International Journal on Advanced Science Engineering Information Technology

Vol.15 (2025) No. 1
ISSN: 2088-5334

Potential of Non-Standard Coconut as a Raw Material for Bioenergy Production

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Abstract*— Coconut (Cocos Nucifera L.) is a tropical palm plant widely used for food, yet the food industry rejects 30% of coconut meat and copra as non-standard. This research aims to study the characteristics of non-standard coconut meat and copra (dried coconut meat) and assess their prospects as feedstock for bioenergy production. Non-standard samples were analyzed in a laboratory, which were small, sprouted, over-mature, rotten coconuts, and non-edible copra. Results revealed that copra from rotten coconuts had the lowest free fatty acid (FFA) value of 0.91%, while the coconut meat from rotten coconuts had the highest FFA value of 13.8%. Crude coconut oil derived from all damaged coconuts exhibited the lowest moisture content of 0.38%, whereas coconut meat from rotten coconuts showed the highest moisture content of 57.17%. Total plate count analysis indicated that crude coconut oil had less than 1.0×10^1, while coconut meat from rotten coconuts recorded the highest at 1.4×10^9. These findings demonstrate that non-standard coconut meat and copra can serve as valuable raw materials for bioavtur production, minimizing competition with food-grade coconuts. Moreover, it is consistent with sustainability to harness these underutilized resources, which acts as a cleaner option in terms of the environment for the aviation industry. As the leader in coconut production, Indonesia benefits by developing non-standard coconuts into bioavtur, integrating economic advantages for millions of people connected to the coconut industries, such as farmers, workers, traders, logistics, and industries while contributing to renewable energy and utilizing waste products.

***Keywords*— Coconut; bioengineering; bioenergy; bio-industry.**

Manuscript received 23 Aug. 2024; revised 18 Dec. 2024; accepted 19 Jan. 2025. Date of publication 28 Feb. 2025.
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I. INTRODUCTION

Biavtur is a sustainable aviation fuel derived from biological feedstocks, offering a key solution for reducing aviation's greenhouse gas emissions. Supported by regulations like ICAO's CORSIA, biavtur plays a central role in accomplishing climate neutrality and astrality and decreasing the industry's reliance on fossil fuels [1]. Biavtur is produced from biomass-derived raw materials such as fibers, sugars, starch, and vegetable oils [2]. Bioenergy significantly influences Indonesia's energy transition by reducing fuel imports and greenhouse gas emissions [3].

Coconut, or its scientific name Cocos nucifera L., is a plantation crop with strategic meaning for the Indonesian people. The coconut plant is classified as one of the most valuable annual plants because everything from the leaves, fruit flesh, stems, and the community can use roots, so it is called the tree of life. Coconut plants are found in tropical areas, namely America, spreading to Polynesia and Asia. Moreover, many coconut plants come from the Indo-Pacific region and have benefits. Coconut is vital in tropical agriculture due to its biological and economic significance. Coconut fruit develops systematically, with growth starting in the third month. By the seventh month, the fruit reaches 62% coir, 7% shell, and 1% flesh, and at harvest (12 months), the proportions shift to 56% coir, 17% shell, and 27% flesh [4], [5].

According to the Food and Agriculture Organization Corporate Statistical Database [6]. Indonesia, the Philippines, India, Sri Lanka, and Brazil are among the top five countries in the world in terms of the production of coconut commodities. The production numbers (in tons) for the year 2021 are, respectively, 17,159,938, 14,717,294, 14,301,000, 2,496,000, and 2,457,860.

Coconuts have economic potential for coir fibers, shell-based charcoal, and oil. A study shows how efficient processing can optimize profitability. These findings underscore the importance of understanding coconut growth and maximizing its industrial applications for economic benefit [7].

In observation, the food industry in Indonesia rejects about 30% of coconuts. This rejected coconut can be called a non-standard coconut, as the standard coconut can be eligible for food processing. This non-standard coconut also includes copra (the dried meat of coconuts). In the field, copra can be found that is not uniform in color and size, has holes or Molds, and is black in color and dirty, so this type of copra is rejected by the oil and other food industries, and we can call this copra is also non-standard for food [8]. In common sense, the quality (and price, of course) of non-standard coconut and non-standard copra are lower than standard one (right figure). Therefore, the characteristics of coconut meat that are not eligible for food can be called non-standard food, and copra is sold at a relatively low price. Figure 1 illustrates standard and non-standard coconuts.

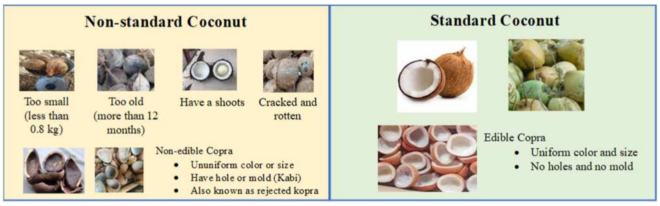

Fig. 1 Non-standard and standard coconut pictures in the field. Non-standard Coconut is too small, too old, has a shoot, and is cracked and rotten. In the form of copra, the non-edible copra is ununiform in color and size and has holes or mold, and in the coconut oil industry, these kinds of copra are rejected.

Raw materials of bioavtur must be hydrocarbons with a carbon chain length of C10-C14, the middle of which is C12. In coconut oil, the fatty acids are precisely C11-C12 hydrocarbons. Natural triglycerides or coconut oil can be produced to be bioavtur by a hydrocracking process conducted using a sulfide NiMo/Al2O3 catalyst [9], [10]. It means coconuts can be processed into oil as a potential bioavtur feedstock. If it is to be made into bioavtur, the problem is that the raw material from coconut will compete with raw materials for food products. Since they do not threaten food supplies, coconuts, and copra found in the wild with non-standard qualities could be suitable for bioavtur raw materials. However, there is a limited reference to both types' physical and chemical properties of coconut as a bioavtur material, especially the non-standard coconut. This study aimed to explore the physical and chemical characteristics and to analyze the potential of the subject in question, so-called non-standard coconuts, as described above.

II. Materials and Method

A. Materials

Coconuts were taken as raw materials from several plantations in Sumatra and Sulawesi, Indonesia. Non-standard coconut samples include coconut meat, copra, and crude coconut oil, while non-standard coconut samples include small coconuts, sprouted coconuts, over-mature coconuts, and rotten coconuts.

B. Method of Analysis

The analysis was conducted at two different locations: the Laboratory of Food Technology and Nutrition, which belongs to the Agriculture Faculty of Sam Ratulangi University, and the Standardization and Industrial Services Center in Manado. The analysis method employed specific parameters, units, and methods that comply with the SNI standard [11], [12] is shown in Table 1.

TABLE I
THE METHOD OF ANALYSIS USES THE SNI METHOD [13]

Parameter	Unit	Method
Free fatty acid	%	SNI 2902.2011 Attachment A.6
Moisture content	%	SNI 2902.2011 Attachment A.3
Total plate count	colony/g	SNI 01-2891-1992 point 1.1
Total Mold	colony/g	SNI 01-2891-1992-point 9

C. Free Fatty Acid (FFA) Analysis Method

1) *Reagent*: sodium hydroxide (KOH) in isopropyl alcohol (0.1 mol/l). A solution of 0.1 mol/l was utilized. A CO_2 absorbent, such as soda lime, shielded the solution from CO2. Determining the tire's tread depth is detailed in the application note "Titter KOH." A 500 ml bottle contains a mixture of 500 ml of diethyl ether and 500 ml of pure ethanol.

2) *Cleaning the electrode*: The electrode was cleaned and conditioned in three stages. Any sample residue was washed off the electrode using the solvent combination. To continue, it underwent water conditioning. Third, the electrode was washed with a solvent combination following conditioning to eliminate any remaining water. The electrode was immersed in an ethanol solution containing 1.5 mol/l of LiCl.

3) *Cleaning the electrode*: Titration with 0.1 M/L KOH is performed in a 150 mL beaker, with 70 mL of solvent as the starting material for a blank titration. The blank should be less than 0.3 mL.

4) *Preparation of sample*: To dissolve the sample, weigh it out and transfer it to a 150 ml beaker with 70 ml of solvent. If the oil or fat is solid (like coconut fat), heating the mixture will make it more soluble. Nitrated with 0.1 mol/l KOH after complete dissolution [14]. Due to the lengthy titration period, the sample weight was chosen so that the titration amount did not exceed four to five milliliters. Table 2 shows that the amount of sample needed is proportional to the predicted acid number in mgKOH/g.

TABLE II
THE ANTICIPATED ACID NUMBER DETERMINES THE SAMPLE SIZE

Expected Acid Number (mgKOH/g)	Amount (g)
0.2-1	10-20
1-10	1-3

D. Moisture Content Analysis Method

To accurately determine the moisture in a sample, following these steps with precision is essential: First, heat the empty weighing bottle in an oven set at 100°C for 15 minutes. When finished, set it aside in a desiccator to cool for at least 15 minutes. Take a reading of the bottle's weight. After ensuring the bottle has reached a steady weight, take a 2-gram sample and put it in the weighing container. Two hours at 100 degrees Celsius will do the trick for the bottle. Next, place it in a desiccator and let it cool for fifteen minutes. Take the sample; next, weigh the bottle. Repeat the process of heating and weighing until a constant weight is achieved. Moisture content (MC) is expressed as % (w/w), iw is the initial weight, and fw is the final weight, calculated to two decimal places using the following formula.

$$MC = \frac{\text{iw (wet sample)} - fw(dry\ sample\ (g)}{iw\ (wet\ sample)(g)} x100\% \quad (1)$$

E. Total Bacteria and Mold Analysis Method

1) Test Procedure for Total Plate Count Test (ALT) on Coconut and Copra Meat: To ensure accurate and reliable results, following a precise test procedure for the Total Plate Count Test (ALT) on Coconut and Copra Meat is essential. First, prepare and clean the necessary tools, ensuring they are dry. Then, enclose the test tube's mouth with cotton covered in gauze before wrapping it in HVS paper and placing it in an oven at 180ºC for an hour. Simultaneously, sterilize petri dishes in an autoclave at 121ºC for 15 minutes. Once the procedures are complete, all tools should be promptly removed. These meticulous steps are critical in maintaining the integrity of the testing process and producing reliable outcomes for quality assurance.

2) Media creation MLB (Modified Letheen Broth): Preparing all necessary tools and materials is crucial when creating Media Creation MLB. Once prepared, weigh MLB to the precise measurement of 6.5 grams and carefully place it in the Erlenmeyer flask. Next, add sufficient distilled water and stir diligently until achieving a homogeneous consistency. Finally, complete the process by adding enough distilled water to reach the 500 ml mark. These meticulous steps ensure the successful creation of Media Creation MLB, resulting in a high-quality final product.

3) Sample preparation: For sample preparation, begin by weighing a 10-gram lotion sample and placing it in a 250-ml Erlenmeyer flask. Next, add 90 ml of MLB to the sample, followed by pipetting 1 ml of the 10-1 dilution into the first tube containing 9 ml of MLB, homogenizing until a 10-2 dilution suspension is achieved. Subsequently, pipette 1 ml into the second 9 ml MLB tube and homogenize until a 10-3 dilution suspension is reached. Ensure that each dilution is pipetted in duplicate. The entire dilution process should be carried out aseptically, emphasizing the importance of precision and accuracy in the preparation of samples.

4) ALT sample testing: Meticulous attention to detail and aseptic techniques are crucial in ALT sample testing. With tools and surfaces meticulously sprayed with alcohol, the process begins with carefully igniting the Bunsen lamp. Following precise labeling, three Petri dishes are prepared for 10-2 to 10-3 dilutions. Each step is methodically executed – from homogenizing the 10-2 reaction tube to carefully pipetting and labeling the samples to ensuring thorough mixing in the Petri dishes. Ultimately, the samples are left to solidify, with every stage of the process reflecting commitment to precision and accuracy in laboratory procedures. After solidification, they are wrapped in paper and incubated upside down in an incubator at 35-37 ºC for 48 hours. Observations are made every 24 hours, specifically counting the number of growing colonies. Finally, the Petri dishes are wrapped and inserted into an autoclave for 15 minutes at 1210 ºC. The tone of the text is informative and instructional.

III. Results and Discussion

As shown in Table 3, broken/rotten coconut meat has the highest FFA value, 13.08%, and too-old copra has the lowest, 0.91 %.

TABLE III
VALUE OF FFA, MOISTURE CONTENT, TOTAL PLATE COUNT, AND TOTAL MOLD OF COCONUT MEAT, COPRA, AND CRUDE COCONUT OIL FROM NON-STANDARD COCONUT

Samples	Small Coconut	Sprouted Coconut	Over Mature Coconut	Rotten Coconut
		Free Fatty Acid (%)		
Coconut Meat	10.48	8.48	8.8	13.08
Copra	7.59	1.28	3.72	0.91
Crude Coconut Oil	4.19	4.19	4.19	4.19
		Moisture Content (%)		
Coconut Meat	42.5	45.05	43.84	57.17
Copra	13.8	14.94	29.16	12.86
Crude Coconut Oil	0.38	0.38	0.38	0.38
		Total Plate Count		
Coconut Meat	1.8×10^8	9.4×10^7	1.6×10^7	1.4×10^9
Copra	1.1×10^7	1.3×10^7	6.6×10^8	2.4×10^7
Crude Coconut Oil	$< 1.0 \times 10^1$	$< 1.0 \times 10^1$	$< 1.0 \times 10^1$	$< 1.0 \times 10^1$
		Total Mold		
Coconut Meat	2.2×10^6	2.1×10^5	2.4×10^5	4.6×10^7
Copra	8.7×10^6	1.2×10^7	3.8×10^7	2.0×10^7
Crude Coconut Oil	$< 1.0 \times 10^1$	$< 1.0 \times 10^1$	$< 1.0 \times 10^1$	$< 1.0 \times 10^1$

Table 3 shows that the FFA for coconut meat ranges from 8.48 (incredibly old coconut) to 13.08 (rotten coconut), whereas the FFA for Copra ranges from 0.91 (rotten coconut) to 7.59 (small coconut). FFA for CCO is 4.19. The lowest FFA is found in copra, which comes from rotten coconuts, and the highest in rotten coconut meat. The lowest water content in CCO was 0.38, and the highest was rotten coconut meat. The lowest total plate count was for CCO, and the highest was for rotten coconut meat (suitable because there are many microbes in rotten coconut meat). For total mold, the lowest value is CCO, and the highest is rotten coconut meat (suitable). Overall, rotten coconut meat with high water content contains high FFA and has high total microbes and mold.

A. Physical and Chemical Characteristics of Non-standard Coconut and Copra for Bioenergy

It has been observed that the increase in free fatty acids (FFA) in coconut meat and copra can be attributed to the activity of lipase-producing microorganisms present in coconut fruit oil. Lipase, a biocatalyst, speeds up the oil-hydrolysis reaction, leading to higher Free Fatty Acids (FFA) levels. This, in turn, can cause rancidity and change the taste and color of the oil. Therefore, it is crucial to consider the properties of FFA and density to produce a commercial bioavtur [14].

The water content in coconut meat varies, with the highest value recorded in Rotten Coconut at 57.17% and the lowest in Crude Coconut Oil (CCO) from all types of non-standard coconut, which has a value of 0.38%. Notably, the higher the water content, the easier the sample decomposes. Hence, changes in the chemical characteristics of a substance can occur due to the water content in the feed ingredient.

The study also found that the total plate number values in Coconut Meat from Rotten Coconut were the highest, with a value of 1.4 x 109 Colony/gram. At the same time, Crude Coconut Oil (CCO) from all types of non-standard coconut had the lowest value, which was <1.0 x 101 Colony/gram. Similarly, the mold total value in Coconut Meat from Rotten Coconut was 4.6 x 107 Colony/gram, and the lowest was found in Crude Coconut Oil (CCO) from all types of non-standard coconut, which had a value of <1.0 x 101 Colony/gram.

The data in Table 3 show that coconut meat and copra samples require reprocessing to obtain maximum results in compliance with SNI guidelines. This study also found that samples in transit or in the field for an extended period tend to have higher humidity levels.

Microbial growth is an increase in the number of cells in a given population of microorganisms. Such growth can be seen in the lab context, generally in an incubator with liquid broth sealed in a bottle. The increase in the number of cells in a culture of microbes can be represented in the typical graph form, which has four main stages. The reason for this delay is termed the Lag Phase, which indicates the adjustment or adaptation that occurs as the cells relocate into a different environment. During this phase, there is little cell division, but cells are metabolically active, synthesizing proteins and enzymes necessary for growth. Several variables, including the nature of the prior culture, the inoculum's age, and the medium's makeup, affect how long the lag phase lasts.

Non-standard coconuts and copra are ideal for producing crude coconut oil (CCO) for biavtur due to their lower cost than standard coconuts and copra, sufficient oil content, and compatibility with the HEFA process. They simplify processing, reduce waste, and support sustainability while maximizing resource efficiency for renewable aviation fuel production.

B. The Potential of Non-standard Coconut to Produce Bioavtur

Japan's Green Power Development Corporation successfully produced 100% biomass-derived SAF (Sustainable Aviation Fuel) from non-standard coconut oil. This SAF meets ASTM (American Society for Testing and Materials) international quality standards, demonstrating its potential for efficient, cost-effective, and environmentally friendly mass production. The use of non-standard coconuts as a sustainable feedstock addressing the growing competition for waste cooking oil [15], [16].

Hydroprocessed Esters and Fatty Acids (HEFA) is a specialized process for converting fats, oils, and greases, including coconut oil, into renewable jet fuel (bioavtur), diesel, and other biofuels [17]. It is particularly suitable for producing sustainable aviation fuels (SAFs). Using the HEFA method, 90% of the feedstock (vegetable and animal oils) can be converted into biofuel, consisting of 46% bioavtur, 46% biodiesel, and 8% other products. With specific feedstocks, the yield of bioavtur could be higher. At the laboratory scale, IJBNet partners have successfully converted 60% (yield ratio) of coconut oil into bioavtur, while other oils achieve a conversion rate of 40-50% [18], [19].

The potential of non-standard coconut to produce bioavtur utilizing non-standard coconuts as a source of bioavtur involves a prototypical and multi-stage process that is wholly the work of Indonesia, observing Indonesian commitment toward greenhouse gases. The production stages and efforts to deploy bioavtur in commercial aviation are outlined based on the comprehensive research and development carried out by the Indonesian State-owned oil and gas company (Pertamina) and its collaborators. The stage to produce bioavtur involves the hydrodecarboxylation process, aiming to produce hydrocarbon diesel and bioavtur at a laboratory scale. In alignment with Indonesia's regulatory framework, Pertamina has been working towards increasing the bioavtur blend in aviation fuel to 3% by 2020 and aiming for 5% by 2025. This step includes the ambition to produce a J100 product and use bioavtur across all Indonesian airlines and potentially internationally.

A triple helix collaboration model involving universities, the industry, and the government has supported the development of bioavtur. This collaborative effort aims to realize Indonesia's vision as research—and innovation-based country, leveraging domestic resources such as palm oil to develop energy independence and promote economic progress. The production of Bioavtur is just one part of a more excellent strategy to reduce the adverse effects of aviation on the environment and support Indonesia's net zero emissions target. These efforts represent a significant step forward in the aviation industry's transition to sustainable and renewable energy sources.

An essential aspect of any alternative fuel source is its economic viability. A 2020 study focused on the economic feasibility of coconut-based bioaviation fuel production. Researchers analyzed the entire production chain, from coconut cultivation to fuel processing. The findings indicated that, with proper infrastructure and scaling, coconut-based bio aviation fuel could become economically competitive with traditional aviation fuels [20].

Indonesia has the potential for abundant standard materials related to bioavtur. Using its abundant coconut supply, Indonesia can strengthen the biofuel supply chain [4], [21]. Additionally, coconuts are a non-edible material, addressing recent concerns regarding the sustainability of fuels derived from food resources [22], [23]. To increase its chances of growing the market and competing with other big coconut-producing nations, the Indonesian government must make its coconut oil more competitive [24].

C. Environmental Concerns Using Non-standard Coconut

The development of bioavtur is crucial due to the increasing demand and environmental concerns [25]. The production of bioenergy and bioavtur reduces greenhouse gas (GHG) emissions and fosters environmental sustainability [26], [27]. One core principle of bioavtur is the lower carbon emissions, which do not exceed 10% compared to the lifecycle emissions level of traditional aviation gasoline [28]. The primary reason for producing biofuels and bio-jet fuels is the reduction of emissions of greenhouse gases, and this is where their effectiveness lies. Nevertheless, prospective sustainability criteria ought to encompass multifaceted dimensions, including considerations of water, soil, air quality, conservation (biodiversity), waste management, and socioeconomic factors, encompassing human and labor rights, land and water use, social development, local and rights, and food security [29], [30]. Sustainable aviation fuels (SAF) manifest a diminished lifecycle carbon footprint compared to traditional jet fuel, rendering them a viable "drop-in" substitute for conventional aviation fuel. These fuels can be derived from biological and non-biological feedstocks [31]. Beyond their environmental merits, the production and processing of SAF feedstocks at scale confer substantial employment and economic advantages to pertinent communities [32]. Bioavtur exhibits the potential to alleviate soot pollution and enhance local air quality because jet fuels have lower sulfur content than existing jet fuels. Alternative fuels, such as bioavtur, would significantly enhance fuel sustainability [33], [34]. Consequently, bioavtur emerges as an environmentally beneficial substitute for aviation fuels that are produced from fossil sources, and it bodes well in alleviating environmental problems associated with aviation [35].

D. The Economic Potential

Using non-standard coconuts as a feedstock for sustainable aviation fuel (bioavtur) offers great potential to enhance economic growth and ecological balance. The abundant availability of non-standard coconuts, particularly in regions like Indragiri Hilir Regency, Indonesia, traditionally considered waste, means these coconuts are emerging as valuable feedstock for bioavtur production [36]. There is a need to manage the risks associated with the supply chain, paying attention to these coconuts as they can be a more cost-effective and environmentally benign feedstock with efficient processes and operations equipment. As a result of this change, even more farmers, as well as those from remote areas, may be able to gain several incomes through the economies of clustering.

Further, the International Coconut Community (ICC) explains how encouraging non-standard coconuts in the biofuels market can benefit coconut growers by enabling them to source new outlets for their produce. However, it is also noted that this new demand needs to be moderated in conjunction with the existing markets to avoid disruption of regular coconut supply. This dual approach ensures that coconuts' economic and cultural significance is preserved [37].

Non-standard Coconuts have the promise to become feedstock for bioavtur. The quantity of coconut oil can be significantly increased by increasing copra oil production, improving cultivation practices, employing good hybrids of coconuts, using adequate irrigation and fertilization methods, and controlling diseases and pests. Utilization of supercritical fluid extraction or enzymatic extraction techniques can increase oil production yield and be environmentally friendlier than conventional extraction processing.

Disregarding the other bioenergy feedstocks, non-standard coconuts stand out for their environmentally friendly nature and sustainability aspects. Coconut waste products such as husks can also be converted into high-end bioproducts. This not only helps to minimize wastage but also goes along with cleaner production technologies and emphasizes the multifunctionality and possibilities of using coconut biomass for renewable energy [38].

According to the ICAO [34], Non-Standard coconuts, however, have the potential to produce environmentally friendly Biofuels that could replace conventional aviation fuels and help reduce aviation emissions. They are beautiful because they do not compete with food feedstocks, so they address one of the key sustainability issues in biofuels. Feedstock chains for biofuel aviation are optimistic about non-food crops like coconut.

However, investment in bioavtur production from non-standard coconuts must be well planned as many possibilities exist. Non-standard coconuts could transform the bioenergy sector into a profit-making business and provide local jobs, helping further meet the global SDGs as they will be sourced from what was once considered trash. This resource is also available in vast quantities, which provides an economic advantage while providing environmental benefits unrivaled by another feedstock. Funding pioneering research projects enabling the transformation of this abundant resource into economically viable feedstock tailored for biofuels is critically essential. Developing technologies and processes integrated with existing biorefineries or petroleum refineries would streamline production and make bioavtur more cost-effective.

With an annual production of 17,159,938 tons, it is the biggest coconut producer in the world [6]. Indonesia has excellent prospects of shifting its coconut sector into a strategic economic asset, such as the coconut industry. Well-prepared feasibility studies appear in key areas like Sumatra and Sulawesi, claiming that almost 30% of the coconuts are non-standard; hence, most are unused or ignored. However, this resource can be harnessed to make a CCO (Crude Copra Oil) and bioavtur (sustainable aviation fuel), creating economic opportunities across multiple sectors. If an industry can process 1 million tons of non-standard coconuts annually, it could yield 120,000 tons of CCO, which, with a conversion rate of 40% to 60%, can produce 48,000 to 72,000 tons of bioavtur per year. The development of bioavtur is not only a step toward renewable energy but also a significant economic potential for Indonesia.

With bioavtur production facilities already established in several countries, this initiative positions Indonesia as a competitive player in the global market. This opportunity extends beyond the industrial sector. Farmers of coconut indeed have a distinct advantage. They can now make money off non-standard coconuts that would otherwise have been wasted. Other than the farmers of coconuts, there is a potential for employment and economic development for workers in the coconut farming, processing, and logistics sectors.

As a strategy, including rural farmers in the value chain and improving the facilities for processing and exporting bioavtur would help Indonesia improve the living conditions of millions of people connected to the coconut industry, such as coconut farmers, workers, traders, logistics, facilities, infrastructures. Through this initiative, the objectives of sustainable agriculture and renewable energies are embraced, consolidating Indonesia's status as a key global player in the coconut and bioenergy sectors.

IV. CONCLUSION

Conclusions: The production of bioenergy using non-standard coconuts is cost-effective, which includes the use of cheap by-products, not vying for food markets, and reducing transport costs. Though there are a few preprocessing difficulties in the approach mentioned, it also normalizes feedstock prices, lowers industrial competition, and even promotes a circular economy by converting waste into worth. It presents an emerging green energy challenge when considering all cost factors.

Parameters like free fatty acid (FFA), moisture content, total plate count/ALT, and total mold are important in determining the difference between standard and non-standard coconut meat, copra, and CCO samples. These parameters are based on coconut meat, copra, and CCO content. During the process of being copra, the FFA value tends to increase in non-standard coconut material, which can be due to high contamination levels. The process of making copra also causes an increase in the ALT value and total mold, indicating that non-standard coconuts are susceptible to contamination before or during Copra production.

Non-standard coconut meat and copra can be maximized as feedstock so that bioavtur does not compete with food. To improve its economic viability, government incentives and policies encourage investment in research development, and the approach involves the production of bioavtur from coconuts. Linking the airlines, fuel manufacturers, and regulators in an organized fashion to create a substantial market for bioavtur is vital for the long-term viability of coconut-based bioavtur. This being the case, coconut can be made more effective and sustainable for producing bio avtur, advancing the cause of a cleaner and environmentally friendly, contributing to a cleaner and more environmentally responsible aviation industry.

ACKNOWLEDGMENT

We thank Dr. Suyoto Rais, IJB Net (Indonesia Japan Business Network), and Mr. Masato Fujii, GPDJ (Green Power Development Japan) Tokyo, for supporting funding and raw materials for this research.

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