Dear Prof. Frank Quina

Associate Editor ACS Omega

I wish to submit a manuscript entitled "Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (*Arenga Pinnata* MERR) Bioethanol and Premium" for possible consideration.

Finally I wish to affirm the manuscript has been prepared in accordance with instructions to authors. I also hereby affirm that the content of this manuscript or a major portion thereof has not been published in a refereed journal, and it is not being submitted for publication elsewhere.

Thank you very much and I shall wait for your kind response.

Warm regards,

Dr. Ansar

Department of Agricultural Engineering

University of Mataram, Indonesia

Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (*Arenga Pinnata* MERR) Bioethanol and Premium

Ansar[1*], Sukmawaty[1], Sirajuddin Haji Abdullah[1], Nazaruddin[2], Erna Safitri[1]

[1]Department of Agricultural Engineering, Faculty of Food Technology and Agroindustries, University of Mataram, Indonesia

[2]Department of Food Science and Technology, Faculty of Food Technology and Agroindustries, University of Mataram, Indonesia

[*]E-mail: ansar72@unram.ac.id

ABSTRACT

Along with the development of the motor vehicle industry technology at this time, the fuel demand is also increasing, while the supply is running low. Thus alternative fuels are needed to meet these energy needs. This study aims to explanation the physical and chemical characteristics of the fuel mixture (MF) between palm sap bioethanol with premium. The results showed that the higher the bioethanol concentration of palm sap, the higher the MF's viscosity, but the heat of the fuel decreased. This decrease is caused by differences in the heating value of the two fuels. The MF's high heat burn value is blue, while the low heat value of flame is reddish yellow. The results of this study are very important as a basis for the development of bioethanol from palm sap as an environmentally friendly vehicle fuel substitution material.

Keywords: bioethanol, calorific values, palm sap, flame, viscosity

1. INTRODUCTION

The human need for fuel is currently increasing along with the development of the motor vehicle industry.[1] The largest source of fuel used by motor vehicles comes from fossil fuels.[2] This fossil fuel cannot be expected for a long period of time because the amount is limited and cannot be renewed.[3, 4]

Bioethanol has been developed in many countries as an energy source for fossil energy substitution.[5, 6] Bioethanol production in the United States is developed from corn to apply bioethanol energy.[7] Brazil has been developing bioethanol sourced from sugar cane by conducting tests on vehicles since 1925.[8] China and Thailand develop bioethanol from cassava.[9] South Korea has been developing biodiesel since 2002 and its consumption is estimated to increase 0.5 percent per year.[5]

Brazil develops bioethanol from sugar cane at a low cost of 14 cent a dollar/liter. Thailand with tapioca 18.5 cent a dollar/liter, and America using corn 25.5 cent a dollar/liter.[10] The success of Brazil in producing bioethanol from sugar cane on an industrial scale, has led many countries to follow these strategic steps. Currently in Brazil motorcyclists can fill fuel tanks with a mixture of 24% ethanol and 76% gasoline.[11] As in Indonesia, the government has given serious attention to developing bioethanol by issuing Presidential Instruction No. 1 of 2006 regarding the supply and use of biofuel as an alternative fuel.[12, 13]

Bioethanol is one type of biofuel that can be used as a substitute for fossil fuels.[14, 15] The use of bioethanol as a fuel mixture is important to save the earth from global warming.[16] The development of bioethanol as an alternative fuel must be supported by several factors, including the availability of abundant raw materials, bioethanol making technology available, the existence of promising market opportunities and benefits.[17, 18]

Bioethanol can be produced from various types of plants, such as sugar cane, cassava, corn, sorghum, palm sap, or other types of plants.[18, 19] Palm sap (*Arenga Pinnata* MERR) is very abundant in Indonesia (Table 1), so it has the potential to be processed into bioethanol.[20] This plant contains glucose, fructose, sucrose with a composition of about 0.4-0.5%, 0.5-0.6%, and 10-13% respectively.[21, 22] The sugar content is quite high, so that palm sap has the potential to be processed into bioethanol.[23] So far, the use of palm sap is still very limited, namely only as the manufacture of palm sugar.[24]

Table 1. Estimation area of palm sap in Indonesia[25]

Province	Estimate of total area (ha)
Nanggro Aceh Darussalam	4,081
North Sumatera	4,357
West Sumatera	1,830
Bengkulu	1,748
West Jawa	13,135
Banten	1,448
Central Jawa	3,078
South Kalimantan	1,442
North Sulawesi	6,000
South Sulawesi	7,293
Southeast Sulawesi	3,070
Maluku	1,000
North Maluku	2,000
Papua	10,000

Total	60,482

Bioethanol has become a very interesting topic and is always up to date in various research communities in the world, from the production process to compatibility with motor vehicles.[1, 26] Some of the advantages of using bioethanol, including exhaust emissions more environmentally friendly compared to premium fuels and Pertamax.[27, 28] Bioethanol is a potential fuel because the raw material can be renewed.[29]

Bioethanol production must focus on plants that are abundant, but its use is not for basic food needs. Brazil has been applying the bioethanol-gasoline mixture since the 1930s and increased 50% in 1943.[30] Indonesia as a country that has a relatively similar geographical condition to Brazil, has the potential to follow Brazil's path in utilizing abundant natural resources to meet domestic energy needs. This is in line with Indonesia's transportation system which mostly uses gasoline.[13] Bioethanol can bring practical benefits, if applied nationally in Indonesia.[28]

Physical and chemical characteristics of bioethanol are very possible to be mixed with gasoline.[31] The need to meet energy demand with apprehensive environmental impacts and limited fuel stock from fossil fuels has led researchers to look for renewable and environmentally friendly energy resources, one of which is bioethanol.[32] However, the bioethanol production process is more complex and requires large investment capital.[33] The main obstacle is bioethanol must be compatible with motor vehicle combustion systems.[34]

Based on the arguments above, in this paper the focus of the study is on the physical and chemical properties of the fuel mixture of palm sap bioethanol with premium (MF). Although there have been studies focusing on aspects of bioethanol production,[35, 36] but it is still urgent to conduct research that focuses to explain of the physical and chemical properties of the palm sap bioethanol after it is mixed with premium fuel.

Many researchers have developed palm sap into bioethanol as a fuel mixture for motor vehicles.[20, 37, 38, 39] However, no valid data has been found about the viscosity, calorific value, and flame after the palm sap bioethanol is mixed with premium. Therefore, it is important to examine in order to reveal the viscosity, calorific value, and flame as physical and chemical characteristics of fuel for motor vehicles. Thus, the purpose of this study is to explain the physical and chemical characteristics of a fuel mixture between palm sap bioethanol and premium.

METHOD AND MATERIAL

A. Material and Tools

The materials used are bioethanol from distillation palm sap (*Arenga Pinnata* MERR) (**Fig. 1**) and premium type fuel with octane number 88 obtained directly from refueling in Mataram, West Nusa Tenggara Province, Indonesia.

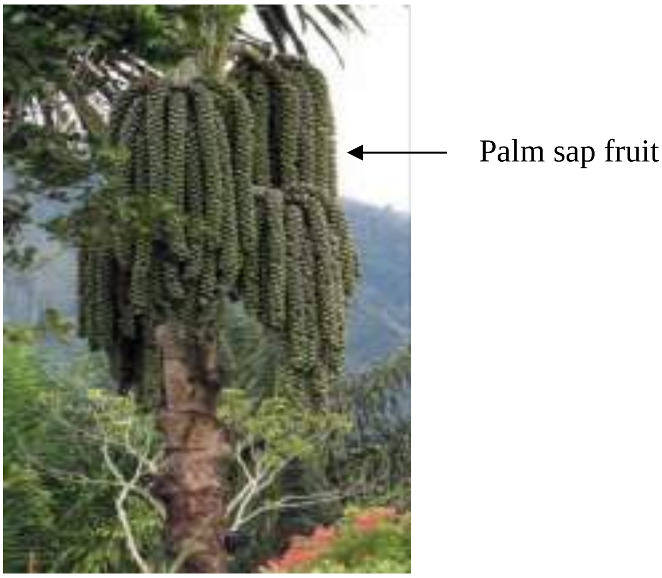

Fig. 1. Palm sap which is widely cultivated in Indonesia.[20]

These ingredients are mixed with various variations of concentration (**Table 1**).

Table 1. Variation of concentrations between bioethanol palm sap with premium

No.	Palm sap bioethanol (ml)	Premium (ml)

1	10	90
2	15	80
3	20	70
4	25	60
5	30	50

The tools used are viscometer, C-5000 calorimeter bomb, thermometer, test tube, analytical balance, oxygen cylinder, oxygen regulator, oxygen hose, test tube, and LPG gas stove.

B. MF Viscosity Measurement

MF viscosity is measured using an open gravity capillary viscometer in the temperature range of 20-30^{o}C.[40] Mathematical the MF viscosity equation can be written:[41]

$$F = \eta A \frac{V}{L} \qquad (1)$$

with, F = force on the surface of the liquid, η = coefficient of fluid viscosity (Ns/m^2), A = liquid area (m^2), V = moving wall velocity (m / s), L = distance of the two surfaces (m).

C. Measurement of MF Calorific Value

MF burn calorie measurement using bomb calorimeter type IKA C-5000 (**Fig. 2**). The reaction that occurs in a bomb calorimeter can produce heat absorbed by water and bombs, so that no heat is wasted into the air, so it can be written as:

$$r_{eaction} = -(q_{air} + q_{bomb}) \qquad (2)$$

Fig. 2. Bomb calorimeter type IKA C-5000.[20]

The amount of heat absorbed by water can be calculated using the formula:

$Q_{water} = m.c.\Delta T$ (3)

where, m = mass of water (g), c = heat type of water (J/kg^{o}C), and ΔT = temperature change (^{o}C).

The amount of heat absorbed by the bomb calorie meter can be calculated using the formula:

$q_{bomb} = c_{bomb}.\Delta T$ (3)

where, c_{bomb} = heat capacity of bomb (J/g^{o}C) and ΔT = temperature change (^{o}C).

D. MF Flame Test

Flame tests were carried out to detect the presence of metal ion elements in MF bioethanol at a premium by dipping cotton bad cotton washed with hydrochloric acid in the MF liquid and then igniting it with fire (**Fig 3**). This flame test is to provide qualitative information on the colors arising from the combustion process based on the light spectrum of the electromagnetic radiation elements present in the sample. The flame that arises will be adjusted to the table of chemical elements with the flame.[42]

Fig. 3. MF bioethanol and premium flame test.[20]

E. Data Analysis

The effect of variations in the concentration of palm sap bioethanol and premium on the physical and chemical characteristics of the MF was analyzed using analysis of variance.[43] If the F-count value is greater than the F-crit, it means that there is a significant difference in the significance level of 95%. The most influential variable can be identified using the DMRT (Duncan's Multiple Ranges Test).

RESULT AND DISCUSSIONS

A. Viscosity of MF

Palm sap bioethanol produced in this study is shown in **Fig. 4**. MF viscosity in various concentrations of bioethanol and premium is shown in **Table 2**. In the table it appears that the higher the concentration of the palm sap bioethanol, the higher the MF's viscosity. Fuel viscosity can affect the fogging process. Fuels that have high viscosity are difficult to atomize. Conversely, fuels with low viscosity are easier to be atomized. Fuels that are more easily atomized, are also easier to ignite and also more perfect combustion.

Fig. 4. Palm sap bioethanol produced in this study.[20]

The results of the bioethanol test of palm sap were obtained a value of 4.7 mm^2/s, while the premium was 7.2 mm^2/s.[42] After mixing the data obtained that the higher the concentration of bioethanol palm sap, the lower the MF's viscosity (**Table 2**). This is thought to be influenced by the viscosity of bioethanol which is lower than the premium viscosity. These results are in line with research reported by Tazi and Sulistiana[2] that the higher the addition of bioethanol, the lower the viscosity of the fuel.

Table 2. MF viscosity at various concentrations between bioethanol and premium.

No	Comparison of fuel mixes (%)		Viscosity of MF (mm^2/s)
	Bio ethanol of palm sap (ml)	Premium (ml)	
1	10	90	5.4
2	15	85	5.4
3	20	80	4.6
4	25	75	4.5
5	30	70	4.3

The results of the two-factor variance analysis show that the calculated F-value (153.963) is greater than the F-table value (3.490). This means that the variation in the concentration of bioethanol palm sap has a significant effect (p> 0.5) on the MF's viscosity (**Table 3**).

Table 3. Results of analysis variance two factors of MF viscosity parameters.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	1.223	4	0.30575	0.007	0.999	3.259
Columns	19625.3	3	6541.7653	153.963	7.647E-10	3.490
Error	509.869	12	42.489083			
Total	20136.39	19				

B. MF Calorific Value

The calorific value of the fuel shows the heat produced from the combustion process. If the combustion is perfect, then the optimal thermal energy can be obtained. Separate test results obtained caloric value of ethanol palm sap is 10.126 kcal/g, while the premium is 11.414 kcal/g. After mixing, the highest heating value of the MF was 11.107 kcal/g and the lowest was 9.445 kcal/g (**Table 4**).

Table 4. MF calorific values for various concentrations between bioethanol and premium.

No.	Comparison of fuel mixes (%)		Calorific values of MF (kcal/g)
	Palm sap bioethanol (ml)	Premium (ml)	
1	10	90	11.107
2	15	85	11.015

3	20	80	10.324
4	25	75	10.152
5	30	70	9.445

Table 4 shows that the higher the concentration of bioethanol palm sap added to the premium, the MF's calorific value decreases. This decrease is caused by the difference in the heating value between the two fuels. The results of this study are in line with the research of Budiprasojo and Pratama [39] who reported that low heating value of fuel can affect high heating value if mixed.

The National Standards Agency (BSN) has set bioethanol quality standards with a minimum heating value of 5,000 kcal/g.[44] Based on the quality standards set by BSN, the MF bioethanol and premium produced in this study were in accordance with the standards.

Table 5. Results of variance analysis two-factor for MF calorific value parameters.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.870752	4	0.217688	0.005	0.99994	3.259
Columns	18509.81	3	6169.936	144.894	1.09E-09	3.490
Error	510.9863	12	42.58219			
Total	19021.66	19				

The results analysis of variance the two-factor show that the calculated F-value (144.894) is greater than the F-table value (3.490) (**Table 5**). This means that the variation in the concentration of bioethanol palm sap has a significant effect ($p > 0.5$) on the heating value of the MF.

C. MF Flame Test

MF flame test results on variations in the concentration of palm sap bioethanol and premium showed 2 different types of fire colors namely blue and reddish yellow. MF which contains low concentrations of palm sap bioethanol produces a blue flame, while for high concentrations produces a reddish yellow flame. This is in line with the report of McLinden et al.[45] that the flame from bioethanol is not only blue, but also reddish yellow. The same thing was reported by Polikarpov et al.[46] that at the time of combustion a blue flame appeared at the bottom and reddish yellow at the top.

The blue combustion results indicate that the methane (CH4) content in the MF has been completely burned. The results of this study are in line with the research of Susanto et al.[47] who reported that methane gas was marked with a blue flame. However, if the reddish yellow fire means incomplete combustion and the flame is unstable. Cahyani[48] also reports that the color of blue flame indicates high ethanol levels.

Comparison of the physical and chemical characteristics of the mixed fuel between the palm sap bioethanol and premium from this study with several other studies is shown in **Table 6**.

Table 6. Comparison of physical and chemical characteristics of mixed fuels.

Combined of fuel mixes	Value			References
	Viscosity at 40^{o}C (mm^2/s)	Calorific (kcal/g)	Flame Test (color)	
Premium of RON 88	7.2	11.414	reddish yellow	[41]
20% bioethanol of liquid polypropylene - 80%	-	11.340	reddish yellow	[39]

Gasoline				
20% bioethanol of pineapple – 80% premium	-	7.331	-	[46]
30% bioethanol of Cassava flours - 70% gasoline	-	23	-	[38]
30% bioethanol of sugar molasses - 70% gasoline	2.2	15	-	[37]
30% palm sap bioethanol - 70% premium	4.7	10.126	reddish yellow	This research

The results of the two-factor variance analysis show that the calculated F-value (68.308) is greater than the F-table value (3.490) (**Table 7**). This means that variations in the concentration of bioethanol palm sap and premium affect the MF's flame. The blue flame color indicates high ethanol content.

Table 7. Results of analysis of variance two-factor of the MF's flame values.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	155.0324	4	38.75809	0.408	0.799	3.259
Columns	19472.58	3	6490.86	68.308	8.23E-08	3.490
Error	1140.277	12	95.02309			
Total	20767.89	19				

CONCLUSIONS AND SUGGESTIONS

A. Conclusions

1. High concentrations of palm sap bioethanol causes the MF viscosity is also higher, but too difficult to obscure.
2. High concentrations of bioethanol palm sap can cause a decrease in the heat of MF burns.
3. MF flames at a variety of concentrations of bioethanol palm sugar and premium reddish yellow and reddish yellow. The blue color shows high ethanol content, while the reddish yellow color shows low ethanol content.

B. Suggestions

The physical and chemical properties of MF fuels still needs to be studied comprehensively by conducting MF trials on various types of motorized vehicles. In addition, further research is needed on mixing palm sap bioethanol with other types of fuel.

Acknowledgment

The Research Team would like to thank the University of Mataram for the facilities support provided, so this research activity could be carried out. Acknowledgments were also conveyed to all those who have helped carry out this research.

Conflict of Interest

All authors declare that there was no conflict interest between authors and the founder.

REFERENCES

(1) Mahlia, T. M. I.; Syazmi, Z. A. H. S.; Mofijur, M.; Abas, A. E. P.; Bilad, M. R.; Ong, H. C.; Silitonga, A. S. Patent landscape review on biodiesel production: Technology updates. *Renewable and Sustainable Energy Reviews* **2020**, *118*, 109526. DOI: 10.1016/j.rser.2019.109526.

(2) Tazi, I.; Sulistiana. Test the heating fuel of a mixture of bioethanol and used cooking oil. *Journal of Neutrino* **2011**, *3,* 163-174.

(3) Rijanto, M. W.; Armawi, A. The role of youth and the community in the development of renewable alternative energy to support energy security. *Journal of National Resilience* **2011**, *16*, 35-52.

(4) Mofijur, M.; Hasan, M. M.; Mahlia, T. M. I.; Rahman, S. M. A.; Silitonga, A. S.; Ong, H. C. Performance and emission parameters of homogeneous charge compression ignition (HCCI) engine: a review. *Energies*, **2019**, *12*, 35-57.

(5) Balat, M. Global bio-fuel processing and production trends. *Energy Explore* **2007**, *25*, 195–218.

(6) Guigou, M.; Lareo, C.; Pérez, L. V.; Lluberas, M. E.; Vázquez, D.; Ferrari, M. D. Bioethanol production from sweet treatments sorghum: evaluation of post-harvest on sugar extraction and fermentation. *Biomass Bioenergy* **2011** *35*, 3058-3062.

(7) Gupta, A.; Verma, J.P. Sustainable agro-residues: bio-ethanol production from a review. *Renew. Sustain. Energy Rev.* **2015,** *41*, 550–567.

(8) Deesuth, O.; Laopaiboon, P.; Klanrit, P.; Laopaiboon, L. Improvement of ethanol production from sweet sorghum juice under high gravity and very high gravity conditions: effects of nutrient supplementation and aeration. *Ind. Crop Prod.* **2015**, *74*, 95–102.

(9) Zhang, C.; Xie, G.; Li, S.; Ge, L.; He, T. The productive potentials of sweet sorghum Ethanol in China. *Applied Energy* **2010**, *87*, 2360–2368.

(10) Gnansounou, E. Production and use of lignocellulosic bioethanol in Europe current situation and perspectives. *Bioresource Technol*. **2010**, *101*, 4842-4850.

(11) Szklo, A.; Schaeffer, R.; Delgado, F. Can one say ethanol is a real threat to gasoline? *Energy Policy*, **2007**, *35*, 5411-5421.

(12) Kusumaningsih, T. Making biodiesel fuel from castor oil. *Biotechnology* **2006**, *3*, 20-26.

(13) Silitonga, A. S.; Masjuki, H. H.; Mahlia, T. M. I.; Ong, H. C.; Chong, W. T.; Boosroh, M. H. Overview properties of biodiesel diesel blends from edible and non-edible feedstock. *Renewable and Sustainable Energy Reviews* **2013**, *22*, 346–360. DOI: 10.1016/j.rser.2013.01.055.

(14) Sebayang, A. H.; Masjuki, H. H.; Ong, H. C.; Dharma, S.; Silitonga, A. S.; Mahlia, T. M. I.; Aditiya, H. B. A perspective on bioethanol production from biomass as alternative fuel for spark ignition engine. *RSC Advances* **2016**, *6*, 14964-14992. DOI: 10.1039/c5ra24983j.

(15) Sebayang, A. H.; Masjuki, H. H.; Ong, H. C.; Dharma, S.; Silitonga, A. S.; Kusumo, F.; Milano, J. Optimization of bioethanol production from sorghum grains using artificial neural networks integrated with ant colony. *Industrial Crops and Products* 2017, *97*, 146–155. DOI: 10.1016/j.indcrop.2016.11.064.

(16) Connelly, E. B.; Colosi, L. M.; Clarens, A. F.; Lambert, J. H. Life Cycle Assessment of Biofuels from Algae Hydrothermal Liquefaction: The Upstream and Downstream Factors Affecting Regulatory Compliance. *Energy & Fuels,* 2015, *29, 1653–1661.* DOI: 10.1021/ef502100f.

(17) Devita, L. Biodiesel as alternative energy and perspective. *Agrica Extensia* **2015**, *9*, 23-26.

(18) Sebayang A. H.; Hassan M. H.; Ong, H. C.; Dharma, S.; Bahar, A. H.; Silitonga, A. S.; Kusumo, F. Enzymatic hydrolysis using ultrasound for bioethanol production from durian (durio zibethinus) seeds as potential biofuel. *Chemical Engineering Transactions*, **2017**, *56*, 553-558 DOI: 10.3303/CET1756093.

(19) Yamada, S.; Shinomiya, N.; Ohba, K.; Sekikawa, M.; Oda, Y. Enzymatic hydrolysis and ethanol fermentation of by-products from potato processing plants. *Food Sci. Technol. Res*. **2009**, *15*, 653-658.

(20) Ansar, Nazaruddin, and Azis, A. D. Effect of Temperature and Time Storage to pH and Color Changes of Palm Sap (*Arenga pinnata* MERR) after Tapping. *Journal of Agricultural Engineering Lampung* **2019,** 8, 40-48.

(21) Pontoh, J. Analytical methods and chemical components in palm sugar and palm sugar. *Proceeding of Seminar Nasional Aren* **2013**, University of Sam Ratulangi, Manado.

(22) Fahrizal, F.; Abubakar, Y.; Muzaifa, M.; Muslim, M. The effects of temperature and length of fermentation on bioethanol production from aren plant (*Arenga pinnata* MERR). *International Journal on Advanced Science, Engineering, Information Technology*, **2013**, *3*, 55-59.

(23) Kismurtono, M. Fed-batch alcoholic fermentation of palm juice (*Arenga pinnata* MERR): Influence of the feeding rate on yeast, yield, and productivity. *International Journal of Engineering & Technology* **2012**, *2*, 795-799.

(24) Victor, I.; Orsat, V. Characterization of *Arenga pinnata* (palm) sugar. *Sugar Tech* **2018**, *20*, 105-109. DOI: 10.1007/s12355-017-0537-3.

(25) Effendi, D. S. Prospect of aren tree development (*Arenga pinnata* MERR) to supporting bioethanol need in Indonesia. *Perspective* **2010,** *9*, 36-46.

(26) Zhang, Q.; Weng, C.; Huang, H.; Achal, V.; Wang, D. Optimization of bioethanol production using the whole plant of water hyacinth as a substrate in the simultaneous saccharification and fermentation process. *Frontiers in Microbiology* **2016**, *6*, 1-9. DOI: 10.3389/fmicb.2015.01411.

(27) Ong, H. C.; Masjuki, H. H.; Mahlia, T. M. I.; Silitonga, A. S.; Chong, W. T.; Yusaf, T. Engine performance and emissions using Jatropha curcas, Ceiba pentandra and Calophyllum inophyllum biodiesel in a CI diesel engine. *Energy*, **2014**, *69*, 427–445. DOI: 10.1016/j.energy.2014.03.035.

(28) Silitonga, A. S.; Masjuki, H. H.; Ong, H. C.; Sebayang, A. H.; Dharma, S.; Kusumo, F.; Sugiyanto, B. Evaluation of the engine performance and exhaust emissions of biodiesel-bioethanol-diesel blends using kernel-based extreme learning machine. *Energy* **2018**, *159*, 1075–1087. DOI: 10.1016/j.energy.2018.06.202.

(29) Tan, L.; Sun, Z. Y.; Okamoto, S.; Takaki, M.; Morimura, S.; Kida, K.; Tang, Y. Q. Production of ethanol from raw juice and thick juice of sugar beet by continuous ethanol fermentation with flocculating yeast strain KF-7. *Biomass and Bioenergy* **2015**, *81*, 256-272. DOI: 10.1016/j.biombioe.2015.07.019.

(30) Soccol, C. R.; Vandenberghe, L. P. d. S.; Medeiros, A. B. P.; Karp, S. G.; Buckeridge, M.; Ramos, L. P.; Pitarelo, A. P.; Ferreira-Leitão, V.; Gottschalk, L. M. F.; Ferrara, M. A.; Silva Bon, E. P. D.; Moraes, L. M. P. D.; Araújo, J. d. A.; Torres, F. A. G. Bioethanol from lignocelluloses: Status and perspectives in Brazil. *Bioresource Technol*. **2010**, *101*, 4820-4825.

(31) Ong, H. C.; Silitonga, A. S.; Masjuki, H. H.; Mahlia, T. M. I.; Chong, W. T.; Boosroh, M. H. Production and comparative fuel properties of biodiesel from non-edible oils:

Jatropha curcas, Sterculia foetida and Ceiba pentandra. *Energy Convers. Manage*. **2013**, *73*, 245–255.

(32) Xuan, F.; Chai, D. J.; Su, H. Local density approximation for the short-range exchange free energy functional. *ACS Omega* **2019**, *4*, 7675-7683. DOI: 10.1021/acsomega.9b00303.

(33) Sun, P.; Gao, G.; Zhao, Z.; Xia, C.; Li, F. Stabilization of cobalt catalysts by embedment for efficient production of valeric biofuel. *ACS Catalysis* **2014**, *4*, 4136-4142.

(34) Dayma, G.; Halter, F.; Foucher, F.; Casimir Togbe, C.; Rousselle, C. M.; Dagaut, P. Experimental and detailed kinetic modeling study of ethyl pentanoate (ethyl valerate) oxidation in a jet stirred reactor and laminar burning velocities in a spherical combustion chamber. *Energy Fuels* **2012,** *26*, 4735-4748.

(35) Galletti, R., A. M.; Antonetti, C.; Ribechini, E.; Colombini, M. P.; Nassio Di Nasso, N.; Bonari, E. From giant reed to levulinic acid and gamma-valerolactone: A high yield catalytic route to valeric biofuels. *Applied Energy* **2013**, *102*, 157-162.

(36) Kon, K.; Onodera, W.; Shimizu, K. Selective hydrogenation of levulinic acid to valeric acid and valeric biofuels by a Pt/HMFI catalyst. *Catalysis Science & Technology* **2014**, *4*, 3227-3234.

(37) Ademiluyi, F. T.; Mepba, H. D. Yield and properties of ethanol biofuel produced from different whole cassava flours. *ISRN Biotechnology* **2013**, 1-7.

(38) Ghazikhani, M., M; Hatami, B.; Safari; Ganji, D. D. Experimental investigation of performance improving and emissions reducing in a two stroke SI engine by using ethanol additives. *Propulsion Power Res*. **2013**, *2*, 276-283.

(39) Budiprasojo, A.; Pratama, A. W. The heating value of premium blends with polypropylene fuel resulting from the pyrolysis process. *Journal of Ilmiah Inovasi* **2016,** *1*, 122-127.

(40) Laesecke, A.; Tara, J.; Fortin; Jolene, D.S. Density, speed of sound, and viscosity measurements of reference materials for biofuels. *Energy & Fuels* **2012**, *26*, 1844-1861. DOI: 10.1021/ef201645r.

(41) Niemeyer, K. E.; Daly, S. R.; Cannella, W. J.; Hagen, C. L. A novel fuel performance index for low-temperature combustion engines based on operating envelopes in light-duty driving cycle simulations. *Journal of Engineering for Gas Turbines and Power* **2015**, *137*, 101601–101601.

(42) Yuliyanto, D.; Widodo, E. Test the heating fuel of a mixture of bioethanol and used cooking oil. *Journal of Manufacturing Energy Engineering* **2018**, *3*, 1-5.

(43) Ansar; Nazaruddin; Azis, A.D. Effect of vacuum freeze-drying condition and maltodextrin on the physical and sensory characteristics of passion fruit (Passiflora edulis sims) extract. *IOP Conf. Ser.: Earth Environ. Sci.* **2019**, *355* 012067. DOI: 10.1088/1755-1315/355/1/012067.

(44) Aditiya, H. B.; Chong, W. T.; Mahlia, T. M. I.; Sebayang, A. H.; Berawi, M. A.; Nur, H. Second generation bioethanol potential from selected Malaysia's biodiversity biomasses: A review. *Waste Management* **2016**, *47*, *46-61.* DOI: 10.1016/j.wasman.2015.07.031.

(45) McLinden, M. O.; Bruno, T. J.; Frenkel, M.; Huber, M. L. Standard reference data for the thermophysical properties of biofuels. *J. ASTM Int.* **2010**, *7*, 1-18.

(46) Polikarpov, E.; Albrecht, K. O.; Page, J. P.; Malhotra, D.; Koech, P.; Cosimbescu, L.; Gaspar, D. J. Critical fuel property evaluation for potential gasoline and diesel biofuel

blend stocks with low sample volume availability. *Fuel* **2019**, *238*, 26-33. DOI: 10.1016/j.fuel.2018.09.129.

(47) Susanto, R.; Jaya, H.; Mulyanto, A. Analysis of the effect of fermentation time and distillation temperature on physical properties (specific gravity and caloric value) of bioethanol made from pineapple (ananas comosus). *Mechanical Engineering Dynamics* **2013**, 3, 91-100.

(48) Cahyani; Anisah. Effect of enzyme volume on alcohol content and caloric value of bioethanol made from yam tubers (Dioscorea hipsida dentist). *Journal of Agricultural Engineering of Tropic and Biosystems* **2015**, 3, 35-42.

Ansar - <ansar72@unram.ac.id>

Ansar, * ao-2020-002477.R2 - Manuscript Revision Request - Formatting Changes 04-May-2020

1 pesan

ACS Omega <onbehalfof@manuscriptcentral.com> 4 Mei 2020 18.53
Balas Ke: quina-office@omega.acs.org
Kepada: ansar72@unram.ac.id

04-May-2020

Journal: ACS Omega
Manuscript ID: ao-2020-002477.R2
Title: "Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (Arenga Pinnata MERR) Bioethanol and Premium"
Author(s): Ansar, *; Sukmawaty, *; Abdullah, Sirajuddin; Nazaruddin, *; Safitri, Erna

COVID-19 Support: Please visit the following website to access important information for ACS authors and reviewers during the COVID-19 crisis: https://axial.acs.org/2020/03/25/chemists-covid-19-coronavirus/

We are flexible in these unprecedented times affecting the global research community. If you need more time to complete authoring or reviewing tasks, please contact the editorial office and request an extension.

Dear Dr. Ansar:

Thank you for submitting your manuscript to ACS Omega.

We are pleased to inform you that your manuscript ao-2020-002477.R2 is about to be accepted for publication in ACS Omega. Prior to formal acceptance please perform the following formatting changes:

- Kindly confirm whether the photos in TOC were taken by one of the authors and clarify if the image is free domain or if permission is required. If permission is required, provide a document that shows a granted permission, and add a credit line accordingly. More information is available at http://pubs.acs.org/page/copyright/permissions_otherpub.html.
- Images such as a company logo require copyright permission from the corporate office. Please remove or blur any such data in Figure 2.

To revise your manuscript, log into ACS Paragon Plus with your ACS ID at http://paragonplus.acs.org/login and select "My Authoring Activity". There you will find your manuscript title listed under "Revisions Requested by Editorial Office." Your original files are available to you when you upload your revised manuscript. If you are replacing files, please remove the old version of the file from the manuscript before uploading the new file.
Please upload manuscript file that is free of any annotations or highlights.

Funding Sources: Authors are required to report ALL funding sources and grant/award numbers relevant to this manuscript. Enter all sources of funding for ALL authors relevant to this manuscript in BOTH the Open Funder Registry tool in ACS Paragon Plus and in the manuscript to meet this requirement. See http://pubs.acs.org/page/4authors/funder_options.html for complete instructions.

ORCID: Authors submitting manuscript revisions are required to provide their own validated ORCID iDs before completing the submission, if an ORCID iD is not already associated with their ACS Paragon Plus user profiles. This iD may be provided during original manuscript submission or when submitting the manuscript revision. You can provide only your own ORCID iD, a unique researcher identifier. If your ORCID iD is not already validated and associated with your ACS Paragon Plus user profile, you may do so by following the ORCID-related links in the Email/Name section of your ACS Paragon Plus account. All authors are encouraged to register for and associate their own ORCID iDs with their ACS Paragon Plus profiles. The ORCID iD will be displayed in the published article for any author on a manuscript who has a validated ORCID iD associated with ACS Paragon Plus when the manuscript is accepted. Learn more at http://www.orcid.org.

Journal Publishing Agreement: ACS Omega offers an electronic Journal Publishing Agreement that can be completed from your Home page in ACS Paragon Plus. You will receive, in a separate email, instructions on how to access and submit your electronic Journal Publishing Agreement.

In publishing only original research, ACS is committed to deterring plagiarism, including self-plagiarism. ACS Publications uses Crossref Similarity Check Powered by iThenticate to screen submitted manuscripts for similarity to published material, and other software to screen previous submissions to ACS journals. Note that your manuscript may be screened during the submission process.

We look forward to seeing your paper in ACS Omega.

Sincerely,

Prof. Frank Quina
Associate Editor
ACS Omega
Phone: + 55 11 3091-2162
Fax: (202) 354-5151
Email: quina-office@omega.acs.org

Ansar - <ansar72@unram.ac.id>

Ansar, * ao-2020-002477.R3 Assigned to Editor 04-May-2020

1 pesan

ACS Omega <onbehalfof@manuscriptcentral.com> 4 Mei 2020 23.29
Balas Ke: Ganesh-office@omega.acs.org
Kepada: ansar72@unram.ac.id
Cc: ansar72@unram.ac.id, sukmawaty14@unram.ac.id, sirajuddintep@yahoo.com, nazaruddin59itp@yahoo.com, ernasafitritep@yahoo.com

04-May-2020

Journal: ACS Omega
Manuscript ID: ao-2020-002477.R3
Title: "Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (Arenga Pinnata MERR) Bioethanol and Premium"
Author(s): Ansar, *; Sukmawaty, *; Abdullah, Sirajuddin; Nazaruddin, *; Safitri, Erna
Manuscript Status: Associate Editor Assigned

Dear Dr. Ansar:

Thank you for submitting your manuscript to ACS Omega, a multidisciplinary, open access journal for the publication of original and scientifically valid research. The journal offers expedited editorial decision-making and immediate open availability. Authors can rapidly publish their important research results and broadly distribute them to the global scientific community. Please note that there are publishing charges associated with this journal. Details can be found at http://acsopenaccess.org. Should your manuscript be accepted, you will be required to pay for the Article Publishing Charges prior to publication. Authors may qualify for discounts. Article Publishing Charges are waived for invited Editorials and Perspectives.

"Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (Arenga Pinnata MERR) Bioethanol and Premium" has been assigned to the following editor:

Prof. Frank Quina
Associate Editor
ACS Omega
Phone: + 55 11 3091-2162
Fax: (202) 354-5151
Email: quina-office@omega.acs.org

Please address all future correspondence regarding this manuscript to the above editor.

Submission of a manuscript to implies that the work reported therein has not received prior publication and is not under consideration for publication elsewhere in any medium, including electronic journals and computer databases of a public nature. This manuscript is being considered with the understanding that it is submitted on an exclusive basis. If otherwise, please advise.

Also please note that according to ACS Ethical Guidelines to Publication of Chemical Research, all authors must have reviewed and approved the submission of their manuscript. If you are a coauthor and approve its submission, no action is necessary. If you do not approve its submission to ACS Omega, please let us know as soon as possible. Refer to the manuscript number listed above in any correspondence, or you may simply reply to this message leaving the subject line intact. For more information on ethical responsibilities of authors, see the Ethical Guidelines to Publication of Chemical Research at http://pubs.acs.org/page/policy/ethics/index.html.

In publishing only original research, ACS is committed to deterring plagiarism, including self-plagiarism. ACS Publications uses Crossref Similarity Check Powered by iThenticate to screen submitted manuscripts for similarity to published material, and other software to screen previous submissions to ACS journals. Note that your manuscript may be screened during the submission process.

Sincerely,

Dr. Krishna Ganesh
Coeditor
ACS Omega
Phone: (202) 657-6323
Email: Ganesh-office@omega.acs.org

Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (Arenga Pinnata MERR) Bioethanol and Premium

Journal:	*ACS Omega*
Manuscript ID	ao-2020-002477
Manuscript Type:	Article
Date Submitted by the Author:	17-Jan-2020

Complete List of Authors:	Ansar, *; Mataram University, Agricultural Engineering Sukmawaty, *; Mataram University, Agricultural Engineering Abdullah, Sirajuddin; Mataram University, Agricultural Engineering Nazaruddin, *; Mataram University, Food Science and Technology Safitri, Erna; Universitas Mataram, Agricultural Engineering

Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (*Arenga Pinnata* MERR) Bioethanol and Premium

Ansar[1*], Sukmawaty[1], Sirajuddin Haji Abdullah[1], Nazaruddin[2], Erna Safitri[1]

[1]Department of Agricultural Engineering, Faculty of Food Technology and Agroindustries, University of Mataram, Indonesia
[2]Department of Food Science and Technology, Faculty of Food Technology and Agroindustries, University of Mataram, Indonesia

[*]E-mail: ansar72@unram.ac.id

ABSTRACT

Along with the development of the motor vehicle industry technology nowadays, the fuel demand is also increasing, while the supply is running low. Thus alternative fuels are needed to meet these energy needs. This study aims to determine the physical and chemical characteristics of the fuel mixture (MF) of palm sap bioethanol with a premium. The results showed that the higher the bioethanol concentration of palm sugar, the higher the MF's viscosity, but the heat of the fuel decreased. This reduction is caused by differences in the heating value of the two fuels. The MF's high heat burn value is blue, while the low heat value of flame is reddish yellow.
Keywords: bioethanol, caloric values, palm sap, flame, viscosity

1. INTRODUCTION

The human need for fuel is currently increasing along with the development of the motor vehicle industry. The largest source of fuel used by motor vehicles comes from fossil fuels.[1] This fossil fuel cannot be expected for a long period because the amount is limited and cannot be renewed.[2]

Indonesia's petroleum reserves are currently around 7.99 billion barrels. If aren't found new reserves, so it will be predicted to be exhausted within the next 23 years.[3] Because it is getting least, it is necessary to find renewable energy sources that can be produced continuously and sustainably.

Several countries have tried to find alternative new and renewable energy sources by utilizing plants that have the potential as raw material for making biofuel, known as biofuels.[4] As in Indonesia, the government has given attention seriously to the development of this biofuel by issuing Presidential Instruction No. 1 of 2006 concerning the supply and utilization of biofuel as an alternative fuel.[5]

Bioethanol is one type of biofuel that can replace fossil fuels[6]. The development of bioethanol as an alternative fuel is supported by several factors, including the availability of abundant raw materials and the bioethanol making technology, the existence of market opportunities and promising benefits.[4,7]

Bioethanol can be produced from various types of plants, such as sugar cane, cassava, corn, sorghum, sugar palm, or other types of plants.[8] These plants are very abundant in Indonesia because they are easily grown. One of them is sugar palm. These plants contain glucose, fructose, sucrose with a composition of about 0.4-0.5%, 0.5-0.6%, and 10-13% respectively.[9] The composition of sugar is pretty high, so palm sugar has the potential to be processed into bioethanol.[10] During this time, the use of palm sugar is still very limited, namely only as of the manufacture of palm sugar.[11]

Bioethanol has become a very interesting topic and is always up to date in various research communities in the world, from the production process to compatibility with motor vehicles.[12] Some of the advantages of using bioethanol, including exhaust emissions more environmentally friendly compared to premium fuels and Pertamax. Bioethanol is a potential fuel because the raw material can be renewed.[13]

Bioethanol production must focus on abundant plants, but it is not for primary food. Some countries such as Brazil produce it from sugar cane, the United States from corn, whereas Indonesia generally comes from sugar cane and palm sugar juice.[14]

The bioethanol production process is more complex and requires a large investment.[15] The main of an obstacle is bioethanol must be compatible with motor vehicle combustion systems.[16]

Among these alternatives, in this paper, the focus of the study is on the physical and chemical properties of the mixture fuel (MF) between palm sap bioethanol with premium. Although there have been studies focusing on aspects of bioethanol production. [17-18], it is still urgent to conduct research that focuses on the disclosure of the physical and chemical properties of the sugar palm bioethanol after it is mixed with premium fuel.

Many researchers have developed palm sap into bioethanol as a fuel mixture for motor vehicles.[7] However, the valid data has not been found about the viscosity, caloric value, and flame after the palm sap bioethanol is mixed with premium.[20] Therefore, it is urgent to be investigated to find out the viscosity, caloric value, and flame as physical and chemical characteristics of motor vehicle fuel.

2. MATERIALS AND METHODS

Material and Tools. The ingredients used are palm sap bioethanol and premium. These ingredients are mixed with various variations of concentration (Table 1).

Table 1. Variation of concentrations between palm sap bioethanol with premium

No.	Palm sap bioethanol (ml)	Premium (ml)
1	10	90
2	15	80
3	20	70
4	25	60
5	30	50

The tools used are viscometer, C-5000 calorimeter bomb, thermometer, test tube, analytical balance, oxygen cylinder, oxygen regulator, oxygen hose, test tube, and LPG gas stove.

MF Viscosity Measurement. The MF viscosity is measured using an open gravity capillary viscometer in the temperature range of 20-30^{o}C.[19] Mathematically the MF viscosity equation can be written:[20]

$$F = \eta A \frac{V}{L}$$

with, F = force on the surface of the liquid, η = coefficient of fluid viscosity (Ns / m2), A = liquid area (m2), V = moving wall velocity (m / s), L = distance of the two surfaces (m).

Measurement of MF Caloric Value. The MF calorie value measurement using bomb calorimeter type IKA C-5000. The reaction that occurs in a bomb calorimeter can produce heat absorbed by water and bombs so that no heat is wasted into the air, so it can be written as:[21]

$$q_{reaction} = -(q_{water} + q_{bomb}) \qquad (1)$$

The amount of heat absorbed by water can be calculated using the equation:

$$Q_{air} = m.c.\Delta T \qquad (2)$$

where, m = mass of water (g), c = heat type of water (J/kg^{o}C), and ΔT = temperature change (^{o}C).

The amount of heat absorbed by the bomb calorie meter can be calculated using the formula:

$$q_{bomb} = c_{bomb}.\Delta T \qquad (3)$$

where, c_{bomb} = heat capacity of bomb (J/kg^{o}C) and ΔT = temperature change (^{o}C).

MF Flame Test. The MF flame tests were carried out to detect the presence of metal ion elements in MF bioethanol at a premium by dipping cotton bad cotton washed with hydrochloric acid in the MF liquid and then igniting it with fire. This flame test is to provide qualitative information on the colors arising from the combustion process based on the light spectrum of the electromagnetic radiation elements present in the sample. The flame that arises will be adjusted to the table of chemical elements with the flame.

Data Analysis. The effect of variations in the concentration of bioethanol of palm sugar and premium on the physical and chemical characteristics of the MF was analyzed using an analysis of variance (ANOVA). If the F-count value is greater than the F-crit, it means that there is a significant difference in the significance level of 95%. The most influential variable can be identified using the DMRT (Duncan's Multiple Ranges Test).

3. RESULT AND DISCUSSIONS

The MF Viscosity. The MF viscosity in various concentrations between palm sap bioethanol and premium is shown in Table 2. In the table, it appears that the higher the concentration of the sugar palm bioethanol, the higher the MF's viscosity. Fuel viscosity can affect the fogging process. Fuels that have high viscosity are difficult to atomize. Conversely, fuels with low viscosity are easier to be atomized, easier to ignite, and also the combustion more perfect.

The results of the bioethanol test of palm sap were obtained a value of 4.7 cSt, while the premium was 7.2 cSt.[21] After mixing was shown that the higher the concentration of palm sap bioethanol, the lower the MF's viscosity (Table 2). It was predicted to be influenced by the viscosity of bioethanol which is lower than the premium viscosity. These results are in line with the researcher reported by Yuliyanto and Widodo[22] that the higher the addition of bioethanol, the lower the viscosity of the fuel.

Table 2. The MF viscosity at various concentrations between bioethanol and premium.

No.	Comparison of MF (%)		The MF viscosity (cSt)
	Bioethanol of palm sap (ml)	Premium (ml)	
1	10	90	5.4
2	15	85	5.4
3	20	80	4.6
4	25	75	4.5
5	30	70	4.3

The results of the two-factor variance analysis show that the calculated F-value (153.963) is greater than the F-table value (3.490). This means that the variation in the concentration of palm sap bioethanol has a significant effect ($p > 0.5$) on the MF's viscosity (Table 3).

Table 3. Results analysis of variance two factors of MF viscosity parameters.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	1.223	4	0.30575	0.007	0.999	3.259
Columns	19625.3	3	6541.7653	153.963	7.647E-10	3.490
Error	509.869	12	42.489083			
Total	20136.39	19				

The MF Caloric Value. The caloric value of the fuel shows the heat produced from the combustion process. If the combustion is perfect, the thermal energy will be optimal. Test results separately obtained caloric value of ethanol palm sap is 10,126 kcal/kg, while the premium is 11,414 kcal/kg. After mixing, the highest heating value of the MF was 11,107 kcal/kg and the lowest was 9,445 kcal/kg (Table 4.).

Table 4. The MF caloric values for various concentrations between bioethanol and premium.

No.	Comparison of fuel mixes (%)		The MF Caloric values (kcal/kg)
	Bioethanol of palm sap (ml)	Premium (ml)	
1	10	90	11.107
2	15	85	11.015
3	20	80	10.324
4	25	75	10.152
5	30	70	9.445

Table 4 shows that the higher the concentration of palm sap bioethanol was added to the premium, the MF's caloric value decreases. The reduction is caused by the difference in the caloric value between the two fuels. The results of this study are in line with the research of Adityo and Budiprasojo[23] who reported that high caloric value will be low if mixed with low caloric value.

The National Standards Agency (NSA) has set bioethanol quality standards with a minimum caloric value of 5,000 kcal/kg.[23] Based on the quality standards set by NSA[24], the MF bioethanol and premium produced in this study were following the standards.

Table 5. Results of analysis of variance two-factor for MF caloric value parameters.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.870752	4	0.217688	0.005	0.99994	3.259
Columns	18509.81	3	6169.936	144.894	1.09E-09	3.490
Error	510.9863	12	42.58219			
Total	19021.66	19				

The results of the analysis of variance two-factor show that the value F-calculated (144.894) is greater than the F-table value (3.490). This means that the variation in the concentration of palm sap bioethanol has a significant effect ($p > 0.5$) on the caloric value of the MF.

MF Flame Test. The MF flame test results on a variety of concentrations of palm sap and bioethanol concentrations showed blue and reddish-yellow color. Low concentrations of palm sap bioethanol obtained blue flame, while high concentrations obtained reddish-yellow flame (Figure 1). This is in line with the report of McLinden et al.[25] that the flame from bioethanol is not only blue but also reddish-yellow. The same reported by Polikarpov et al.[26] that at the time of combustion a blue flame appeared at the bottom and reddish yellow at the top.

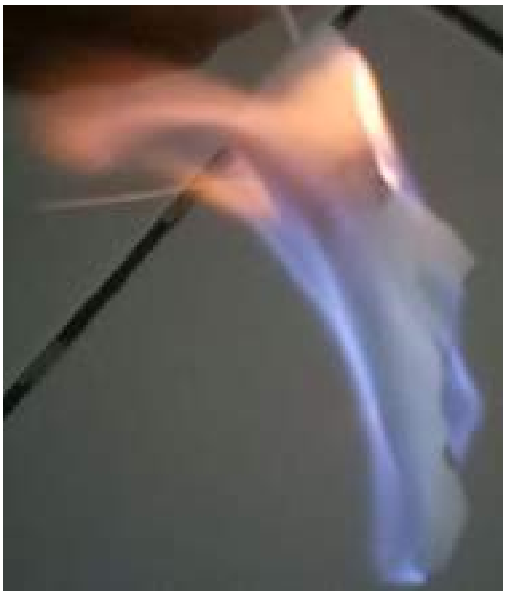

Figure 1. MF flame test

The blue flame indicates the methane gas content (CH_4) on the MF which can be used as fuel for motor vehicles. The results of this study are in line with the research of Susanto et al.[27] and Fahrizal et al.[28] who reported that methane gas was marked with a blue flame. If the reddish-yellow fire means that the combustion is incomplete and the flame is unstable. Cahyani and Anisah[29] also report that the color of the blue flame indicates high ethanol levels.

Table 6. Results analysis of variance two-factor of the MF's flame values.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	155.0324	4	38.75809	0.408	0.799	3.259
Columns	19472.58	3	6490.86	68.308	8.23E-08	3.490
Error	1140.277	12	95.02309			
Total	20767.89	19				

The results of the analysis of variance two-factor show that the F-calculated value (68.308) is greater than the F-table value (3.490) (Table 6). This means that variations in the concentration of palm sap bioethanol and premium affect the MF's flame. The blue flame color indicates high ethanol content.

CONCLUSIONS AND SUGGESTIONS

A. Conclusions

1. High concentrations of sugar palm bioethanol caused the MF viscosity is also higher, but too difficult to obscure.
2. High concentrations of palm sap bioethanol can cause a reduction in the heat of MF burns.
3. MF flames at a variety of concentrations of palm sugar bioethanol and premium are blue and reddish-yellow. The blue color shows high ethanol content, while the reddish-yellow shows low ethanol content.

B. Suggestions

The physical and chemical properties of MF fuels still need to be studied comprehensively by conducting MF trials on various types of motorized vehicles. Besides, research is needed for mixing bioethanol with other types of fuel further.

REFERENCES

(1) Tazi, I., and Sulistiana. Test the heating fuel of a mixture of bioethanol and used cooking oil. *Journal of Neutrino* **2011**, 3(2): 163-174.

(2) Rijanto, M.W. dan Armawi, A. The role of youth and the community in the development of renewable alternative energy to support energy security. *Journal of National Resilience* **2011**, 16(3): 35-52.

(4) Devita, L. Biodiesel as alternative energy and perspective. *Agrica Extensia* **2015**, 9(2): 23-26.

(5) Kusumaningsih, T. Making biodiesel fuel from castor oil. *Biotechnology* **2006**, 3(1): 20-26.

(6) Liu, H.; Yao, M.; Zhang, B.; Zheng, Z. Influence of fuel and operating conditions on combustion characteristics of a homogeneous charge compression ignition engine. *Energy & Fuels* **2009**, 23, 1422–1430.

(7) Lacey, J., Kameshwaran, K., Sathasivam, S., Filipi, Z., Cannella, W., Fuentes, P.A. Effects of refinery stream gasoline property variation on the auto-ignition quality of fuel and homogeneous charge compression ignition combustion. *International Journal of Engine Research* **2016**, 25(1): 1-14.

(8) Pontoh, J. Analytical methods and chemical components in palm sugar and palm sugar. *Prosiding Seminar Nasional Aren* **2013**, Univerity of Sam Ratulangi, Manado.

(9) Ansar, Nazaruddin, and Azis, A.D. Effect of Temperature and Time Storage to pH and Color Changes of Palm Sap (Arenga pinnata Merr) after Tapping. *Journal of Agricultural Engineering Lampung* **2019,** 8(1), 40-48.

(10) Kismurtono, M. Fed-batch alcoholic fermentation of palm juice (*Arenga pinnata* MERR): Influence of the feeding rate on yeast, yield, and productivity. *International Journal of Engineering & Technology* **2012**, 2(5): 795-799.

(11) Victor, I. and Orsat, V. Characterization of *Arenga pinnata* (palm) sugar. *Sugar Tech* **2018**, 20(1): 105-109. DOI: 10.1007/s12355-017-0537-3.

(12) Zhang, Q., Weng, C., Huang, H., Achal, V., and Wang, D. Optimization of bioethanol production using the whole plant of water hyacinth as a substrate in the simultaneous saccharification and fermentation process. *Frontiers in Microbiology* **2016**, 6(1):1-9. DOI:10.3389/fmicb.2015.01411.

(13) Tan, L., Sun, Z.Y., Okamoto, S., Takaki, M., Morimura, S., Kida, K., & Tang, Y.Q. Production of ethanol from raw juice and thick juice of sugar beet by continuous ethanol fermentation with flocculating yeast strain KF-7. *Biomass and Bioenergy* **2015**, 81(1): 256-272. DOI:10.1016/j.biombioe. 2015.07.019.

(14) Elijah, I., Ohimain, Patrick, E., Tuwon, and Ekiemene, A. Traditional fermentation, and distillation of raffia palm sap for the production of bioethanol in Bayelsa State, Nigeria. *Journal of Technology Innovations in Renewable Energy* **2012.** 1(2), 131-141.

(15) Sun, P. Gao, G. Zhao, Z., Xia, C., Li, F. Stabilization of cobalt catalysts by embedment for efficient production of valeric biofuel. *ACS Catalysis* **2014**, 4, 4136–4142.

(16) Dayma, G., Halter, F., Foucher, F., Casimir Togbe, C., Rousselle, C.M., Dagaut, P. Experimental and detailed kinetic modeling study of ethyl pentanoate (ethyl valerate) oxidation in a jet stirred reactor and laminar burning velocities in a spherical combustion chamber. *Energy Fuels* **2012,** 26(8): 4735-4748

(17) Galletti, R., A. M.; Antonetti, C.; Ribechini, E.; Colombini, M. P.; Nassio Di Nasso, N.; Bonari, E. From giant reed to levulinic acid and gamma-valerolactone: A high yield catalytic route to valeric biofuels. *Applied Energy* **2013**, 102, 157–162.

(18) Kon, K.; Onodera, W.; Shimizu, K. Selective hydrogenation of levulinic acid to valeric acid and valeric biofuels by a Pt/HMFI catalyst. *Catalysis Science & Technology* **2014**, 4, 3227–3234.

(19) Laesecke, A., Tara, J. Fortin, and Jolene, D.S. Density, speed of sound, and viscosity measurements of reference materials for biofuels. *Energy & Fuels* **2012**, 26 (3): 1844-1861. doi.org/10.1021/ef201645r.

(20) Rapp, V. H.; Cannella, W. J.; Chen, J.-Y.; Dibble, R. W. Predicting fuel performance for future HCCI Engines. *Combustion Science and Technology* **2013**, 185, 735–748.

(21) Niemeyer, K. E.; Daly, S. R.; Cannella, W. J.; Hagen, C. L. A novel fuel performance index for low-temperature combustion engines based on operating envelopes in light-duty driving cycle simulations. *Journal of Engineering for Gas Turbines and Power* **2015**, 137, 101601–101601.

(22) Yuliyanto, D and Widodo, E. Test the heating fuel of a mixture of bioethanol and used cooking oil. *Journal of Manufacturing Energy Engineering* **2018**, 3(1): 1-5.

(23) Budiprasojo, A. and Pratama, A.W. The heating value of premium blends with polypropylene fuel resulting from the pyrolysis process. *Journal of Ilmiah Inovasi* **2016,** 1(2): 122-127.

(24) Effendi, D.S. Prospect of aren tree development (*Arenga pinnata* MERR) to supporting bioethanol need in Indonesia. *Perspektif* **2010,** 9(1): 36-46.

(25) McLinden, M. O.; Bruno, T. J.; Frenkel, M.; Huber, M. L. Standard reference data for the thermophysical properties of biofuels. J. ASTM Int. **2010**, 7, 1-18.

(26) Polikarpov, E., Albrecht, K.O., Page, J.P., Malhotra, D., Koech, P., Cosimbescu, L., and Gaspar, D.J. Critical fuel property evaluation for potential gasoline and diesel biofuel blendstocks with low sample volume availability. *Fuel* **2018**, 24(9). https://doi.org/10.1016/j.fuel.2018.09.129**.**

(27) Susanto, R., Jaya, H., and Mulyanto, A. Analysis of the effect of fermentation time and distillation temperature on physical properties (specific gravity and caloric value) of bioethanol made from pineapple (ananas comosus). *Mechanical Engineering Dynamics* **2013**, 3(2): 91-100.

(28) Fahrizal, F., Abubakar, Y., Muzaifa, M., and Muslim, M. The effects of temperature and length of fermentation on bioethanol production from the arenga plant (Arenga pinnata MERR). *International Journal on Advanced Science, Engineering, Information Technology* **2013**, 3(1): 55-59.

(29) Cahyani and Anisah. Effect of enzyme volume on alcohol content and caloric value of bioethanol made from yam tubers (Dioscorea hipsida dentist). *Journal of Agricultural Engineering of Tropic and Biosystem* **2015**, 3(1): 35-42.

1. The official language is appropriate. There are some spelling mistakes
2. The authors should be add the bioethanol production
3. The authors should be add the equipment which using to measure the properties of fuel and accuracy of the equipment
4. The authors should be compare the result with other study
5. The authors should be uncertainty experiment
6. The authors should be calculate energy consumption of the bioethanol production
7. The authors can added the reference related to bioethanol as below:
    - A perspective on bioethanol production from biomass as alternative fuel for spark ignition engine
    - Optimization of Bioethanol Production from Sorghum Grains using Artificial Neural Networks Integrated with Ant Colony
    - Enzymatic Hydrolysis Using Ultrasound for Bioethanol Production from Durian (Durio zibethinus) Seeds as Potential Biofuel

Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (Arenga Pinnata MERR) Bioethanol and Premium

Journal:	*ACS Omega*
Manuscript ID	ao-2020-002477.R1
Manuscript Type:	Article
Date Submitted by the Author:	n/a

Complete List of Authors:	Ansar, *; Mataram University, Agricultural Engineering Sukmawaty, *; Mataram University, Agricultural Engineering Abdullah, Sirajuddin; Mataram University, Agricultural Engineering Nazaruddin, *; Mataram University, Food Science and Technology Safitri, Erna; Universitas Mataram, Agricultural Engineering

Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (*Arenga Pinnata* MERR) Bioethanol and Premium

Ansar[1*], Sukmawaty[1], Sirajuddin Haji Abdullah[1], Nazaruddin[2], Erna Safitri[1]

[1]Department of Agricultural Engineering, Faculty of Food Technology and Agroindustries, University of Mataram, Indonesia

[2]Department of Food Science and Technology, Faculty of Food Technology and Agroindustries, University of Mataram, Indonesia

[*]E-mail: ansar72@unram.ac.id

ABSTRACT

Along with the development of the motor vehicle industry technology at this time, the fuel demand is also increasing, while the supply is running low. Thus alternative fuels are needed to meet these energy needs. This study aims to explain the physical and chemical characteristics of the fuel mixture (MF) between palm sap bioethanol with a premium. The results showed that the higher the bioethanol concentration of palm sap, the higher the MF's viscosity, but the heat of the fuel decreased. This decrease is caused by differences in the heating value of the two fuels. The MF's high heat burn value is blue, while the low heat value of flame is reddish yellow. The results of this study are very important as a basis for the development of bioethanol from palm sap as an environmentally friendly vehicle fuel substitution material.

Keywords: bioethanol, calorific values, palm sap, flame, viscosity

1. INTRODUCTION

The human need for fuel is currently increasing along with the development of the motor vehicle industry.[1] The largest source of fuel used by motor vehicles comes from fossil fuels.[2] This fossil fuel cannot be expected for a long period because the amount is limited and cannot be renewed.[3, 4]

Bioethanol has been developed in many countries as an energy source for fossil energy substitution.[5, 6] Bioethanol production in the United States is developed from corn to apply bioethanol energy.[7] Brazil has been developing bioethanol sourced from sugar cane by conducting tests on vehicles since 1925.[8] China and Thailand develop bioethanol from cassava.[9] South Korea has been developing biodiesel since 2002 and its consumption is estimated to increase 0.5 percent per year.[5]

Brazil develops bioethanol from sugar cane at a low cost of 14 cents a dollar/liter. Thailand with tapioca 18.5 cents a dollar/liter, and America using corn 25.5 cents a dollar/liter.[10] The success of Brazil in producing bioethanol from sugar cane on an industrial scale has led many countries to follow these strategic steps. Currently in Brazil motorcyclists can fill fuel tanks with a mixture of 24% ethanol and 76% gasoline.[11] As in Indonesia, the government has given serious attention to developing bioethanol by issuing Presidential Instruction No. 1 of 2006 regarding the supply and use of biofuel as an alternative fuel.[12, 13]

Bioethanol is one type of biofuel that can be used as a substitute for fossil fuels.[14, 15] The use of bioethanol as a fuel mixture is important to save the earth from global warming.[16] The development of bioethanol as an alternative fuel must be supported by several factors, including the availability of abundant raw materials, bioethanol making technology available, the existence of promising market opportunities and benefits.[17, 18]

Bioethanol can be produced from various types of plants, such as sugar cane, cassava, corn, sorghum, palm sap, or other types of plants.[18, 19] Palm sap (*Arenga Pinnata* MERR) is very abundant in Indonesia (Table 1), so it has the potential to be processed into bioethanol.[20] This plant contains glucose, fructose, sucrose with a composition of about 0.4-0.5%, 0.5-0.6%, and 10-13% respectively.[21, 22] The sugar content is quite high, so that palm sap has the potential to be processed into bioethanol.[23] So far, the use of palm sap is still very limited, namely only as of the manufacture of palm sugar.[24]

Table 1. Estimation area of palm sap in Indonesia[25]

Province	An estimate of the total area (ha)
Nanggro Aceh Darussalam	4,081
North Sumatera	4,357
West Sumatera	1,830
Bengkulu	1,748
West Jawa	13,135
Banten	1,448
Central Jawa	3,078
South Kalimantan	1,442
North Sulawesi	6,000
South Sulawesi	7,293
Southeast Sulawesi	3,070
Maluku	1,000
North Maluku	2,000
Papua	10,000
Total	60,482

Bioethanol has become a very interesting topic and is always up to date in various research communities in the world, from the production process to compatibility with motor vehicles.[1, 26] Some of the advantages of using bioethanol, including exhaust emissions more environmentally friendly compared to premium fuels and Pertamax.[27, 28] Bioethanol is a potential fuel because the raw material can be renewed.[29]

Bioethanol production must focus on abundant plants, but its use is not for basic food needs. Brazil has been applying the bioethanol-gasoline mixture since the 1930s and increased 50% in 1943.[30] Indonesia as a country that has a relatively similar geographical condition to Brazil, has the potential to follow Brazil's path in utilizing abundant natural resources to meet domestic energy needs. This is in line with Indonesia's transportation system which mostly uses gasoline.[13] Bioethanol can bring practical benefits if applied nationally in Indonesia.[28]

Physical and chemical characteristics of bioethanol are very possible to be mixed with gasoline.[31] The need to meet energy demand with apprehensive environmental impacts and limited fuel stock from fossil fuels has led researchers to look for renewable and environmentally friendly energy resources, one of which is bioethanol.[32] However, the bioethanol production process is more complex and requires large investment capital.[33] The main obstacle is bioethanol must be compatible with motor vehicle combustion systems.[34]

Based on the arguments above, in this paper, the focus of the study is on the physical and chemical properties of the fuel mixture of palm sap bioethanol with premium (MF). Although there have been studies focusing on aspects of bioethanol production,[35, 36] it is still urgent to conduct research that focuses to explain of the physical and chemical properties of the palm sap bioethanol after it is mixed with premium fuel.

Many researchers have developed palm sap into bioethanol as a fuel mixture for motor vehicles.[20, 37, 38, 39] However, no valid data has been found about the viscosity, calorific value, and flame after the palm sap bioethanol are mixed with premium. Therefore, it is important to examine to reveal the viscosity, calorific value, and flame as physical and chemical characteristics of fuel for motor vehicles. Thus, the purpose of this study is to explain the physical and chemical characteristics of a fuel mixture between palm sap bioethanol and premium.

2. METHOD AND MATERIAL

2.1. Material and Tools

The materials used are bioethanol from distillation palm sap (*Arenga Pinnata* MERR) (**Fig. 1**) and premium type fuel with octane number 88 obtained directly from refueling in Mataram, West Nusa Tenggara Province, Indonesia.

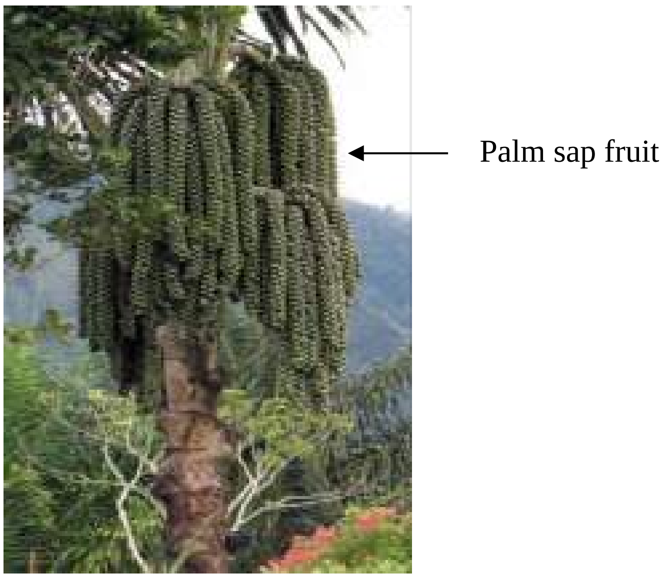

Fig. 1. Palm sap is widely cultivated in Indonesia.[20]

These ingredients are mixed with various variations of concentration (**Table 1**).

Table 1. Variation of concentrations between bioethanol palm sap with premium

No.	Palm sap bioethanol (ml)	Premium (ml)
1	10	90

2	15	80
3	20	70
4	25	60
5	30	50

The tools used are viscometer, C-5000 calorimeter bomb, thermometer, test tube, analytical balance, oxygen cylinder, oxygen regulator, oxygen hose, test tube, and LPG gas stove.

2.2. MF Viscosity Measurement

MF viscosity is measured using an open gravity capillary viscometer in the temperature range of 20-30^{o}C.[40] Mathematical the MF viscosity equation can be written:[41]

$$F = \eta A \frac{V}{L} \qquad (1)$$

with, F = force on the surface of the liquid, η = coefficient of fluid viscosity (Ns/m^2), A = liquid area (m^2), V = moving wall velocity (m / s), L = distance of the two surfaces (m).

2.3. Measurement of MF Calorific Value

MF burn calorie measurement using bomb calorimeter type IKA C-5000 (**Fig. 2**). The reaction that occurs in a bomb calorimeter can produce heat absorbed by water and bombs, so that no heat is wasted into the air, so it can be written as:

$$r_{eaction} = -(q_{air} + q_{bomb}) \qquad (2)$$

Fig. 2. Bomb calorimeter type IKA C-5000.[20]

The amount of heat absorbed by water can be calculated using the formula:

$Q_{water} = m.c.\Delta T$ (3)

where, m = mass of water (g), c = heat type of water (J/kg^{o}C), and ΔT = temperature change (^{o}C).

The amount of heat absorbed by the bomb calorie meter can be calculated using the formula:

$q_{bomb} = c_{bomb}.\Delta T$ (3)

where, c_{bomb} = heat capacity of bomb (J/g^{o}C) and ΔT = temperature change (^{o}C).

2.4. MF Flame Test

Flame tests were carried out to detect the presence of metal ion elements in MF bioethanol at a premium by dipping cotton bad cotton washed with hydrochloric acid in the MF liquid and then igniting it with fire (**Fig. 3**). This flame test is to provide qualitative information on the colors arising from the combustion process based on the light spectrum of the electromagnetic radiation elements present in the sample. The flame that arises will be adjusted to the table of chemical elements with the flame.[42]

Fig. 3. MF bioethanol and premium flame test.[20]

2.5. Data Analysis

The effect of variations in the concentration of palm sap bioethanol and premium on the physical and chemical characteristics of the MF was analyzed using analysis of variance.[43] If the F-count value is greater than the F-crit, it means that there is a significant difference in the significance level of 95%. The most influential variable can be identified using the DMRT (Duncan's Multiple Ranges Test).

3. RESULT AND DISCUSSIONS

3.1. Viscosity of MF

Palm sap bioethanol produced in this study is shown in **Fig. 4**. MF viscosity in various concentrations of bioethanol and premium is shown in **Table 2**. In the table, it appears that the higher the concentration of the palm sap bioethanol, the higher the MF's viscosity. Fuel viscosity can affect the fogging process. Fuels that have high viscosity are difficult to atomize. Conversely, fuels with low viscosity are easier to be atomized. Fuels that are more easily atomized, are also easier to ignite and also more perfect combustion.

Fig. 4. Palm sap bioethanol produced in this study.[20]

The results of the bioethanol test of palm sap were obtained a value of 4.7 mm^2/s, while the premium was 7.2 mm^2/s.[42] After mixing the data obtained that the higher the concentration of bioethanol palm sap, the lower the MF's viscosity (**Table 2**). This is thought to be influenced by the viscosity of bioethanol which is lower than the premium viscosity. These results are in line with research reported by Tazi and Sulistiana[2] that the higher the addition of bioethanol, the lower the viscosity of the fuel.

Table 2. MF viscosity at various concentrations between bioethanol and premium.

No	Comparison of fuel mixes (%)		The viscosity of MF (mm^2/s)
	Bioethanol of palm sap (ml)	Premium (ml)	
1	10	90	5.4
2	15	85	5.4
3	20	80	4.6
4	25	75	4.5
5	30	70	4.3

The results of the two-factor variance analysis show that the calculated F-value (153.963) is greater than the F-table value (3.490). This means that the variation in the concentration of bioethanol palm sap has a significant effect ($p > 0.5$) on the MF's viscosity (**Table 3**).

Table 3. Results of analysis variance two factors of MF viscosity parameters.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	1.223	4	0.30575	0.007	0.999	3.259
Columns	19625.3	3	6541.7653	153.963	7.647E-10	3.490
Error	509.869	12	42.489083			
Total	20136.39	19				

3.2. MF Calorific Value

The calorific value of the fuel shows the heat produced from the combustion process. If the combustion is perfect, then the optimal thermal energy can be obtained. Separate test results obtained caloric value of ethanol palm sap is 10.126 kcal/g, while the premium is 11.414 kcal/g. After mixing, the highest heating value of the MF was 11.107 kcal/g and the lowest was 9.445 kcal/g (**Table 4**).

Table 4. MF calorific values for various concentrations between bioethanol and premium.

No.	Comparison of fuel mixes (%)		Calorific values of MF (kcal/g)
	Palm sap bioethanol (ml)	Premium (ml)	
1	10	90	11.107
2	15	85	11.015

3	20	80	10.324
4	25	75	10.152
5	30	70	9.445

Table 4 shows that the higher the concentration of bioethanol palm sap added to the premium, the MF's calorific value decreases. This decrease is caused by the difference in the heating value between the two fuels. The results of this study are in line with the research of Budiprasojo and Pratama [39] who reported that low heating value of fuel can affect the high heating value if mixed.

The National Standards Agency (BSN) has set bioethanol quality standards with a minimum heating value of 5,000 kcal/g.[44] Based on the quality standards set by BSN, the MF bioethanol and premium produced in this study were following the standards.

Table 5. Results of variance analysis two-factor for MF calorific value parameters.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.870752	4	0.217688	0.005	0.99994	3.259
Columns	18509.81	3	6169.936	144.894	1.09E-09	3.490
Error	510.9863	12	42.58219			
Total	19021.66	19				

The results analysis of variance the two-factor show that the calculated F-value (144.894) is greater than the F-table value (3.490) (**Table 5**). This means that the variation in the concentration of bioethanol palm sap has a significant effect (p> 0.5) on the heating value of the MF.

3.3. MF Flame Test

MF flame test results on variations in the concentration of palm sap bioethanol and premium showed 2 different types of fire colors namely blue and reddish-yellow. MF which contains low concentrations of palm sap bioethanol produces a blue flame, while for high concentrations produces a reddish yellow flame. This is in line with the report of McLinden et al.[45] that the flame from bioethanol is not only blue but also reddish-yellow. The same thing was reported by Polikarpov et al.[46] that at the time of combustion a blue flame appeared at the bottom and reddish yellow at the top.

The blue combustion results indicate that the methane (CH4) content in the MF has been completely burned. The results of this study are in line with the research of Susanto et al.[47] who reported that methane gas was marked with a blue flame. However, if the reddish-yellow fire means incomplete combustion and the flame is unstable. Cahyani[48] also reports that the color of the blue flame indicates high ethanol levels.

A comparison of the physical and chemical characteristics of the mixed fuel between the palm sap bioethanol and premium from this study with several other studies is shown in **Table 6**.

Table 6. Comparison of physical and chemical characteristics of mixed fuels.

Combined of fuel mixes	Value			References
	Viscosity at 40°C (mm^2/s)	Calorific (kcal/g)	Flame Test (color)	
The premium of RON 88	7.2	11.414	reddish-yellow	[41]
20% bioethanol of liquid polypropylene - 80%	-	11.340	reddish-yellow	[39]

Gasoline				
20% bioethanol of pineapple – 80% premium	-	7.331	-	[46]
30% bioethanol of Cassava flours - 70% gasoline	-	23	-	[38]
30% bioethanol of sugar molasses - 70% gasoline	2.2	15	-	[37]
30% palm sap bioethanol - 70% premium	4.7	10.126	reddish-yellow	This research

The results of the two-factor variance analysis show that the calculated F-value (68.308) is greater than the F-table value (3.490) (**Table 7**). This means that variations in the concentration of bioethanol palm sap and premium affect the MF's flame. The blue flame color indicates high ethanol content.

Table 7. Results of analysis of variance two-factor of the MF's flame values.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	155.0324	4	38.75809	0.408	0.799	3.259
Columns	19472.58	3	6490.86	68.308	8.23E-08	3.490
Error	1140.277	12	95.02309			
Total	20767.89	19				

4. CONCLUSIONS

The high concentrations of palm sap bioethanol causes the MF viscosity is also higher, but too difficult to obscure. The higher the concentration of bioethanol palm sap, the lower the heating value of MF. The MF flame test results on variations in the concentration of bioethanol palm sap and premium showed 2 different types of fire colors namely blue and reddish-yellow. The blue color indicates high ethanol content, while the reddish-yellow color indicates low ethanol content

The physical and chemical properties of MF fuels still need to be studied comprehensively by conducting MF trials on various types of motorized vehicles. Besides, further research is needed on mixing palm sap bioethanol with other types of fuel.

Acknowledgment

The Research Team would like to thank the Faculty of Food Technology and Agroindustries, University of Mataram for all the facilities support, so this research activity could be carried out. Acknowledgments were also conveyed to all those who have helped carry out these research.

Conflict of Interest

All authors declare no conflict of interest.

REFERENCES

(1) Mahlia, T. M. I.; Syazmi, Z. A. H. S.; Mofijur, M.; Abas, A. E. P.; Bilad, M. R.; Ong, H. C.; Silitonga, A. S. Patent landscape review on biodiesel production: Technology

updates. *Renewable and Sustainable Energy Reviews* **2020**, *118*, 109526. DOI: 10.1016/j.rser.2019.109526.

(2) Tazi, I.; Sulistiana. Test the heating fuel of a mixture of bioethanol and used cooking oil. *Journal of Neutrino* **2011**, *3*, 163-174.

(3) Rijanto, M. W.; Armawi, A. The role of youth and the community in the development of renewable alternative energy to support energy security. *Journal of National Resilience* **2011**, *16*, 35-52.

(4) Mofijur, M.; Hasan, M. M.; Mahlia, T. M. I.; Rahman, S. M. A.; Silitonga, A. S.; Ong, H. C. Performance and emission parameters of homogeneous charge compression ignition (HCCI) engine: a review. *Energies*, **2019**, *12*, 35-57.

(5) Balat, M. Global bio-fuel processing, and production trends. *Energy Explore* **2007**, *25*, 195-218.

(6) Guigou, M.; Lareo, C.; Pérez, L. V.; Lluberas, M. E.; Vázquez, D.; Ferrari, M. D. Bioethanol production from sweet treatments sorghum: evaluation of post-harvest on sugar extraction and fermentation. *Biomass Bioenergy* **2011** *35*, 3058-3062.

(7) Gupta, A.; Verma, J.P. Sustainable agro-residues: bio-ethanol production from a review. *Renew. Sustain. Energy Rev.* **2015,** *41*, 550-567.

(8) Deesuth, O.; Laopaiboon, P.; Klanrit, P.; Laopaiboon, L. Improvement of ethanol production from sweet sorghum juice under high gravity and very high gravity conditions: effects of nutrient supplementation and aeration. *Ind. Crop Prod.* **2015**, *74*, 95-102.

(9) Zhang, C.; Xie, G.; Li, S.; Ge, L.; He, T. The productive potentials of sweet sorghum Ethanol in China. *Applied Energy* **2010**, *87*, 2360-2368.

(10) Gnansounou, E. Production and use of lignocellulosic bioethanol in Europe current situation and perspectives. *Bioresource Technol*. **2010**, *101*, 4842-4850.

(11) Szklo, A.; Schaeffer, R.; Delgado, F. Can one say ethanol is a real threat to gasoline? *Energy Policy*, **2007**, *35*, 5411-5421.

(12) Kusumaningsih, T. Making biodiesel fuel from castor oil. *Biotechnology* **2006**, *3*, 20-26.

(13) Silitonga, A. S.; Masjuki, H. H.; Mahlia, T. M. I.; Ong, H. C.; Chong, W. T.; Boosroh, M. H. Overview properties of biodiesel diesel blends from the edible and non-edible feedstock. *Renewable and Sustainable Energy Reviews* **2013**, *22*, 346-360. DOI: 10.1016/j.rser.2013.01.055.

(14) Sebayang, A. H.; Masjuki, H. H.; Ong, H. C.; Dharma, S.; Silitonga, A. S.; Mahlia, T. M. I.; Aditiya, H. B. A perspective on bioethanol production from biomass as an alternative fuel for the spark-ignition engine. *RSC Advances* **2016**, *6*, 14964-14992. DOI: 10.1039/c5ra24983j.

(15) Sebayang, A. H.; Masjuki, H. H.; Ong, H. C.; Dharma, S.; Silitonga, A. S.; Kusumo, F.; Milano, J. Optimization of bioethanol production from sorghum grains using artificial neural networks integrated with an ant colony. *Industrial Crops and Products* **2017**, *97*, 146–155. DOI: 10.1016/j.indcrop.2016.11.064.

(16) Connelly, E. B.; Colosi, L. M.; Clarens, A. F.; Lambert, J. H. Life Cycle Assessment of Biofuels from Algae Hydrothermal Liquefaction: The Upstream and Downstream Factors Affecting Regulatory Compliance. *Energy & Fuels*, **2015**, *29*, *1653–1661*. DOI: 10.1021/ef502100f.

(17) Devita, L. Biodiesel as an alternative energy and perspective. *Agrica Extensia* **2015**, *9*, 23-26.

(18) Sebayang A. H.; Hassan M. H.; Ong, H. C.; Dharma, S.; Bahar, A. H.; Silitonga, A. S.; Kusumo, F. Enzymatic hydrolysis using ultrasound for bioethanol production from

durian (Durio zibethinus) seeds as a potential biofuel. *Chemical Engineering Transactions*, **2017**, *56*, 553-558 DOI: 10.3303/CET1756093.

(19) Yamada, S.; Shinomiya, N.; Ohba, K.; Sekikawa, M.; Oda, Y. Enzymatic hydrolysis and ethanol fermentation of by-products from potato processing plants. *Food Sci. Technol. Res*. **2009**, *15*, 653-658.

(20) Ansar, Nazaruddin, and Azis, A. D. Effect of Temperature and Time Storage to pH and Color Changes of Palm Sap (*Arenga pinnata* MERR) after Tapping. *Journal of Agricultural Engineering Lampung* **2019,** *8*, 40-48.

(21) Sia, J.; Yee, H. B.; Santos, J. H.; Abdurrahman, M. K. A. Cyclic voltammetric analysis of antioxidant activity in cane sugars and palm sugars from Southeast Asia. *Food Chemistry* **2010**, *118*, 840-846.

(22) Fahrizal, F.; Abubakar, Y.; Muzaifa, M.; Muslim, M. The effects of temperature and length of fermentation on bioethanol production from aren plant (*Arenga pinnata* MERR). *International Journal on Advanced Science, Engineering, Information Technology* **2013**, *3*, 55-59.

(23) Kismurtono, M. Fed-batch alcoholic fermentation of palm juice (*Arenga pinnata* MERR): Influence of the feeding rate on yeast, yield, and productivity. *International Journal of Engineering & Technology* **2012**, *2*, 795-799.

(24) Victor, I.; Orsat, V. Characterization of *Arenga pinnata* (palm) sugar. *Sugar Tech* **2018**, *20*, 105-109. DOI: 10.1007/s12355-017-0537-3.

(25) Effendi, D. S. Prospect of aren tree development (*Arenga pinnata* MERR) to supporting bioethanol need in Indonesia. *Perspective* **2010,** *9*, 36-46.

(26) Zhang, Q.; Weng, C.; Huang, H.; Achal, V.; Wang, D. Optimization of bioethanol production using the whole plant of water hyacinth as a substrate in the simultaneous

saccharification and fermentation process. *Frontiers in Microbiology* **2016**, *6*, 1-9. DOI: 10.3389/fmicb.2015.01411.

(27) Ong, H. C.; Masjuki, H. H.; Mahlia, T. M. I.; Silitonga, A. S.; Chong, W. T.; Yusaf, T. Engine performance, and emissions using Jatropha curcas, Ceiba pentandra and Calophyllum inophyllum biodiesel in a CI diesel engine. *Energy* **2014**, *69*, 427–445. DOI: 10.1016/j.energy.2014.03.035.

(28) Silitonga, A. S.; Masjuki, H. H.; Ong, H. C.; Sebayang, A. H.; Dharma, S.; Kusumo, F.; Sugiyanto, B. Evaluation of the engine performance and exhaust emissions of biodiesel-bioethanol-diesel blends using kernel-based extreme learning machine. *Energy* **2018**, *159*, 1075–1087. DOI: 10.1016/j.energy.2018.06.202.

(29) Tan, L.; Sun, Z. Y.; Okamoto, S.; Takaki, M.; Morimura, S.; Kida, K.; Tang, Y. Q. Production of ethanol from raw juice and thick juice of sugar beet by continuous ethanol fermentation with flocculating yeast strain KF-7. *Biomass and Bioenergy* **2015**, *81*, 256-272. DOI: 10.1016/j.biombioe.2015.07.019.

(30) Soccol, C. R.; Vandenberghe, L. P. d. S.; Medeiros, A. B. P.; Karp, S. G.; Buckeridge, M.; Ramos, L. P.; Pitarelo, A. P.; Ferreira-Leitão, V.; Gottschalk, L. M. F.; Ferrara, M. A.; Silva Bon, E. P. D.; Moraes, L. M. P. D.; Araújo, J. d. A.; Torres, F. A. G. Bioethanol from lignocelluloses: Status and perspectives in Brazil. *Bioresource Technol*. **2010**, *101*, 4820-4825.

(31) Ong, H. C.; Silitonga, A. S.; Masjuki, H. H.; Mahlia, T. M. I.; Chong, W. T.; Boosroh, M. H. Production and comparative fuel properties of biodiesel from non-edible oils: Jatropha curcas, Sterculia foetida, and Ceiba pentandra. *Energy Convers. Manage*. **2013**, *73*, 245-255.

(32) Xuan, F.; Chai, D. J.; Su, H. Local density approximation for the short-range exchange free energy functional. *ACS Omega* **2019**, *4*, 7675-7683. DOI: 10.1021/acsomega.9b00303.

(33) Sun, P.; Gao, G.; Zhao, Z.; Xia, C.; Li, F. Stabilization of cobalt catalysts by embedment for efficient production of valeric biofuel. *ACS Catalysis* **2014**, *4*, 4136-4142.

(34) Dayma, G.; Halter, F.; Foucher, F.; Casimir Togbe, C.; Rousselle, C. M.; Dagaut, P. Experimental and detailed kinetic modeling study of ethyl pentanoate (ethyl valerate) oxidation in a jet stirred reactor and laminar burning velocities in a spherical combustion chamber. *Energy Fuels* **2012,** *26*, 4735-4748.

(35) Galletti, R., A. M.; Antonetti, C.; Ribechini, E.; Colombini, M. P.; Nassio Di Nasso, N.; Bonari, E. From giant reed to levulinic acid and gamma-valerolactone: A high yield catalytic route to valeric biofuels. *Applied Energy* **2013**, *102*, 157-162.

(36) Kon, K.; Onodera, W.; Shimizu, K. Selective hydrogenation of levulinic acid to valeric acid and valeric biofuels by a Pt/HMFI catalyst. *Catalysis Science & Technology* **2014**, *4*, 3227-3234.

(37) Ademiluyi, F. T.; Mepba, H. D. Yield, and properties of ethanol biofuel produced from different whole cassava flours. *ISRN Biotechnology* **2013**, 1-7.

(38) Ghazikhani, M., M; Hatami, B.; Safari; Ganji, D. D. Experimental investigation of performance improvement and emissions reduction in a two-stroke SI engine by using ethanol additives. *Propulsion Power Res*. **2013**, *2*, 276-283.

(39) Budiprasojo, A.; Pratama, A. W. The heating value of premium blends with polypropylene fuel resulting from the pyrolysis process. *Journal of Ilmiah Inovasi* **2016,** *1*, 122-127.

(40) Laesecke, A.; Tara, J.; Fortin; Jolene, D.S. Density, speed of sound, and viscosity measurements of reference materials for biofuels. *Energy & Fuels* **2012**, *26*, 1844-1861. DOI: 10.1021/ef201645r.

(41) Niemeyer, K. E.; Daly, S. R.; Cannella, W. J.; Hagen, C. L. A novel fuel performance index for low-temperature combustion engines based on operating envelopes in light-duty driving cycle simulations. *Journal of Engineering for Gas Turbines and Power* **2015**, *137*, 101601. DOI: 10.1115/1.4029948.

(42) Yuliyanto, D.; Widodo, E. Test the heating fuel of a mixture of bioethanol and used cooking oil. *Journal of Manufacturing Energy Engineering* **2018**, *3*, 1-5.

(43) Ansar; Nazaruddin; Azis, A.D. Effect of vacuum freeze-drying condition and maltodextrin on the physical and sensory characteristics of passion fruit (Passiflora edulis Sims) extract. *IOP Conf. Ser.: Earth Environ. Sci.* **2019**, *355* 012067. DOI: 10.1088/1755-1315/355/1/012067.

(44) Aditiya, H. B.; Chong, W. T.; Mahlia, T. M. I.; Sebayang, A. H.; Berawi, M. A.; Nur, H. Second generation bioethanol potential from selected Malaysia's biodiversity biomasses: A review. *Waste Management* **2016**, *47, 46-61*. DOI: 10.1016/j.wasman.2015.07.031.

(45) McLinden, M. O.; Bruno, T. J.; Frenkel, M.; Huber, M. L. Standard reference data for the thermophysical properties of biofuels. *J. ASTM Int.* **2010**, *7*, 1-18.

(46) Polikarpov, E.; Albrecht, K. O.; Page, J. P.; Malhotra, D.; Koech, P.; Cosimbescu, L.; Gaspar, D. J. Critical fuel property evaluation for potential gasoline and diesel biofuel blend stocks with low sample volume availability. *Fuel* **2019**, *238*, 26-33. DOI: 10.1016/j.fuel.2018.09.129.

(47) Susanto, R.; Jaya, H.; Mulyanto, A. Analysis of the effect of fermentation time and distillation temperature on physical properties (specific gravity and caloric value) of

bioethanol made from pineapple (ananas comosus). *Mechanical Engineering Dynamics* **2013**, *3*, 91-100.

(48) Cahyani; Anisah. Effect of enzyme volume on alcohol content and caloric value of bioethanol made from yam tubers (Dioscorea hipsida dentist). *Journal of Agricultural Engineering of Tropic and Biosystems* **2015**, *3*, 35-42.

Ansar - <ansar72@unram.ac.id>

Ansar, * ao-2020-002477.R2 - Revised Manuscript Submission to ACS Omega 29-Apr-2020

1 pesan

ACS Omega <onbehalfof@manuscriptcentral.com> 29 April 2020 17.26
Balas Ke: support@services.acs.org
Kepada: ansar72@unram.ac.id
Cc: ansar72@unram.ac.id, sukmawaty14@unram.ac.id, sirajuddintep@yahoo.com, nazaruddin59itp@yahoo.com, ernasafitritep@yahoo.com

29-Apr-2020

Journal: ACS Omega
Manuscript ID: ao-2020-002477.R2
Title: "Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (Arenga Pinnata MERR) Bioethanol and Premium"
Authors: Ansar, *; Sukmawaty, *; Abdullah, Sirajuddin; Nazaruddin, *; Safitri, Erna
Manuscript Status: Submitted

Dear Dr. Ansar:

Your manuscript has been successfully submitted to ACS Omega, a multidisciplinary, open access journal for the publication of original and scientifically valid research. The journal offers expedited editorial decision-making and immediate open availability. Authors can rapidly publish their important research results and broadly distribute them to the global scientific community. Please note that there are publishing charges associated with this journal. Details can be found at http://acsopenaccess.org. Should your manuscript be accepted, you will be required to pay for the Article Publishing Charges prior to publication. Authors may qualify for discounts. Article Publishing Charges are waived for invited Editorials and Perspectives.

Please reference the above manuscript ID in all future correspondence. If there are any changes in your contact information, please log in to ACS Paragon Plus with your ACS ID at http://paragonplus.acs.org/login and select "Edit Your Profile" to update that information.

You can view the status of your manuscript by checking your "Authoring Activity" tab on ACS Paragon Plus after logging in to http://paragonplus.acs.org/login.

ACS Authoring Services

Did you know that ACS provides authoring services to help scientists prepare their manuscripts and communicate their research more effectively? Trained chemists with field-specific expertise are available to edit your manuscript for grammar, spelling, and other language errors, and our figure services can help you increase the visual impact of your research.

Visit https://authoringservices.acs.org to see how we can help you! Please note that the use of these services does not guarantee that your manuscript will be accepted for publication.

Thank you for submitting your manuscript to ACS Omega.

Sincerely,

Dr. Krishna Ganesh and Dr. Deqing Zhang
ACS Omega

Ansar - <ansar72@unram.ac.id>

Ansar, * ao-2020-002477.R2 Assigned to Editor 29-Apr-2020

1 pesan

ACS Omega <onbehalfof@manuscriptcentral.com> 29 April 2020 17.26
Balas Ke: Ganesh-office@omega.acs.org
Kepada: ansar72@unram.ac.id
Cc: ansar72@unram.ac.id, sukmawaty14@unram.ac.id, sirajuddintep@yahoo.com, nazaruddin59itp@yahoo.com, ernasafitritep@yahoo.com

29-Apr-2020

Journal: ACS Omega
Manuscript ID: ao-2020-002477.R2
Title: "Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (Arenga Pinnata MERR) Bioethanol and Premium"
Author(s): Ansar, *; Sukmawaty, *; Abdullah, Sirajuddin; Nazaruddin, *; Safitri, Erna
Manuscript Status: Associate Editor Assigned

Dear Dr. Ansar:

Thank you for submitting your manuscript to ACS Omega, a multidisciplinary, open access journal for the publication of original and scientifically valid research. The journal offers expedited editorial decision-making and immediate open availability. Authors can rapidly publish their important research results and broadly distribute them to the global scientific community. Please note that there are publishing charges associated with this journal. Details can be found at http://acsopenaccess.org. Should your manuscript be accepted, you will be required to pay for the Article Publishing Charges prior to publication. Authors may qualify for discounts. Article Publishing Charges are waived for invited Editorials and Perspectives.

"Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (Arenga Pinnata MERR) Bioethanol and Premium" has been assigned to the following editor:

Prof. Frank Quina
Associate Editor
ACS Omega
Phone: + 55 11 3091-2162
Fax: (202) 354-5151
Email: quina-office@omega.acs.org

Please address all future correspondence regarding this manuscript to the above editor.

Submission of a manuscript to implies that the work reported therein has not received prior publication and is not under consideration for publication elsewhere in any medium, including electronic journals and computer databases of a public nature. This manuscript is being considered with the understanding that it is submitted on an exclusive basis. If otherwise, please advise.

Also please note that according to ACS Ethical Guidelines to Publication of Chemical Research, all authors must have reviewed and approved the submission of their manuscript. If you are a coauthor and approve its submission, no action is necessary. If you do not approve its submission to ACS Omega, please let us know as soon as possible. Refer to the manuscript number listed above in any correspondence, or you may simply reply to this message leaving the subject line intact. For more information on ethical responsibilities of authors, see the Ethical Guidelines to Publication of Chemical Research at http://pubs.acs.org/page/policy/ethics/index.html.

In publishing only original research, ACS is committed to deterring plagiarism, including self-plagiarism. ACS Publications uses Crossref Similarity Check Powered by iThenticate to screen submitted manuscripts for similarity to published material, and other software to screen previous submissions to ACS journals. Note that your manuscript may be screened during the submission process.

Sincerely,

Dr. Krishna Ganesh
Coeditor
ACS Omega
Phone: (202) 657-6323
Email: Ganesh-office@omega.acs.org

Ansar - <ansar72@unram.ac.id>

Ansar, * ao-2020-002477.R3 - Manuscript Accepted 15-May-2020

1 pesan

ACS Omega <onbehalfof@manuscriptcentral.com> 15 Mei 2020 20.39
Balas Ke: quina-office@omega.acs.org
Kepada: ansar72@unram.ac.id

15-May-2020

Journal: ACS Omega
Manuscript ID: ao-2020-002477.R3
Title: "Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (Arenga Pinnata MERR) Bioethanol and Premium"
Author(s): Ansar, *; Sukmawaty, *; Abdullah, Sirajuddin; Nazaruddin, *; Safitri, Erna
Manuscript Status: Accept

Dear Dr. Ansar:

We are pleased to inform you that your manuscript has been accepted for publication in ACS Omega, a multidisciplinary, open access journal for the publication of original and scientifically valid research. The journal offers expedited editorial decision-making and immediate open availability. Authors can rapidly publish their important research results and broadly distribute them to the global scientific community.

Your manuscript has been forwarded to the ACS Publications office. Although production of your manuscript will start immediately, your manuscript will not be published until you pay the Article Publishing Charges, http://acsopenaccess.org. You may qualify for discounts. You will be contacted shortly with information on how to pay your publishing charges. Article Publishing Charges are waived for invited Editorials and Perspectives.

You will be contacted in the near future by the ACS Journal Publishing Staff regarding the proofs for your manuscript. Please note: An ACS ID is required to access proof materials. If you do not have an ACS ID, you will be prompted to create one.

After you approve your proofs, your manuscript will be ready to be published on the Web in approximately 48 hours. Article publishing charges must be paid before your manuscript will be published. In view of this fast publication time, it is important to review your proofs carefully. Once a manuscript appears on the Web it is considered published. Any change to the manuscript once it appears on the Web will need to be submitted to the journal office as a separate Addition & Correction manuscript via the ACS Paragon Plus environment.

Once your paper is published, you can track downloads and citations of your work by logging into the ACS Publishing Center (https://pubs.acs.org/publish/dashboard) and selecting "Published".

Sincerely,

Prof. Frank Quina
Associate Editor
ACS Omega
Phone: + 55 11 3091-2162
Fax: (202) 354-5151
Email: quina-office@omega.acs.org

Ansar - <ansar72@unram.ac.id>

Case #01081448 - Author Charges Inquiry [ref:_00D30oeGz._5004Q1zfWg5:ref]

2 pesan

publicationservices@copyright.com <publicationservices@copyright.com> 22 Mei 2020 07.06
Kepada: "ansar72@unram.ac.id" <ansar72@unram.ac.id>

Dear Dr. Ansar Ansar,

Thank you for contacting Copyright Clearance Center's RightsLink for Scientific Communications. My name is Allan and it will be my pleasure to assist you. I apologize for the delayed response, due to the current global situation our usual response time has increased more than expected.

I was able to confirm that you have successfully generated an invoice for **Manuscript ID: 10.1021/acsomega.0c00247**. As per your request, I have attached a copy of the Invoice **APC600119453** and Order #**10000153494** to this email. You'll find detailed instructions on how to pay by credit card, check, or wire transfer on the second page of your invoice.

I'm glad I was able to assist you today. Let me know if you have any additional questions and I'll be happy to further assist.

Kind regards,
Allan

Allan Chavarria
Customer Account Specialist
Copyright Clearance Center
222 Rosewood Drive
Danvers, MA 01923
www.copyright.com
Toll Free US +1.855.239.3415
International +1.978-646-2600
Facebook - Twitter - LinkedIn

ref:_00D30oeGz._5004Q1zfWg5:ref

---------------- Original Message ----------------
From: Ansar - [ansar72@unram.ac.id]
Sent: 5/19/2020 10:28 PM
To: publicationservices@copyright.com
Subject: Author Charges Inquiry

Dear ACS Publication

I am Ansar
I want to ask you where my invoice APC with order number 10000153494
Best regards,
Ansar

ref:_00D30oeGz._5004Q1zfWg5:ref

2 lampiran

Invoice APC600119453.pdf
128K

Order #10000153494.pdf
78K

Ansar - <ansar72@unram.ac.id> 22 Mei 2020 19.16
Kepada: publicationservices@copyright.com

Dear Allan
Thank you for your informatian. I will pay the invoice on Thuesday, bacause tomorrow until Sunday is holliday.
Best wishes,
Ansar
[Kutipan teks disembunyikan]

Ansar - <ansar72@unram.ac.id>

Invitation to Review Proofs for ao-2020-002477

1 pesan

acsproof@acs.org <acsproof@acs.org> 27 Mei 2020 02.30
Kepada: ansar72@unram.ac.id

May 26, 2020

Journal: ACS Omega
Manuscript No.: ao-2020-002477 (acsomega.0c00247)
Title: Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (Arenga Pinnata MERR) Bioethanol and Premium .
Authors: * Ansar, * Sukmawaty, Sirajuddin Haji Abdullah Si, * Nazaruddin Ir, Erna Safitri .
Manuscript Status: Accept - Review Proof

Dear ? JBOSS_ENV OLD backup boot.properties boot.properties20150929 configuration data deployments java.net.ConnectException:.proofing java.net.ConnectException:.reprint lib log modpath.pl runcli.ksh s1.dtd setDomainFileSystemPerms.ksh showmyports standalone.PID startServer.sh startServer.sh.orig stopServer.sh stopServer.sh.orig system.jvmDefs tmp work Ansar,

We invite you to review the proof of this article. To access the proof and associated materials, please visit this link:

https://proof-review.acs.org/aprs/APRSHome.html?x=iOziC75NM1rWAuT2uYeh4A

Please note: An ACS ID is required to access proof materials. If you do not have an ACS ID, visit https://pubs.acs.org/publish/ to register for an account.

Please carefully review your proof as soon as possible, ideally within 48 hours. An e-mail reminding you that this task is overdue will be sent in 5 days. We will not publish your paper until we receive your corrections or your permission to publish as is. All recommended corrections must be submitted in one correspondence. NOTE: Author publication charges have not been paid for this paper. Publication will be delayed until these charges are paid.

Your article may now be cited using the DOI assigned to it: http://dx.doi.org/10.1021/acsomega.0c00247.

Sincerely,
ACS Journal Production Team
Most Trusted. Most Cited. Most Read.
http://pubs.acs.org

ACS OMEGA

http://pubs.acs.org/journal/acsodf Article

Physical and Chemical Properties of a Mixture Fuel between Palm Sap (*Arenga pinnata* Merr) Bioethanol and Premium Fuel

Ansar,* Sukmawaty, Sirajuddin Haji Abdullah, Nazaruddin, and Erna Safitri

Cite This: https://dx.doi.org/10.1021/acsomega.0c00247 Read Online

ABSTRACT: Along with the development of motor vehicle industry technology at this time, the fuel demand is also increasing while the supply is running low. Thus, alternative fuels are needed to meet these energy needs. This study aims to explain the physical and chemical characteristics of a fuel mixture (MF) between palm sap bioethanol with premium fuel. The results showed that the higher the bioethanol concentration of the palm sap, the higher the MF's viscosity, but the lower the heat of the fuel. This decrease is caused by differences in the heating value of the two fuels. The MF's high heat burn value is blue, while the low heat value of the flame is reddish yellow. The results of this study are very important as a basis for the development of bioethanol from palm sap as an environmentally friendly vehicle-fuel substitute material.

1. INTRODUCTION

The human need for fuel is currently increasing along with the development of the motor vehicle industry.[1] The largest source of fuel used by motor vehicles is fossil fuels.[2] These fossil fuels cannot be expected to be around for a long period of time because their amount is limited and they cannot be renewed.[3,4]

Bioethanol has been developed in many countries as an energy source for fossil energy substitution.[5,6] Bioethanol production in the United States is developed from corn to apply bioethanol energy.[7] Brazil has been developing bioethanol sourced from sugar cane by conducting tests on vehicles since 1925.[8] China and Thailand develop bioethanol from cassava.[9] South Korea has been developing biodiesel since 2002, and its consumption is estimated to increase by 0.5% per year.[5]

Brazil develops bioethanol from sugar cane at a low cost of 14 cents a dollar per liter, Thailand with tapioca, 18.5 cents a dollar per liter, and America using corn, 25.5 cents a dollar per liter.[10] The success of Brazil in producing bioethanol from sugar cane on an industrial scale has led many countries to follow their strategic steps. Currently, in Brazil, motorcyclists can fill fuel tanks with a mixture of 24% ethanol and 76% gasoline.[11] As for Indonesia, the government has given serious attention to developing bioethanol by issuing Presidential Instruction no. 1 of 2006 regarding the supply and use of biofuel as an alternative fuel.[12,13]

Bioethanol is one type of biofuel that can be used as a substitute for fossil fuels.[14,15] The use of bioethanol as a fuel mixture is important to save the earth from global warming.[16] The development of bioethanol as an alternative fuel must be supported by several factors, including the availability of abundant raw materials, bioethanol-making technology available, and the existence of promising market opportunities and benefits.[17,18]

Bioethanol can be produced from various types of plants, such as sugar cane, cassava, corn, sorghum, palm sap, or other types of plants.[18,19] Palm sap (*Arenga pinnata* Merr, *A. pinnata*) is very abundant in Indonesia (Table 1), so it has the potential to be processed into bioethanol.[20] This plant contains glucose,

Table 1. Estimated Area of Palm Sap in Indonesia[25]

province	an estimate of the total area (ha)
Nanggro Aceh Darussalam	4081
North Sumatera	4357
West Sumatera	1830
Bengkulu	1748
West Jawa	13,135
Banten	1448
Central Jawa	3078
South Kalimantan	1442
North Sulawesi	6000
South Sulawesi	7293
Southeast Sulawesi	3070
Maluku	1000
North Maluku	2000
Papua	10,000
total	60,482

Received: January 17, 2020
Accepted: May 15, 2020

https://dx.doi.org/10.1021/acsomega.0c00247
ACS Omega XXXX, XXX, XXX−XXX

fructose, and sucrose with a composition of approximately 0.4−0.5%, 0.5−0.6%, and 10−13%, respectively.[21,22] The sugar content is quite high, so palm sap has the potential to be processed into bioethanol.[23] So far, the use of palm sap is still very limited, namely, only in the manufacture of palm sugar.[24]

Bioethanol has become a very interesting topic and is always an updated study in various research communities in the world from the production process to compatibility with motor vehicles.[1,26] Some advantages of using bioethanol include exhaust emissions that are more environmentally friendly compared to premium fuels and Pertamax.[27,28] Bioethanol is a potential fuel because the raw material can be renewed.[29]

Bioethanol production must be focused on abundant plants, but its use is not for basic food needs. Brazil has been applying the bioethanol−gasoline mixture since the 1930s and increased its application by 50% in 1943.[30] Indonesia as a country that has a relatively similar geographical condition to that of Brazil has the potential to follow Brazil's path in utilizing abundant natural resources to meet domestic energy needs. This is in line with Indonesia's transportation system, which mostly uses gasoline.[13] Bioethanol can bring practical benefits if applied nationally in Indonesia.[28]

It is very possible to mix the physical and chemical characteristics of bioethanol with those of gasoline.[31] The need to meet energy demand with apprehensive environmental impacts and limited fuel stock from fossil fuels has led researchers to look for renewable and environmentally friendly energy resources, one of which is bioethanol.[32] However, the bioethanol production process is more complex and requires a large investment capital.[33] The main obstacle is that bioethanol must be compatible with motor vehicle combustion systems.[34]

Based on the arguments above, in this paper, the focus of the study is on the physical and chemical properties of the fuel mixture of palm sap bioethanol with premium fuel (MF). Although there have been studies focusing on aspects of bioethanol production,[35,36] it is still urgent to conduct research that focuses on explaining the physical and chemical properties of palm sap bioethanol after it is mixed with premium fuel.

Many researchers have developed palm sap into bioethanol as a fuel mixture for motor vehicles.[20,37−39] However, no valid data has been found about the viscosity, calorific value, and flame after the palm sap bioethanol is mixed with premium fuel. Therefore, it is important to examine and reveal the viscosity, calorific value, and flame as physical and chemical characteristics of fuel for motor vehicles. Thus, the purpose of this study is to explain the physical and chemical characteristics of a fuel mixture between palm sap bioethanol and premium.

2. METHOD AND MATERIALS

2.1. Materials and Tools. The materials used are bioethanol from distilled palm sap (*A. pinnata* MERR) (Figure 1) and premium-type fuel with an octane number of 88 obtained directly from refueling in Mataram, West Nusa Tenggara Province, Indonesia.

These ingredients are mixed with various variations of the concentration (Table 2).

The tools used are a viscometer, C-5000 calorimeter bomb, thermometer, test tube, analytical balance, oxygen cylinder, oxygen regulator, oxygen hose, test tube, and LPG gas stove.

2.2. MF Viscosity Measurement. MF viscosity is measured using an open gravity capillary viscometer in the temperature range of 20−30 °C.[40] Mathematically, the MF viscosity equation can be written[41] as

Figure 1. Palm sap is widely cultivated in Indonesia.

Table 2. Variation of Concentrations between Bioethanol Palm Sap and Premium Fuel

no.	palm sap bioethanol (mL)	premium (mL)
1	10	90
2	15	80
3	20	70
4	25	60
5	30	50

Figure 2. MF bioethanol and premium flame test.

$$F = \eta A \frac{V}{L} \tag{1}$$

with F as the force on the surface of the liquid, η as the coefficient of fluid viscosity (Ns/m^2), A as the liquid area (m^2), V as the moving wall velocity (m/s), and L as the distance of the two surfaces (m).

2.3. Measurement of the MF Calorific Value. MF burn calorie measurements were done using a bomb calorimeter, type IKA C-5000. The reaction that occurs in a bomb calorimeter can produce heat absorbed by water and bombs so that no heat is wasted into the air, so it can be written as

$$r_{\text{eaction}} = -(q_{\text{air}} + q_{\text{bomb}}) \tag{2}$$

The amount of heat absorbed by water can be calculated using the formula

$$Q_{\text{water}} = mc\Delta T \tag{3}$$

https://dx.doi.org/10.1021/acsomega.0c00247
ACS Omega XXXX, XXX, XXX−XXX

Figure 3. Palm sap bioethanol produced in this study.

Table 3. MF Viscosity at Various Concentrations between Bioethanol and Premium Fuel

	comparison of fuel mixtures (%)		
no.	bioethanol of palm sap (mL)	premium (mL)	viscosity of MF (mm^2/s)
1	10	90	5.4
2	15	85	5.4
3	20	80	4.6
4	25	75	4.5
5	30	70	4.3

where m is the mass of water (g), c is the heat type of water (J/kg °C), and ΔT is the temperature change (°C).

The amount of heat absorbed by the bomb calorimeter can be calculated using the formula

$$q_{\text{bomb}} = c_{\text{bomb}} \Delta T \quad (4)$$

where c_{bomb} = heat capacity of bomb (J/g °C) and ΔT is the temperature change (°C).

2.4. MF Flame Test. Flame tests were carried out to detect the presence of metal ion elements in the MF of bioethanol and premium fuel by dipping cotton buds washed with hydrochloric acid in the MF liquid and then igniting it with fire (Figure 2). This flame test is to provide qualitative information on the colors arising from the combustion process based on the light spectrum of the electromagnetic radiation elements present in the sample. The flame that arises will be adjusted to the table of chemical elements with their flames.[42]

2.5. Data Analysis. The effect of variations in the concentration of palm sap bioethanol and premium fuel on the physical and chemical characteristics of the MF was analyzed using analysis of variance.[43] If the F-count value is greater than the F-crit, it means that there is a significant difference in the significance level of 95%. The most influential variable can be identified using the DMRT (Duncan's multiple-range test).

3. RESULTS AND DISCUSSION

3.1. Viscosity of MF. Palm sap bioethanol produced in this study is shown in Figure 3. The MF viscosity in various concentrations of bioethanol and premium fuel is shown in Table 3. In the table, it appears that the higher the concentration of the palm sap bioethanol, the higher the MF's viscosity. Fuel viscosity can affect the fogging process. Fuels that have high viscosity are difficult to atomize. Conversely, fuels with low viscosity are easier to atomize. Fuels that are more easily atomized are also easier to ignite and also more perfect for combustion.

The result of the bioethanol test of palm sap was a value of 4.7 mm^2/s, while that of the premium fuel was 7.2 mm^2/s.[42] After mixing, the data obtained showed that the higher the concentration of palm sap bioethanol, the lower the MF's viscosity (Table 3). This is thought to be influenced by the viscosity of bioethanol, which is lower than the premium viscosity. These results are in line with research reported by Tazi and Sulistiana[2] in that the higher the addition of bioethanol, the lower the viscosity of the fuel.

The results of the two-factor variance analysis show that the calculated F-value (153.963) is greater than the F-table value (3.490). This means that the variation in the concentration of palm sap bioethanol has a significant effect ($p > 0.5$) on the MF's viscosity (Table 4).

Table 5. MF Calorific Values for Various Concentrations between Bioethanol and Premium Fuel

	comparison of fuel mixtures (%)		
no.	palm sap bioethanol (mL)	premium (mL)	calorific values of MF (kcal/g)
1	10	90	11.107
2	15	85	11.015
3	20	80	10.324
4	25	75	10.152
5	30	70	9.445

3.2. MF Calorific Value. The calorific value of the fuel shows the heat produced from the combustion process. If the combustion is perfect, then the optimal thermal energy can be obtained. Separate test results obtained show that the caloric value of palm sap ethanol is 10.126 kcal/g, while that of the premium is 11.414 kcal/g. After mixing, the highest heating value of the MF was 11.107 kcal/g and the lowest was 9.445 kcal/g (Table 5).

Table 5 shows that the higher the concentration of palm sap bioethanol added to the premium fuel, the lower the MF's calorific value. This decrease is caused by the difference in the heating value between the two fuels. The results of this study are in line with the research of Budiprasojo and Pratama[39] who reported that the low heating value of fuel can affect the high heating value if mixed.

The National Standards Agency (BSN) has set bioethanol quality standards with a minimum heating value of 5000 kcal/g.[44] Based on the quality standards set by BSN, the MF bioethanol and premium produced in this study were following the standards.

The results of the two-factor analysis of variance show that the calculated F-value (144.894) is greater than the F-table value (3.490) (Table 6). This means that the variation in the

Table 4. Results of the Two-Factor Analysis of Variance of MF Viscosity Parameters

source of variation	SS	df	MS	F	P value	F crit
rows	1.223	4	0.30575	0.007	0.999	3.259
columns	19625.3	3	6541.7653	153.963	7.647×10^{-10}	3.490
error	509.869	12	42.489083			
total	20136.39	19				

https://dx.doi.org/10.1021/acsomega.0c00247
ACS Omega XXXX, XXX, XXX−XXX

Table 6. Results of Two-Factor Variance Analysis for MF Calorific-Value Parameters

source of variation	SS	df	MS	F	P value	F crit
rows	0.870752	4	0.217688	0.005	0.99994	3.259
columns	18509.81	3	6169.936	144.894	1.09×10^{-9}	3.490
error	510.9863	12	42.58219			
total	19021.66	19				

Table 7. Comparison of Physical and Chemical Characteristics of Mixed Fuel

	value			
combined of fuel mixes	viscosity at 40 °C (mm^2/s)	calorific (kcal/g)	flame test (color)	references
premium of RON 88	7.2	11.414	reddish yellow	41
20% bioethanol of liquid polypropylene−80% Gasoline		11.340	reddish yellow	39
20% bioethanol of pineapple−80% premium		7.331		46
30% bioethanol of cassava flour−70% gasoline		23		38
30% bioethanol of sugar molasses−70% gasoline	2.2	15		37
30% palm sap bioethanol−70% premium	4.7	10.126	reddish yellow	this research

concentration of palm sap bioethanol has a significant effect ($p > 0.5$) on the heating value of the MF.

3.3. MF Flame Test.

MF flame test results on variations in the concentration of palm sap bioethanol and premium fuel showed two different types of flame colors, namely, blue and reddish yellow. MF that contains low concentrations of palm sap bioethanol, produces a blue flame while, with high concentrations, produces a reddish yellow flame. This is in line with the report of McLinden et al.[45] in that the flame from bioethanol is not only blue but also reddish yellow. The same thing was reported by Polikarpov et al.[46] in that, at the time of combustion, a blue flame appeared at the bottom and a reddish yellow one appeared at the top.

The blue combustion results indicate that the methane (CH_4) in the MF was completely burned. The results of this study are in line with the research of Susanto et al.[47] who reported that methane gas was marked with a blue flame. However, the reddish yellow fire means incomplete combustion and that the flame is unstable. Cahyani[48] also reports that the color of the blue flame indicates high ethanol levels.

A comparison of the physical and chemical characteristics of the mixed fuel between the palm sap bioethanol and premium fuel from this study with several other studies is shown in Table 7.

The results of the two-factor variance analysis show that the calculated F-value (68.308) is greater than the F-table value (3.490) (Table 8). This means that variations in the concentration of palm sap bioethanol and premium fuel affect the MF's flame. The blue flame color indicates high ethanol content.

4. CONCLUSIONS

The high concentrations of palm sap bioethanol cause the MF viscosity to also be higher, but too difficult to obscure. The higher the concentration of palm sap bioethanol, the lower the heating value of MF. The MF flame test results on variations in the concentration of palm sap bioethanol and premium fuel showed two different types of flame colors, namely, blue and reddish yellow. The blue color indicates high ethanol content, while the reddish yellow color indicates low ethanol content.

The physical and chemical properties of MF fuels still need to be studied comprehensively by conducting MF trials on various types of motorized vehicles. Besides, further research is needed on mixing palm sap bioethanol with other types of fuel.

AUTHOR INFORMATION

Corresponding Author

Ansar − *Department of Agricultural Engineering, Faculty of Food Technology and Agroindustries, University of Mataram, Mataram 83115, Indonesia*; Email: ansar72@unram.ac.id

Authors

Sukmawaty − *Department of Agricultural Engineering, Faculty of Food Technology and Agroindustries, University of Mataram, Mataram 83115, Indonesia*

Sirajuddin Haji Abdullah − *Department of Agricultural Engineering, Faculty of Food Technology and Agroindustries, University of Mataram, Mataram 83115, Indonesia*

Nazaruddin − *Department of Food Science and Technology, Faculty of Food Technology and Agroindustries, University of Mataram, Mataram 83115, Indonesia*

Erna Safitri − *Department of Agricultural Engineering, Faculty of Food Technology and Agroindustries, University of Mataram, Mataram 83115, Indonesia*

Complete contact information is available at:
https://pubs.acs.org/10.1021/acsomega.0c00247

Notes

The authors declare no competing financial interest.

ACKNOWLEDGMENTS

This work was supported by the University of Mataram through the Student Joint Research (SJR) scheme under contract no. 1954/UN/2019 so this research activity could be carried out. Acknowledgments are also conveyed to all those who have helped carry out this research.

Table 8. Results of Two-Factor Analysis of Variance of the MF's Flame Value

source of variation	SS	df	MS	F	P value	F crit
rows	155.0324	4	38.75809	0.408	0.799	3.259
columns	19472.58	3	6490.86	68.308	8.23×10^{-8}	3.490
error	1140.277	12	95.02309			
total	20767.89	19				

■ REFERENCES

(1) Mahlia, T. M. I.; Syazmi, Z. A. H. S.; Mofijur, M.; Abas, A. E. P.; Bilad, M. R.; Ong, H. C.; Silitonga, A. S. Patent landscape review on biodiesel production: Technology updates. *Renewable Sustainable Energy Rev.* **2020**, *118*, 109526.

(2) Tazi, I.; Sulistiana. Test the heating fuel of a mixture of bioethanol and used cooking oil. *Journal of Neutrino* **2011**, *3*, 163−174.

(3) Rijanto, M. W.; Armawi, A. The role of youth and the community in the development of renewable alternative energy to support energy security. *Journal of National Resilience* **2011**, *16*, 35−52.

(4) Mofijur, M.; Hasan, M. M.; Mahlia, T. M. I.; Rahman, S. M. A.; Silitonga, A. S.; Ong, H. C. Performance and emission parameters of homogeneous charge compression ignition (HCCI) engine: a review. *Energies* **2019**, *12*, 35−57.

(5) Balat, M. Global bio-fuel processing, and production trends. *Energy Explor. Exploit.* **2007**, *25*, 195−218.

(6) Guigou, M.; Lareo, C.; Pérez, L. V.; Lluberas, M. E.; Vázquez, D.; Ferrari, M. D. Bioethanol production from sweet treatments sorghum: evaluation of post-harvest on sugar extraction and fermentation. *Biomass Bioenergy* **2011**, *35*, 3058−3062.

(7) Gupta, A.; Verma, J. P. Sustainable agro-residues: bio-ethanol production from a review. *Renew. Sustain. Energy Rev.* **2015**, *41*, 550−567.

(8) Deesuth, O.; Laopaiboon, P.; Klanrit, P.; Laopaiboon, L. Improvement of ethanol production from sweet sorghum juice under high gravity and very high gravity conditions: effects of nutrient supplementation and aeration. *Ind. Crop Prod.* **2015**, *74*, 95−102.

(9) Zhang, C.; Xie, G.; Li, S.; Ge, L.; He, T. The productive potentials of sweet sorghum Ethanol in China. *Appl. Energy* **2010**, *87*, 2360−2368.

(10) Gnansounou, E. Production and use of lignocellulosic bioethanol in Europe current situation and perspectives. *Bioresour. Technol.* **2010**, *101*, 4842−4850.

(11) Szklo, A.; Schaeffer, R.; Delgado, F. Can one say ethanol is a real threat to gasoline? *Energy Policy* **2007**, *35*, 5411−5421.

(12) Kusumaningsih, T. Making Biodiesel from Jatropha Oil: Effect of temperature and KOH concentration on the transesterification reaction based on Base Catalysts. *Biotek. Biotechnol. Stud.* **2006**, *3*, 20−26.

(13) Silitonga, A. S.; Masjuki, H. H.; Mahlia, T. M. I.; Ong, H. C.; Chong, W. T.; Boosroh, M. H. Overview properties of biodiesel diesel blends from the edible and non-edible feedstock. *Renewable Sustainable Energy Rev.* **2013**, *22*, 346−360.

(14) Sebayang, A. H.; Masjuki, H. H.; Ong, H. C.; Dharma, S.; Silitonga, A. S.; Mahlia, T. M. I.; Aditiya, H. B. A perspective on bioethanol production from biomass as an alternative fuel for the spark-ignition engine. *RSC Adv.* **2016**, *6*, 14964−14992.

(15) Sebayang, A. H.; Masjuki, H. H.; Ong, H. C.; Dharma, S.; Silitonga, A. S.; Kusumo, F.; Milano, J. Optimization of bioethanol production from sorghum grains using artificial neural networks integrated with an ant colony. *Ind. Crops Prod.* **2017**, *97*, 146−155.

(16) Connelly, E. B.; Colosi, L. M.; Clarens, A. F.; Lambert, J. H. Life Cycle Assessment of Biofuels from Algae Hydrothermal Liquefaction: The Upstream and Downstream Factors Affecting Regulatory Compliance. *Energy Fuels* **2015**, *29*, 1653−1661.

(17) Devita, L. Biodiesel as an alternative energy and perspective. *Agrica Extensia* **2015**, *9*, 23−26.

(18) Sebayang, A. H.; Hassan, M. H.; Ong, H. C.; Dharma, S.; Bahar, A. H.; Silitonga, A. S.; Kusumo, F. Enzymatic hydrolysis using ultrasound for bioethanol production from durian (Durio zibethinus) seeds as a potential biofuel. *Chem. Eng. Trans.* **2017**, *56*, 553−558.

(19) Yamada, S.; Shinomiya, N.; Ohba, K.; Sekikawa, M.; Oda, Y. Enzymatic hydrolysis and ethanol fermentation of by-products from potato processing plants. *Food Sci. Technol. Res.* **2009**, *15*, 653−658.

(20) Ansar; Nazaruddin; Azis, A. D. Effect of temperature and time storage to ph and color changes of palm sap (*Arenga pinnata* MERR) after tapping. *Journal Teknik Pertanian Lampung* **2019**, *8*, 40−48.

(21) Sia, J.; Yee, H.-B.; Santos, J. H.; Abdurrahman, M. K.-A. Cyclic voltammetric analysis of antioxidant activity in cane sugars and palm sugars from Southeast Asia. *Food Chem.* **2010**, *118*, 840−846.

(22) Fahrizal, F.; Abubakar, Y.; Muzaifa, M.; Muslim, M. The effects of temperature and length of fermentation on bioethanol production from aren plant (*Arenga pinnata* MERR). *Int. J. Adv. Sci. Eng. Inf. Technol.* **2013**, *3*, 244−247.

(23) Kismurtono, M. Fed-batch alcoholic fermentation of palm juice (*Arenga pinnata* MERR): Influence of the feeding rate on yeast, yield, and productivity. *Int. J. Eng. Technol.* **2012**, *2*, 795−799.

(24) Victor, I.; Orsat, V. Characterization of *Arenga pinnata* (palm) sugar. *Sugar Tech* **2018**, *20*, 105−109.

(25) Effendi, D. S. Prospect of aren tree development (*Arenga pinnata* MERR) to supporting bioethanol need in Indonesia. *Perspective* **2010**, *9*, 36−46.

(26) Zhang, Q.; Weng, C.; Huang, H.; Achal, V.; Wang, D. Optimization of bioethanol production using the whole plant of water hyacinth as a substrate in the simultaneous saccharification and fermentation process. *Front. Microbiol.* **2016**, *6*, 1−9.

(27) Ong, H. C.; Masjuki, H. H.; Mahlia, T. M. I.; Silitonga, A. S.; Chong, W. T.; Yusaf, T. Engine performance, and emissions using *Jatropha curcas, Ceiba pentandra* and *Calophyllum inophyllum* biodiesel in a CI diesel engine. *Energy* **2014**, *69*, 427−445.

(28) Silitonga, A. S.; Masjuki, H. H.; Ong, H. C.; Sebayang, A. H.; Dharma, S.; Kusumo, F.; Milano, J.; Daud, K.; Mahlia, T. M. I.; Chen, W.-H.; Sugiyanto, B. Evaluation of the engine performance and exhaust emissions of biodiesel-bioethanol-diesel blends using kernel-based extreme learning machine. *Energy* **2018**, *159*, 1075−1087.

(29) Tan, L.; Sun, Z.-Y.; Okamoto, S.; Takaki, M.; Tang, Y.-Q.; Morimura, S.; Kida, K. Production of ethanol from raw juice and thick juice of sugar beet by continuous ethanol fermentation with flocculating yeast strain KF-7. *Biomass Bioenergy* **2015**, *81*, 256−272.

(30) Soccol, C. R.; de Souza Vandenberghe, L. P.; Medeiros, A. B. P.; Karp, S. G.; Buckeridge, M.; Ramos, L. P.; Pitarelo, A. P.; Ferreira-Leitão, V.; Gottschalk, L. M. F.; Ferrara, M. A.; da Silva Bon, E. P.; Moraes, L. M. P. D.; Araújo, J. D. A.; Torres, F. A. G. Bioethanol from lignocelluloses: Status and perspectives in Brazil. *Bioresour. Technol.* **2010**, *101*, 4820−4825.

(31) Ong, H. C.; Silitonga, A. S.; Masjuki, H. H.; Mahlia, T. M. I.; Chong, W. T.; Boosroh, M. H. Production and comparative fuel properties of biodiesel from non-edible oils: Jatropha curcas, Sterculia foetida, and Ceiba pentandra. *Energy Convers. Manage.* **2013**, *73*, 245−255.

(32) Xuan, F.; Chai, D.-J.; Su, H. Local density approximation for the short-range exchange free energy functional. *ACS Omega* **2019**, *4*, 7675−7683.

(33) Sun, P.; Gao, G.; Zhao, Z.; Xia, C.; Li, F. Stabilization of cobalt catalysts by embedment for efficient production of valeric biofuel. *ACS Catal.* **2014**, *4*, 4136−4142.

(34) Dayma, G.; Halter, F.; Foucher, F.; Togbé, C.; Mounaim-Rousselle, C.; Dagaut, P. Experimental and detailed kinetic modeling study of ethyl pentanoate (ethyl valerate) oxidation in a jet stirred reactor and laminar burning velocities in a spherical combustion chamber. *Energy Fuels* **2012**, *26*, 4735−4748.

(35) Galletti, R. A. M.; Antonetti, C.; Ribechini, E.; Colombini, M. P.; Nassio Di Nasso, N.; Bonari, E. From giant reed to levulinic acid and gamma-valerolactone: A high yield catalytic route to valeric biofuels. *Appl. Energy* **2013**, *102*, 157−162.

(36) Kon, K.; Onodera, W.; Shimizu, K.-i. Selective hydrogenation of levulinic acid to valeric acid and valeric biofuels by a Pt/HMFI catalyst. *Catal. Sci. Technol.* **2014**, *4*, 3227−3234.

(37) Ademiluyi, F. T.; Mepba, H. D. Yield, and properties of ethanol biofuel produced from different whole cassava flours. *ISRN Biotechnol.* **2013**, 1−6.

(38) Ghazikhani, M.; Hatami, B.; Safari, B.; Ganji, D. D. Experimental investigation of performance improvement and emissions reduction in a two-stroke SI engine by using ethanol additives. *Propulsion Power Res.* **2013**, *2*, 276−283.

(39) Budiprasojo, A.; Pratama, A. W. The heating value of premium blends with polypropylene fuel resulting from the pyrolysis process. *Journal of Ilmiah Inovasi* **2016**, *1*, 122−127.

https://dx.doi.org/10.1021/acsomega.0c00247
ACS Omega XXXX, XXX, XXX−XXX

(40) Laesecke, A.; Fortin, J. D.; Splett, J. D. Density, speed of sound, and viscosity measurements of reference materials for biofuels. *Energy Fuels* **2012**, *26*, 1844−1861.
(41) Niemeyer, K. E.; Daly, S. R.; Cannella, W. J.; Hagen, C. L. A novel fuel performance index for low-temperature combustion engines based on operating envelopes in light-duty driving cycle simulations. *J. Eng. Gas Turbines Power* **2015**, *137*, 101601.
(42) Yuliyanto, D.; Widodo, E. Test the heating fuel of a mixture of bioethanol and used cooking oil. *J. Manuf. Energy Eng.* **2018**, *3*, 1−5.
(43) Ansar; Nazaruddin; Azis, A. D. Effect of vacuum freeze-drying condition and maltodextrin on the physical and sensory characteristics of passion fruit (Passiflora edulis Sims) extract. In *IOP Conference Series: Earth and Environmental Science*; IOP Publishing: 2019, *355* 012067. DOI: DOI: 10.1088/1755-1315/355/1/012067.
(44) Aditiya, H. B.; Chong, W. T.; Mahlia, T. M. I.; Sebayang, A. H.; Berawi, M. A.; Nur, H. Second generation bioethanol potential from selected Malaysia's biodiversity biomasses: A review. *Waste Manage.* **2016**, *47*, 46−61.
(45) McLinden, M.; Bruno, T.; Frenkel, M.; Huber, M. Standard reference data for the thermophysical properties of biofuels. In *Biofuels*; ASTM International: 2011, *7*, 1−18.
(46) Polikarpov, E.; Albrecht, K. O.; Page, J. P.; Malhotra, D.; Koech, P.; Cosimbescu, L.; Gaspar, D. J. Critical fuel property evaluation for potential gasoline and diesel biofuel blend stocks with low sample volume availability. *Fuel* **2019**, *238*, 26−33.
(47) Susanto, R.; Jaya, H.; Mulyanto, A. Analysis of the effect of fermentation time and distillation temperature on physical properties (specific gravity and caloric value) of bioethanol made from pineapple (ananas comosus). *Mech. Eng. Dyn.* **2013**, *3*, 91−100.
(48) Cahyani; Anisah. Effect of enzyme volume on alcohol content and caloric value of bioethanol made from yam tubers (Dioscorea hipsida dentist). *J. Agric. Eng. Trop. Biosystems* **2015**, *3*, 35−42.

Ansar - <ansar72@unram.ac.id>

Publication for ao-2020-002477

1 pesan

support@services.acs.org <support@services.acs.org> 29 Mei 2020 08.14
Kepada: ansar72@unram.ac.id

May 28, 2020

Journal: ACS Omega
Manuscript No.: ao-2020-002477 (10.1021/acsomega.0c00247)
Title: Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (Arenga Pinnata MERR) Bioethanol and Premium
Authors: * Ansar, * Sukmawaty, Sirajuddin Haji Abdullah Si, * Nazaruddin Ir, Erna Safitri .
Manuscript Status: Published

Dear * Ansar,

Your article is now published on the ACS Omega website. The DOI assigned to this article is 10.1021/acsomega.0c00247, and is an accepted form of citation from publication to perpetuity. To view your article, please click on the DOI link below:

http://doi.org/10.1021/acsomega.0c00247

The link seamlessly directs readers to the full text version of the article on the ACS Publications website. Because ACS Omega is an open access journal, readers will have full and immediate access to your research paper.

To retrieve ACS Articles on Request links for any of your published ACS articles, login to the ACS Publishing Center (https://pubs.acs.org/publish/dashboard) and select 'Published'. You can then share any of your publications by clicking the 'Share full text' link below each of your publications. You may also find your ACS Articles on Request links on your ACS Paragon Plus Author Dashboard 24 hours after the ASAP Article is posted.

To order high-quality reprints of the article for convenient distribution, please click the link below:

http://pubstore.acs.org/file.aspx?&m=ao-2020-002477

You may order between 50 and 300 copies, and orders can be shipped globally.

Please note that ACS also offers a Citation Alert feature. Registering for an ACS ID allows you to, among other things, track all citations to your paper, lets you set your alert preferences, and gives you the option of maintaining a list of Favorite Articles and Saved Searches.

Thank you for choosing to publish with ACS Journals and ACS Omega.

If you have questions or require assistance, please contact the ACS Help Desk:
E-mail: support@services.acs.org
Phone: +1 800-227-9919 (U.S. only)
+1 202-872-4357 (outside the U.S.)
6:00 AM to 7:00 PM EST

Sincerely,
ACS Publications Team
Most Trusted. Most Cited. Most Read.
http://pubs.acs.org

Ansar - <ansar72@unram.ac.id>

ACS Publications Author Survey

1 pesan

ACS <survey@services.acs.org> 30 Mei 2020 01.09
Balas Ke: ACS <survey@services.acs.org>
Kepada: ansar72@unram.ac.id

Dear * Ansar,

Congratulations on your recent publication in ACS Omega. ACS Publications thanks you for helping us publish the highest quality research in chemistry and the allied sciences. We seek to foster strong relationships with our authors worldwide as part of our commitment to excellence in scientific publishing.

We would value your completion of a brief survey that will enable ACS to assemble feedback from our community of authors. Please click on the survey link below to answer questions that pertain to your experience with your recent publication of Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (Arenga Pinnata MERR) Bioethanol and Premium.

https://s-3d0521-i.sgizmo.com/s3/i-mykOXPFOljkHyVen1-3806001/?sguid=mykOXPFOljkHyVen1

If you are unable to directly access the survey by clicking on the above link, please try to copy and paste the URL into your browser.

Your feedback is highly valued and will be carefully considered as part of our ongoing commitment to serving the needs and expectations of authors in ACS journals. The survey should take 10 minutes or less to complete. Your answers will be anonymous unless you choose to submit your name.

Thank you,
ACS Publications

ACS Publications
Most Trusted. Most Cited. Most Read.

Ansar - <ansar72@unram.ac.id>

ACS Omega - Open Access for DOI 10.1021/acsomega.0c00247

2 pesan

Walker, Michael E (Contractor) <mwalker4@acs.org> 19 Mei 2020 05.35
Kepada: "ansar72@unram.ac.id" <ansar72@unram.ac.id>
Cc: "Parrett, Heather N" <HParrett@acs.org>

Dear Dr. Ansar,

Congratulations on your accepted manuscript titled "Physical and Chemical Properties of Mixture Fuels (MF) between Palm Sap (Arenga Pinnata MERR) Bioethanol and Premium" DOI 10.1021/acsomega.0c00247 in *ACS Omega.*

I am reaching out to answer any questions and offer my assistance, if needed, during the ordering process.

ACS Omega is a gold open access journal with a goal of publishing your manuscript expeditiously. An order and payment must be completed prior to publication, which can be completed at the link below at your earliest convenience.

https://oa.copyright.com/apc-payment-ui/overview?id=7b184d60-07b8-4d08-b487-7789a6d60d58

I have attached a PDF containing ordering instructions to assist you with the process, if needed.

If you have any questions or if I can be of any assistance, please let me know.

Thank You,

Mike Walker

Sales Support Analyst

ACS Publications

614-447-3975

I am currently unable to be reached by phone

ACS Chemistry for Life

ACS Omega - Open Access Author Experience.pdf
277K

Ansar - <ansar72@unram.ac.id> 19 Mei 2020 05.53
Kepada: "Walker, Michael E (Contractor)" <mwalker4@acs.org>
Cc: "Parrett, Heather N" <HParrett@acs.org>

Thank you for the information.
[Kutipan teks disembunyikan]

2 lampiran

image005.png
8K

image005.png
8K