (Giri *et al.*, 2013; Kumar *et al.*, 2014). Alternative fuels in the form of biofuels (biodiesel, bioethanol and biogas) can be sourced from various plants such as coconut, oil palm, jatropha, candlenut, sugarcane and other oil-producing plants (Giri *et al.*, 2013; Aliyu *et al.*, 2017; Thangaraj *et al.*, 2018; Konur, 2021). Biodiesel is a potential alternative fuel as an environmentally friendly substitute for diesel oil (Xu and Wu, 2003; Karmakar and Mukherjee, 2017; Anwar *et al.*, 2019; Ragade *et al.*, 2022).

Candlenut oil is one of the vegetable oils has the potential to be used as biodiesel (Salamah, 2010), containing oil ranging from 30%-60%, can be a promising source for commercial biodiesel production (Shaah *et al.*, 2021), suitable if free fatty acids are low (Pranowo *et al.*, 2016), this is also supported by the increase in candlenut production in Indonesia from 106,280 tons in 2015 to 118,150 tons in 2020 (BPS, 2021). Candlenut oil can be obtained by extraction after heating the kernel which will affect the oil yield (Shaah *et al.*, 2021). The results showed that the oil yield reached 60 per cent (Pranowo *et al.*, 2016), however, the condition of the fine or coarse kernel and the roasting temperature are factors that influences the yield and quality of the *i.e* candlenut oil produced. The finely ground kernels produced a higher amount of oil than whole kernels. Putri (2019) revealed that powder kernels with 90°C roasting resulted in higher oil weight and oil yield. This is due to the fact that the cell walls of the candlenut powder break easily when heated and the extraction process will be more evenly distributed (Arlene *et al.*, 2010; Gürdil *et al.*, 2020) .

The amount of hazelnut oil obtained is also influenced by temperature and roasting time. The right temperature and roasting time affect the breakdown of cells and coagulate the proteins present in the kernel and will speed up the release of oil. In addition, temperature affects the water content in the oil, the less water content in the oil produces better quality. The high amount of water content causes the

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oil to be hydrolyzed which can cause a high acid value, the oil will go rancid easily or cannot withstand long storage (Estrada *et al.*, 2007).

Arlene *et al.* (2010) reported that, the powder-sized kernels produced higher oil than whole-sized kernels, while the temperature showed that the best conditions for obtaining candlenut oil at a temperature of 60°C were to produce a yield of 89.63% v/v (Hariani *et al.*, 2013), the maximum yield was obtained when the size of the hazelnut seeds was powdered and at a temperature of 90°C (Arlene *et al.*, 2010).

Furthermore, information that is not widely known is how the potential yield and quality of candlenut oil from whole kernels are roasted first and then mashed compared to kernels that are mashed first and then roasted at 80°C, 90°C and 100°C, whether there is a relationship between whole kernels and mashed kernels with temperature gradations on the amount of yield and quality of the oil obtained. Based on this background, a study was conducted to determine the amount of yield and quality of candlenut oil in whole kernels and finely ground kernels with innovative heating temperatures. The results of this study obtained good kernels (whole or fine powder) with optimal roasting temperature in producing the highest amount of yield and good quality of candlenut oil to be used as a source of biodiesel. The purpose of this study was to determine the condition of the kernel at various roasting temperatures on the production, yield and quality of the oil.

MATERIALS AND METHODS

The research was carried out at the Agroecotechnology Laboratory, Faculty of Agriculture, Universitas Malikussaleh from August 2021 to November 2021 using a one-factor completely randomized design. Kernel conditions with variations in roasting temperature, consisting of 7 (seven) such as T_0= Fine powder kernel, without roasting, then extracted; T_1= Whole kernel, roasted at 80°C for one hour, then mashed and extracted; T_2= Whole kernel condition, roasted at 90ºC for one hour, then mashed and extracted; T_3= Whole kernel roasted at 100°C for one hour and, then ground and extracted; T_4= Finely ground kernel powder, roasted at 80°C for one hour and extracted; T_5= Finely ground kernel powder, roasted at 90°C for one hour and extracted; T_6= Finely ground kernel powder, roasted at 100°C for one hour and extracted. Each treatment level was repeated 5 times and if there was a significant difference, it was further tested with Duncan's multiple range test level at 0.01. The materials used were hazelnut kernel, thimble soxhlet, n-hexane and alcohol; the tools used were oven, thermometer, soxhlet, analytical balance, 10 ml vial, blender and measuring cup. Candlenut seeds were obtained from community gardens and then dried in the sun for two days to reduce the moisture content. Before separating the shell from the hazelnut meat (kernel), the hazelnut seeds were put in the freezer for 24 hours to facilitate the release of the kernel from the shell. Kernel separation was done mechanically with a shell-breaking machine, whole kernels and broken kernels were sorted. The process of extracting oil from the kernel was carried out by the following procedure: 1) T_0 treatment was carried out by breaking the kernel into a fine powder using a blender and then extracting the oil, 2) treatments T_1, T_2 and T_3 were done by roasting the whole kernels for 1 hour in an oven at 80°C, 90°C and 100°C, then crushed into powder with a blender and extracted the oil, 3) T_4, T_5 and T_6 treatments were done by breaking the kernels into powder smooth using a blender, then baked for 1 hour in an oven at a temperature of 80°C, 90°C and 100°C then extracted the oil. A total of 50 grams of kernel according to the treatment was extracted using Soxhlet and n-hexane as solvent at 67°C for 1 hour. The extracted oil was collected in a 10 mm vial and measured by the weight of oil (grams), amount of oil production (milliliters), oil yield (%) and free fatty acid content in oil (%).

RESULTS AND DISCUSSION

Oil weight and oil production

The results of showed that, the level of treatment of finely ground kernels roasted at 90°C for 1 hour (T_5) resulted in the largest weight of oil (24.41 g±1.47) and production of candlenut oil (29.05 ml±5.05) which was significantly make differed from the control treatment level (T_0) and the whole kernel roasted at 80°C, 90°C and 100°C (T_1, T_2 and T_3), but not significantly different from the level of treatment of fine powder kernel in the oven at 80°C and 100°C (T_4 and T_6). The lowest yields of oil weight (15.78 g±0.66) and total oil production 18.23 ml±0.53) were obtained at the control treatment (T_0) (Fig 1 and Fig 2).

Roasted fine powder kernels (T_4, T_5 and T_6) yielded higher oil weight and oil production than control (T_0) or roasted whole kernels (T_1, T_2 and T_3). The amount of weight and oil production at the treatment level of fine powder kernel roasted at 90°C is thought to be caused by the higher the roasting temperature, the lower the oil viscosity so that the oil comes out easily from the seed cells. One that affects the viscosity is the roasting temperature (Subroto *et al.*, 2017). In addition, fine powder kernels (small size) have a wider surface area and are more easily in contact with heat during the heating process in the oven (Nurnasari and Prabowo, 2019), making it easier to reduce the viscosity of the oil. In addition, when roasting at a temperature of 90°C, the pores of the cell walls of the finely ground candlenut material become easily broken. Heating the material which is smooth and has a large surface area makes the pores of the cell wall of the material open due to rupture, thus the oil easily comes out when extracted (Orhevba and Jinadu, 2011).

Oil yield

The results showed that the level of treatment of finely ground kernel powder roasted at 90°C for 1 hour (T_5) resulted in the highest oil yield of 48.82% (±2.95) which was significantly make differed from the control treatment level (T_0) and the treatment level. Whole kernels were roasted at 80°C, 90°C and 100°C (T_1, T_2 and T_3), but not significantly

make differed from the level of treatment with finely ground kernels roasted at 80°C and 100°C. The lowest yield of oil was obtained at the control treatment level (T_0), which was 31.56% (±1.32) (Fig 3).

The finely ground and roasted kernels (T_4, T_5 and T_6) produced a higher oil yield than the control (T_0) or roasted whole kernels (T_1, T_2 and T_3). The high oil yield at the treatment level of fine powder kernels and roasted at a temperature of 90°C is thought to be caused by higher heating which can coagulate proteins in the kernel so that the viscosity of the oil decreases and makes it easier for the oil to come out when extracted (Putri, 2019). The higher the heating temperature, the easier it is for the oil to leave the seed cells when extracted (Lumbantoruan *et al.*, 2014; Gürdil *et al.*, 2020) because the cell membranes are damaged a lot during heating and the amount of protein

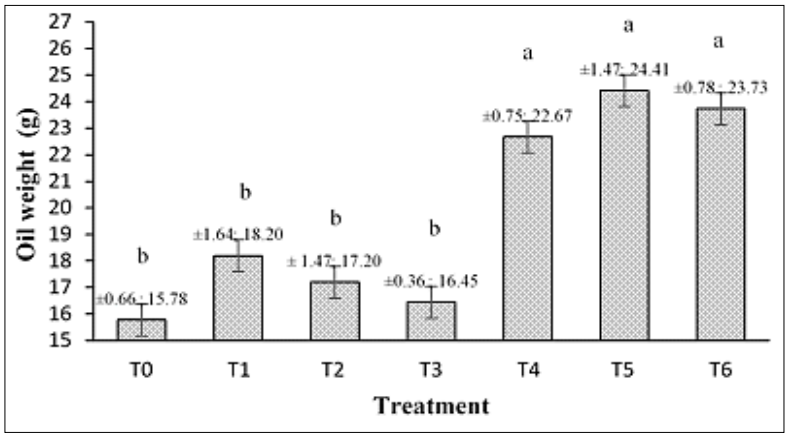


Fig 1: Candlenut oil weight.

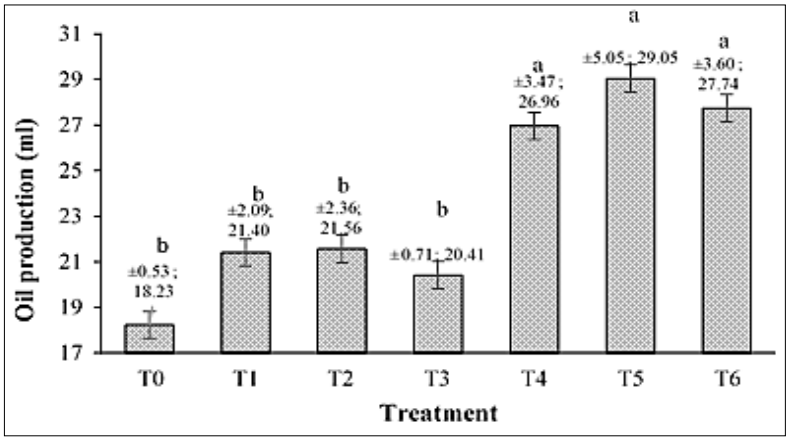


Fig 2: Candlenut oil production.

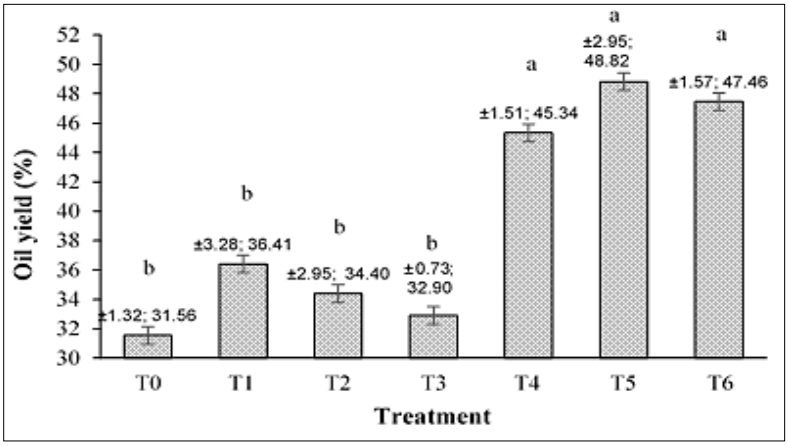


Fig 3: Candlenut oil yield.

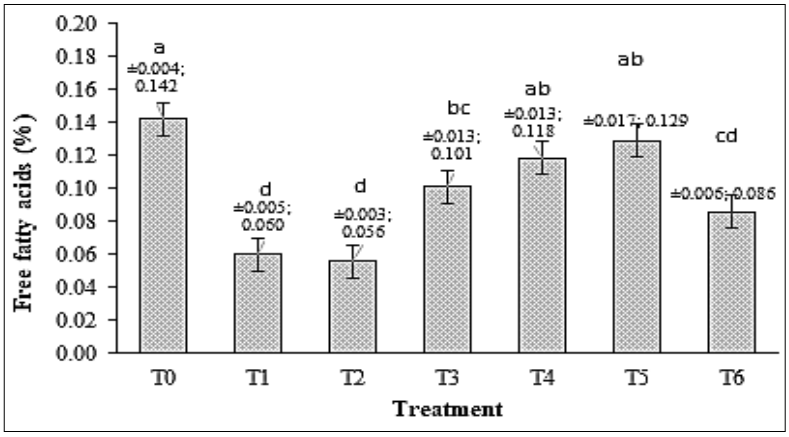


Fig 4: Candlenut oil free fatty acids.

denaturation is higher (Amaral *et al.*, 2006). In addition, it is also influenced by the water content in the seeds, where the oil yield obtained increases with increasing heating temperature, this is because the water content in the material has decreased. However, the results of present finding are differed from the research conducted by Riyanta *et al.* (2021) who reported that, the higher the roasting temperature, the lower the yield of hazelnut oil produced. In present study, the best roasting temperature was obtained at 90°C and decreased at 100°C although this decrease was not significantly differend from the 90°C roasting temperature.

The yield of candlenut oil without roasting (T_0) was lower than that of roasting (T_1-T_6) either with whole kernels or finely ground kernels. The roasting treatment of finely ground kernels (T_4, T_5 and T_6) resulted in a higher oil yield than roasting whole grains (T_1, T_2 and T_3). This shows that the kernel condition (size) and roasting temperature affects the yield of candlenut oil produced. The fine powder kernel and roasting temperature of 90°C resulted in a high oil yield (Fig 3). In present study, the kernel roasting temperature of 90°C for one hour was sufficient to provide a higher oil yield, although it did not show a significant difference between 80°C and 100°C.

Free fatty acids

The results of the *anova* showed that the candlenut oil from the kernel without roasting (T_0) produced higher free fatty acids, of 0.142% (±0.004) compared to the roasting temperature treatment and showed a very significant difference as compared to T_1, T_2, T_3 and T_6 (Fig 4). It can be seen that, result of roasting the kernels (whole or fine powder) were found to be in lower free fatty acids than those without roasting. Fine powder kernels at 80°C and 90°C (T_4 and T_5) roasting temperatures did not show significant differences with T_0. The lower free fatty acids in the kernel roasting temperature treatment were thought to be due to a fast reaction caused by the effect of the heat generated. Higher temperature reduces free fatty acids in candlenut oil (Özdemir *et al.*, 2001; Amaral *et al.*, 2006). Increasing the temperature carried out in the roasting process results in a decrease in free fatty acid levels (Özdemir *et al.*, 2001), but will increase the quality of candlenut oil as biodiesel which is of better quality (Saputra *et al.*, 2019; Ardjmand *et al.*, 2020). Higher temperature reduces free fatty acid levels in candlenut oil and this indicates that the quality of candlenut oil was found to be better, this result has been proven by testing lower levels of exhaust emissions *i.e.* carbon monoxide and hydrocarbons (Pham *et al.*, 2018).

CONCLUSION

From the present study it is concluded that, fine powder kernel roasted at 90°C resulted in higher oil weight, oil production and oil yield. Roasted whole kernels produce lower free fatty acids than finely ground kernels. The roasting temperature decreased the free fatty acids in the candlenut oil produced, the best temperature was obtained at 90°C.

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Conflict of interest: None.

REFERENCES

Aliyu, A.S., Deba, A.A. and Saidu, H. (2017). Green energy initiative: An overview of biodiesel production from jatropha feedstock in Nigeria. Journal of Advanced Research in Fluid Mechanics and Thermal Sciences. 35(1): 11-22.

Amaral, J.S., Casal, S., Seabra, R.M. and Oliveira, B.P.P. (2006). Effects of roasting on hazelnut lipids. J. Agric Food Chem. 54(4): 1315-1321. doi: 10.1021/jf052287v.

Anwar, M., Rasul, M.G., Ashwath, N. and Nabi, M.N. (2019). The potential of utilising papaya seed oil and stone fruit kernel oil as non-edible feedstock for biodiesel production in Australia-A review. Energy Reports. 5: 280-297.

Ardjmand, M., Jafarihaghighi, F., Hassani, M.S., Bazel, N. and Bahrami, H. (2020). A comprehensive review on the physical and chemical properties of the three generations of biofuels. Advances in Biotechnology: Openaccesse Book.com. pp. 41.

Arlene, A., Suharto, I. and Jessica, J.N. (2010). Effect of temperature and seed size on the recovery of candlenut oil on the extraction of candlenut seeds by mechanical pressing. Paper presented at the Seminar Nasional Teknik Kimia "Kejuangan" Pengembangan Teknologi Kimia untuk Pengolahan Sumber Daya Alam Indonesia Yogyakarta, 26 Januari 2010: 1-6 (in Indonesia).

BPS, (2021). BPS-Statistics Indonesia. from bps.go.id.

Estrada, F., Gusmao, R. and Indraswati, N. (2007). Extracting candlenut oil by pressing and followed by cake oil extraction. Widya Teknik. 6(2): 121-130 (in Indonesia).

Giri, R., Kundu, B., Diwan, P., Raj, K. and Wati, L. (2013). Ethanol production from direct sugarcane and juice by yeast. Agricultural Science Digest. 33(3): 188-192.

Gürdil, G.A.K., Kabutey, A., Selvi, K.Ç., Mizera, Č., Herák, D. and Fraňková, A. (2020). Evaluation of postharvest processing of hazelnut kernel oil extraction using uniaxial pressure and organic solvent. Processes. 8(8): 957. https://doi.org/10.3390/pr8080957.

Hariani, P.L., Riyanti, F. and Riska, M. (2013). Effect of temperature variations and oil concentration on yield and characteristics of biodiesel from candlenut seed oil (*Aleurites moluccana*). Paper presented at the Semirata FMIPA Universitas Lampung 2013, Lampung. 333-338. (in Indonesia).

Karmakar, A. and Mukherjee, S. (2017). Process optimization of biodiesel production from Neem oil. Indian Journal of Agricultural Research. 51(6): 529-535.

Konur, O. (2021). Edible Oil-based Biodiesel Fuels: A Scientometric Review of the Research Biodiesel Fuels based on Edible and Nonedible Feedstocks, Wastes and Algae: Boca Raton: CRC Press. pp. 418.

Kumar, R., Dixit, A., Singh, S.K., Sachdeva, M. and Singh, A. (2014). Studies on compatible fuel properties of sunflower ethyl ester and its blends with diesel for fuel use in compression ignition engines. Agricultural Science Digest. 34(2): 87-91.

Lumbantoruan, D., Rohanah, A. and Rindang, A. (2014). Test the effect of the heating temperature of candlenut seeds using a screw type oil press on the yield and quality of the oil produced. J. Rekayasa Pangan dan Pertan. 2: 92-98 (in Indonesia).

Nurnasari, E. and Prabowo, H. (2019). Effect of sample size and destilation time on rendement of Indonesian tobacco essential oil. Buletin Tanaman Tembakau, Serat and Minyak Industri. 11(2): 47-57 (in Indonesia).

Orhevba, B.A. and Jinadu, A. (2011). Determination of Physico-Chemical Properties and Nutritional Contents of Avocado Pear (*Persea americana* M.). Paper presented at the International Conference and 32nd Annual Generral Meeting of The Nigerian Institution of Agricultural Engineers (NIAE): 673-679.

Özdemir, M., Açkurt, F., Yildiz, M., Biringen, G., Gürcan, T. and Löker, M. (2001). Effect of roasting on some nutrients of hazelnuts (*Corylus avellena* L.). Food Chem. 73(2): 185-190. doi: https://doi.org/10.1016/S0308-8146(00)00260-0.

Pham, L.N., Luu, B.V., Phuoc, H.D., Le, H.N.T., Truong, H.T., Luu, P.D., Furuta, M., Imamura, K. and Maeda, Y. (2018). Production of biodiesel from candlenut oil using a two-step co-solvent method and evaluation of Its gaseous emissions. J. Oleo Sci, advpub. (ess17220): 1-10. doi: 10.5650/jos.ess17220.

Pranowo, D., Herman, M. and Syarifuddin (2016). The multiple benefits of developing kemiri sunan [*Reutealis trisperma* (Blanco) Airy Shaw] in degraded land. Perspektif. 14(2): 87-101 (in Indonesia).

Putri, E.M. (2019). Quality test of candlenut [*Aleurites moluccana* (L.) Willd] oil by pressing method using variations in temperature and seed size. (Thesis), Fakultas Matematika dan Ilmu Pengetahuan Alam. Universitas Jember (in Indonesia).

Ragade, V.R., Phadtare, S., Kharat, K.R., Kharat, A., Achary, P. and Kengar, A. (2022). Production and characterization of biodiesel from fatty residues of *Capra hircus*. Agricultural Science Digest. 42(4): 511-515.

Riyanta, A.B., Nabila, M.F. and Barlian, A. A. (2021). The effect of variations in roasting temperature on yield and percentage of inhibition of dpph radical reduction in candlenut oil the uv-vis spectrophotometric method. Jurnal Farmasi Sains dan Praktis. 7(2): 120-125 (in Indonesia).

Salamah, S. (2010). Production of alternative biodiesel fuel from candlenut oil. Paper presented at the Seminar Nasional Kimia dan Pendidikan Kimia II (SN-KPK II)" Riset dan Pembelajaran Kimia dalam Pengembangan Kompetensi Profesional. pp 186-190 (in Indonesia).

Saputra, E.D., Sarifah Nurjanah, H., Kramadibrata, A.M., Mardawati, E., Daradjat, W., Handarto, T. H., Rosalinda, S., Saukat, M. and Prijatna, D. (2019). The effect of increasing the capacity of the esterification stage of sunan candlenut oil (*Reutalis trisperma*) as a production raw material. Teknotan: Jurnal Industri Teknologi Pertanian. 13(2): 55-60. (in Indonesia).

Shaah, M.A., Allafi, F., Hossain, M.S., Alsaedi, A., Ismail, N., Kadir, M.O.A. and Ahmad, M.I. (2021). Candlenut oil: Review on oil properties and future liquid biofuel prospects. International Journal of Energy Research. 45(12): 17057-17079. doi: https://doi.org/10.1002/er.6446.

Subroto, E., Widjojokusumo, E., Veriansyah, B. and Tjandrawinata, R.R. (2017). Supercritical CO_2 extraction of candlenut oil: Process optimization using taguchi orthogonal array and physicochemical properties of the oil. Journal of Food Science and Technology. 54(5): 1286-1292. doi: 10.1007/s13197-017-2542-7.

Thangaraj, B., Solomon, P.R., Muniyandi, B., Ranganathan, S. and Lin, L. (2018). Catalysis in biodiesel production- A review. Clean Energy. 3(1): 2-23. doi: 10.1093/ce/zky020.

Xu, G. and Wu, G.Y. (2003). The investigation of blending properties of biodiesel and no. 0 diesel fuel. Journal of Jiangsu Polytechnic University. 15: 16-18.