ISSN 2599-3496 print
ISSN 2614-2376 online
Volume 6, Number 2, 2023

INTERNATIONAL JOURNAL of OIL PALM

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ISSN: 2599-3496 print
ISSN: 2614-2376 online
Volume 6, Number 2, 2023

INTERNATIONAL JOURNAL of OIL PALM

By Indonesian Oil Palm Society

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PUBLISHER
Indonesian Oil Palm Society
International Journal of Oil Palm

INTERNATIONAL JOURNAL of OIL PALM

Volume 6, Number 2, 2023

ISSN: 2599-3496 print
ISSN: 2614-2376 online

INTERNATIONAL JOURNAL of OIL PALM

Volume 6, Number 2, 2023
Page 1–12
DOI: 10.35876/ijop.v6i2.105

ISSN: 2599-3496 print
ISSN: 2614-2376 online

The Palm Oil Industry in Nigeria and Malaysia: Decline and Economic Sustainability

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ABSTRACT

Oil palm is a west African crop. The trade in palm oil has emerged during the industrial revolution led by Britain, this palm oil was used to lubricate machines. In 1960s, Nigeria was the largest producer of palm oil globally, which accounted for the 43% of palm oil production entirely, but then the entire production declined due to some factors that slowed the palm oil production growth. While in Malaysia, oil palm production serves as the leading and contributing sector to its economy; and it also achieved recognition globally. Palm oil has made a huge contribution to Malaysia economic growth by providing employment, improving infrastructure, alleviating poverty, and generating income for workers and government. This paper objective is to explore the Nigerian decline and Malaysian sustainability on palm oil. It is a qualitative paper, it used primary and secondary method to collect data. The primary method used open-ended interview to collect data, while the secondary method used documents such as: books, journal, conference papers to collect data; and it employed inductive thematic analysis for analysing the interview data collected. It used ATLAS.ti 8 software to help analyse the data. The finding is Nigerian decline which includes: oil boom in 1970s and decline in agriculture, civil war, and traditional palm oil production; and Malaysian sustainability on palm oil includes: environmental consciousness, economic escalation, and social commitment. In conclusion, Nigeria has to learn from Malaysian sustainability to recover its production.

Keywords: Malaysian sustainability, nigerian decline, oil palm

INTRODUCTION

The geographical location of Nigeria is situated in west Africa on the Gulf of Guinea. It has a border with Benin Republic Niger, Cameroon and Chad (Douglas 2004). Nigeria has the area of 923,768 km^2 with five major geographical areas (Nigeria Fact Sheet 2001). In 1960s, Nigeria was ranked as major global producer and exporter of palm oil. However, this production declined from 43% to 1.7% of global production due to some factors slowed the production. Then Nigeria lost its position to Malaysia (PIND 2011). In early 1901, Nigeria was a palm oil dominant

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producer and supplied it globally. Palm oil served as its major foreign exchange source till 1960s. As a result of other factors, then Nigeria failed to meet up the global need of palm oil (Ayodele & Eshalomi 2010).

The federation of Malaysia came into being in 1963, it formerly consisted of Malaya, Sabah, Sarawak and Singapore. Later on in 1965, Singapore separated from the federation due to politic pressure. Now the Malaya became peninsular Malaysia, while the other two colonies are now east Malaysia on the Borneo island. These were formerly colonies of Britain in 18 centuries, the Malaya became independent in 1957, while Sarawak and Sabah attained their independence in 1963, and Singapore in 1965 completely achieved the independence.

Malaysia was ranked as a major exporter of palm oil in 1966, and the second largest producer of palm oil in 1971. In 2008, Malaysia was also ranked as the major palm oil exporter. Palm oil sector became the main income source, it promotes economic development and poverty alleviation (Ismail 2013). This study is to uncover the factors that necessitated to Nigeria decline on palm oil and led to Malaysian sustainability on palm oil.

MATERIALS AND METHODS

Research methodology is used for data obtaining and analysing. Study is usually conducted for explaining a particular phenomenon (Creswell 2012). The research employed qualitative method for understanding the research problem. It is exploratory approach, and systematically used for data collection and analysis (Zhang & Wildemuth 2009).

Qualitative document analysis generally relied on explaining the data, analyzing it and making a conclusion (Manheim *et al.* 2002). The study used both primary and secondary data. The primary data were collected from interviews, and the secondary data were collected from documents such as: journals, papers, books, articles, dissertations, newspapers, and magazines. The interview is open-ended (semi-structured) interview. Six participants both from Nigeria and Malaysia were selected to provide their views. The interviewees from Malaysia responded based on this study face-to-face, the interviewees from Nigeria responded through telephone. This study is non-probability which is purposive sampling (Creswell 2012). It used inductive thematic analysis for analysing the interview, it was immediately coded after it was conducted, and analysed and critically interpreted based on the information from the participants (Cohen 2007). This study employed ATLAS.ti for interview data analyst. This software is used in qualitative study for analysing, coding, and organizing qualitative data (Zhang and Wildemuth 2009).

Literature Review

The oil palm originated from West Africa, it is a crop named monocious plant. In 1870 Britain took it to Malaysia, this oil palm tree could yield 8 to 15 fresh fruit bunches every year. This weighs 10 to 25 kg each with 1000 to 1300 fruitlets for each bunch. Each fruitlet is shaped spherical. It is nearly black at times purple, the colour used to turn orange red if it ripened. There is hard kernel inside it named endocarp covered by fibrous mesocarp (Teoh 2002). Palm oil contained vitamin E called tocotrienol, it has carotenoids. The crude palm oil appeared to be deep red orange with carotenoids. Tocotrienols prevents oxidative deterioration. Palm oil has a natural semi solid character. Therefore, it does not require hydrogenation for use as food ingredient. Palm oil has a balanced ratio of saturated acid. This composition results in an edible oil that is suitable for use in a variety of food applications (Teoh 2002).

The Nigerian oil palm production started producing, cultivating, and processing fruitful oil palm trees. Nigeria has two significant palm oil production types: planted farms and wild grove; the planted farms occupied only 20% of the plantation, while the wild grove occupied 80% of the production. Oil palm production in Nigeria is under critical condition due to the palm oil industry's long-time production (PIND 2011). At the beginning of the 1960s, Nigeria became the major producer and exporter of palm oil globally. Palm oil contributed a lot towards the Nigerian exports but later declined. In 2007 CBN indicated threats facing the production of oil palm in Nigeria; started from the military regime in the 1970s up to the civilian government in 1999 (Anthony 2014).

Nigeria was a significant palm oil producer and exporter in the global palm oil market in 1960s. The production was more than the required local consumption within the country, due to the high output, the excesses were exported to global palm oil market. Later, this oil palm production faced a decline due to civil war, oil discovery for commercial purposes, the use of local techniques to process crude palm oil, and traditional method of production and cultivating oil palm, which is outdated to be applied in terms of the current output. Oil discovery dominated the oil palm sector and has been neglected as a source of income to the economy. Nigeria intentionally lost its position of being the major global producing and exporting country to Malaysia and Indonesia. It caused the increasing domestic consumption and slow growth in palm oil production (PIND 2011).

According to Ntaryike, a VOA reporter in 2008 said, oil palm trees' availability is almost everywhere in West and Central African countries. The major problem in Nigeria is how to develop the palm oil industries to produce, cultivate, and process this yielding crop. The industries are very weak with low production, the plantations are very aging and yield less than the expectation, outdated techniques and lack of modern approaches to be functioning efficiently, lack of funding to conduct research and produce high-quality planting materials, and lack of technology to cultivate and process significantly. The United Nations Industrial Development Organization funded a project to develop the palm oil production in Nigeria (Anthony 2014). The above report and scenario from the VOA reporter indicated the threat and inefficiency of Nigerian palm oil industries to cater to people's needs. In contrast, the palm oil demand locally increased in the country. Due to these problems, incidentally, Nigeria remained an importer of palm oil from Malaysia, which was initially a country Nigeria assisted with seedlings.

Oil palm production has regularly and globally been risen from 1964 to 2018 from 1.2m metric tonnes to 73.3m metric tonnes. Despite the expansion of the arable land of over 34 million hectares for oil palm plantation, Nigeria still could not cater to palm oil's domestic consumption and regardless of export. Numerous challenges face the palm oil sector and hinder it in producing and exporting the products efficiently. These challenges comprised of; the smallholders dominance of the industry, inadequate access to credit facilities, and poor infrastructure. In comparison, the situation is undoubtedly associated with economic implications.

In the early 1960s, Nigeria became the leading global palm oil and palm kernel producing and exporting country, accounting for 43% of global exports. Presently, it produces insufficient, not more than 1.7% meager of global production. Even though in 2012, it domestically produces 940,000 tonnes, while the large imports are from Malaysia, Benin, Ghana, Ivory Coast, and Togo has been estimated at 870,000 tonnes.

Palm oil production in Nigeria is not competitive globally and is more expensive than Malaysian and Indonesian ones (PIND 2012). In Malaysia, the farms expanded and multiplied by five times than various cultivation, while in Indonesia, they multiplied by 23 times due to more expansion by private investments. In Indonesia, it was expanded rapidly in 2000, while in 2009, it covered the area of 5.3 million ha. In the 1980s, the annually planted areas reached 100,000 ha; since then, it annually increases by 200,000 ha up to the 1990s. From 1999 to 2003, the rate of expansion in plantations estimated was around 500,000 ha annually. Malaysia remains a sustainable produce; and a sustainable palm oil chain of supplier to the worldwide market. Oil palm is a yielding crop with a higher value than the other crops. Malaysia became the largest exporting and second producing country globally due to its tactics for positively communicating in terms of palm oil. The main objective to be achieved by Malaysia is to show the contribution of palm oil in terms of human consumption, suitable for human health, employment, generating income, and make it globally recognized vegetable oil. The challenges from Europe on palm oil is another opportunity to make palm oil sustainable and trendsetting to Malaysia to transfer the challenge into the best chance (MGCC 2017).

In 1966, Malaysia was a top palm oil-exporting country and the second-largest palm oil-producing country after Nigeria in 1971. Malaysia was exceeded by Indonesia in 2006 and it was ranked the largest producer of palm oil globally. In 2008, Malaysia remained the most extensive global palm oil-exporting country. Palm oil rose as the primary source of income, which generates revenue, promotes economic development, and alleviates poverty in the South Asian and West African countries (Ismail 2013). During the 1980s, Indonesia unlocked its borders for Malaysian investors. Later on, it considered the palm oil industry role; it opened the border for investors. In the decade, these companies gave support to the ambition of yearly oil palm growth in Indonesia. The quick enlargement of oil palm plantations emanated at the outflow of natural forests, peatlands, and less efficient plantations, which were substituted by commercial oil palm plantations. This extension of land use for palm oil production in Indonesia has been sustained due to land available for agriculture. In 2005, Indonesia exceeded Malaysia to become both the largest grower and producer of palm oil in the world.

Palm oil in Malaysia achieved develoment due to the contributing factors. The factors emerged as result of sustainability and good economic policies from the government. In the 1960s, the oil palm production increased in Malaysia with a 21.1% annual growth. The demand of palm oil increased and the Malaysian government's provision led to the rise of local private investment in oil palm estates. In 25-years between 1961 and 1986, palm oil production in Malaysia rose to an impressive annual rate of 180.8%. At the same time, in the 1980s, Malaysia's government acquired different foreign plantations, mainly from the source owned before by Britain. This has successfully boosted the development of palm oil.

Going by the above literature on decline of palm oil industry in Nigeria from different scholars, it confirmed that, palm oil industry in Nigeria faces challenges which restricted its development. These challenges are the necessitating factors that caused its decline ranging from lack of investment; lack of extraction technology, inadequate training, technical income-petence, poor management of palm oil plantations, inadequate access to credit facilities, poor infrastructure, aging and less yielding trees, outdated techniques, lack of modern approaches to be functioning efficiently, lack of funding to conduct research and produce high quality planting materials, and lack of technology to cultivate and process significantly. These factors necessitated the decline of palm oil industry in Nigeria. In Malaysia and Indonesia, the big plantations accounted for the 80% of the production, and the smallholders accounted for 20%. Secondly, the oil palm production entirely declined as a result of civil war, oil discovery for commercial purposes, the use of local techniques to process crude palm oil, and traditional method of production and cultivating oil palm, which is outdated to be applied in terms of the current output.

RESULTS AND DISCUSSION

Nigerian Decline on Palm Oil

Oil boom in 1970s and decline in agriculture

Nigeria received almost two hundred and fifty million dollars as revenue from oil in 1964 (Myers 1990). Although, during the early 1970, the growth of the petroleum industry has transformed the Nigerian economy. The states creation extended economic dependency on revenue from oil by local and state government. The revenue from oil used to fluctuate due to the prices of oil and the Nigerian oil demand for the global economy (Watts 1983). According to Michael Watts and Paul Lubeck (1983), Nigeria extended and enlarged production. The advent of oil allowed a size of self-sufficiency from collecting foreign aid and the beginning of a great bureaucracy to be centralised. However, 1980s became similarly an inconsistent era, and resulting disparity in price rises which created economic destruction and generated poverty in urban and rural area. In 1970s, there was a quick growth in the petroleum industry which augmented the nation state revenue separate from agriculture. The domestic mixture with global activities, caused the Organization of Petroleum Exporting Countries (OPEC) to be created, and directed in rises the petroleum prices from 1971 to 1980 (Watts and Lubeck 1983).

Moreover, the 1973 Arab-Israeli war that banned petroleum supply to Israeli alliance, in particular Western countries which buttressed Israel, this activated the prices of petroleum to rise intensively. The 1979 Iranian Revolt caused over 130% additional increase of price of oil. The periodic dividend sustained into the 1990s. Nigeria generated huge amount of revenue from the two crises. There was increase of price of oil in October 1973 to early 1974, from \$3.78 per barrel to \$14.69 per barrel (Okolie 1995). In 1970s to early 1980s, the boom in export caused the GDP to annually increase with almost 10% (Kolko 1988). In 1970, there was an increase in revenue from 411 million dollars to 1980 sum of 26.62 billion dollars (International Financial Statistics 2018). The Nigerian government interests in agriculture was identified insignificant due to shift to petroleum which is more profitable. This modification in revenue coming to government from agricultural production, caused the agricultural decline and more dependence on import from abroad (Watts and Lubeck 1983).

Civil war

In 1966, Nigeria faced political conflict that has broken into the 1967 civil war of Nigeria - Biafra. As a result of conflict from political aspect, it became a civil war caused by the government of colonial administration, whereby Fredrick Lugard amalgamated the three regions into one Nigeria in 1914. The 1954 constitution complicated the issue in Nigeria through the introduction of regionalism, and came up with three regions of North, West and East. This amendment caused ethnicity and regionalism. In 1966, it led to military coup. There was a competition for economic and political development among the regions (Watts 1983). In the middle of 1960 and 1966, the production of oil palm stayed reasonably huge. The incomes earned by the farmers were sufficient to invest in transport and trade. The roads construction and lorries penetration into remote villages increased trade and induced migration to urban centre. As sources of income, significance of cassava, yam and other agricultural crops, similarly enlarged urban development. This decreased rural dependency on export, even though oil palm sustained as an essential source of money. On the other hand, the inconsistencies in the estate scheme and the negligence of farmers wellbeing linked with environmental and demographic issues drive farmers away from their land. This affected farmers' food and other financial needs (Korieh 2018).

Due to civil war from 1967 to 1970, different problems impacted on the capability of farmers and the regional governments to improve agricultural production. The war influenced the eastern region agricultural economy, and the war political occurrences affected the rural area. The petroleum industry enlargement created conflicts in the economy rural agriculture. Generally, for safeguarding food security, farmers from rural areas replied to the disaster facing agriculture by accepting policies which are new. However, the general public traditionally engaged into the existing policies. The existing policies sustained by influencing social, cultural, and local schemes and a very solid structure (Korieh 2018). The strategy was applied to starve the secessionists so that the Nigerian government would quickly defeat the Biafrans and bring them back to order. The central government blocked the eastern region and enforced the Biafrans to retreat and surrender to one Nigeria for their survival. The other tactics incorporated the blocking Biafran access to food outside the region and behind federal outlines, the halting of international relief, the central authority gunshot an airplane owned by the Red Cross carrying foodstuff to the surrounded Biafrans. This organization served as main aid action in the region, but it lost its plain and was not able to fly again for humanitarian aid. Due to this blockage, Biafrans encountered crisis of food which caused the loss of more than one million people in eastern region (Korieh 2018).

Traditional palm oil production

The traditional palm oil production in Nigeria, oil palm tree became a long standing resource which is natural grove, whereby due to agricultural activities, clearance of forest was done. Some spaces were provided for oil palm trees to be planted. In addition, oil palm trees are implanted as family or community system of agroforestry farming. The fruits of oil palm collection were traditionally done, the processing of palm oil into red one was locally and manually made. At times, some consist of mechanical press, while others manually operate. Soap and other produces were manually made from palm kernels, and palm wine is produced from tree sap (PIND 2011). Traditionally, the trees ages of oil palm estates existing in Nigeria, it is more than thirty years and is facing production decline. It imposes danger on sufficient and available fresh fruit bunches (FFB) quality and quantity to be processed. Majority of the palm nuts originated from the wild groves and collected to be processed. The variety of Dura existed in the wild trees, it yields low and is old. Majority of the palm trees, is individual possession, instead of someone that would harvest it. The productivity activity is local without the fertilizer use, and the weeding is inadequate. In addition, the processors use traditional techniques such as mortar and pestles to process 20 L daily. This yields 9% which is below the oil half of fruit content. Most of the commercial farmers purchased modern and small techniques that could extract 12% and per hour could process 250 kg of oil (PIND 2011).

Necessitating factors to Nigerian decline on palm oil

This research paper used semi-structured interview to investigate the necessitating factors to Nigerian decline on palm oil. These six participants have expertise in this study, and responded to this interview. All are Nigerians with the age grades from 40 to 50 years, and they are professionally educated. First participant is a chief agriculture superintendent; he holds Master degree. The second participant holds Master degree and research officer one. The third participant is a senior technical officer in production and processing sector, he is a degree holder. All are from Nigeria Institute of Oil Palm Research (NIFOR). Participant four is a degree holder and senior quality assurance in production and processing sector from West African Soil Industrial Limited (WASIL), Nigeria. The fifth participant is from Northwest University, Kano. He is a PhD holder and lecturer. And the participant six is a PhD holder, and lecturer from Federal University, Gashua, Yobe State, Nigeria. This selection is based on the participants' will and knowledge. These interviewees were interviewed on the necessitating factors to Nigerian decline on palm oil. The following Figure 1 represents the result from the interview. The main view of the participants from Figure 1, confirmed that, there are necessitating factors that led to Nigerian decline on palm oil. The participant 1 viewed that, the current situation of oil palm in Nigeria is booming, but the negli-

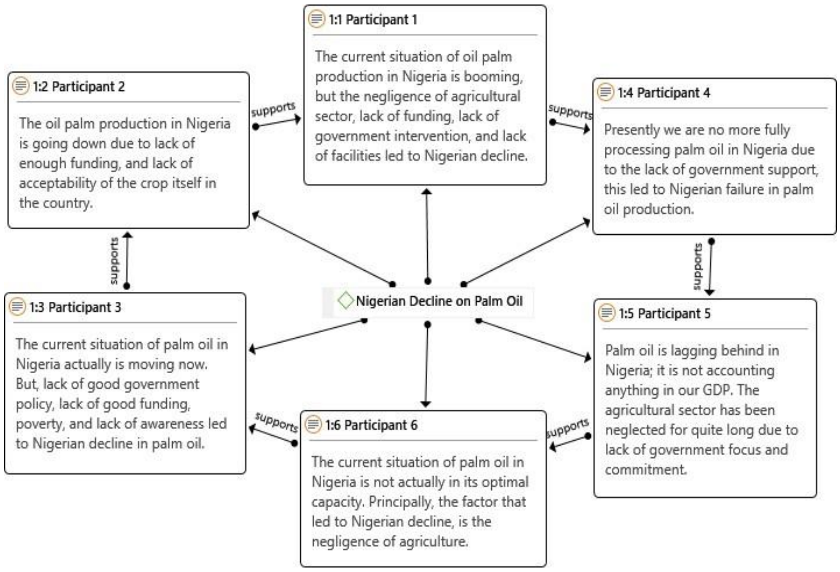

Figure 1 Nigerian decline on palm oil.

gence of agricultural sector, lack of funding, lack of government intervention and lack of facilities to the farmers in many years, led to oil palm production decline in Nigeria. The participant 2 confirmed that, oil palm production is going down in Nigeria due to lack of sufficient funding, and farmers have not widely accepted the crop. The participant 3 stated that, there are some of the factors that led to Nigeria failure in terms of palm oil which included lack of good government policy, lack of good funding, poverty and lack of awareness. The participant four highlighted that, due to lack of government support, palm oil is not fully processed in Nigeria, and this led to its failure. The fifth participant exposed the main factor that led to Nigerian failure on palm oil, which is negligence of agriculture by government due to lack of focus and commitment. The participant six supported the participant five and explained that palm oil in Nigeria is not in its optimal capacity due to negligence of agriculture. All the six participants confirmed that, palm oil declined in Nigeria due to these above-mentioned factors.

Malaysian Sustainability on Palm Oil

The factors for Malaysian sustainability on palm oil are the key fundamental reasons of shifting the industry to competitive stage which improved the sustainability. The factors for Malaysian sustainability are of three key viewpoints: environmental consciousness, economic escalation, and social commitment. All these factors play a vital role in contributing to the Malaysian sustainability on palm oil.

Environmental consciousness

Environmental consciousness is a significant plan formulated and implemented by the Malaysian government to alleviate the environmental effect of palm oil industry. This policy of conservation of environment was introduced in 1976, and identified in the third Malaysian development plan. This palm industry has been well regulated whereby all growers, millers, refiners, processors and traders were registered and applied for licenses before their operation. The awareness on environment is to manage palm oil wastes and control pollution in the society. The practice of contrary logistics in the establishment proposed that POME could be recycled for manufacturing of different fertilizers and animal feeds in through bio-technological developments (Lee and Farzipoor 2012). Life Cycle Assessment (LCA) is one of numerous managing utensils for appraising environmental issues and is imperative as a support for supervisory utensil. It is tactically sustainable due to its contribution in solving the environmental problem of waste dumping in a good manner and to improve energy uses (Hassan *et al.* 2012).

Environmental awareness similarly fetches political tension through heavy-duty rules for emissions and pollution. Regulation imposes important reforms in industrial activities and tactical methods of the palm oil trade. Plan and ruling elements originate from governments either via legislation or through a by-law calling for that corporations to obey environmental ethics. The environmental limitations in the industry offer an instrument for allowing adjustable emission ethics, and law enacts restrictions on environment, sums of atmosphere releases and shipping canal by mills and refineries.

Economic escalation

Palm oil industry is an imperative income source to the country and it succeeded in poverty eradication among poor people. This industry has created multiplier effect through the creation of different supportive industries. Oil palm has various applications either in food or non-food. For that reason, government implements strategies to improve palm oil support to the national economy (Patthanaissaranukool *et al.* 2013). The Malaysian government introduced the National Biofuel Policy in March 2006. Its main objective was meant for stabilizing the crude palm oil (CPO) price as well as exploiting the new opportunities in export market (Chin 2011). Due to the significance of the palm oil industry to the Malaysian economy, the government has selected palm oil industry as one of 12 New Key Economic Areas (NKEAs) towards accomplish of high income status by year 2020. This motivation had been declared in the 10th Malaysia Plan (2011–2015) in 2010. This palm oil industry was placed in central Economic Transformation Program (ETP) to get extraordinary government support in terms of financing and special dimensions. The Malaysia government supported the palm oil industry due to its contribution to increase the gross national income by 2020. The eight core entry point projects (EPP) implementation would help to accomplish the target (Ng e*t al.* 2011).

Social commitment

The socio-economic benefits of a sustainable oil palm plantation eradicate poverty and provide long term opportunities of employments. Sharing of profit offers a more incentive, attracts additional labours to the palm oil sector, and provides good working conditions and better living (Alban and Cardenas, 2007). In terms of oil palm production, smallholder significantly benefit from its higher yields than other crops (Rist *et al.* 2010). In Malaysia, there is a new attention on real inaccuracy and liability of corporate activities that impact on the society and the environment. The government is implementing policies in response to key sustainability concerns, incorporating greenhouse gas emissions, labour and human rights, water use and toxic chemicals especially in the palm oil industry. POM are pleased to follow global and national policies to solve the concerns that affect workers, socioeconomic matters such as wages, healthcare, safety, climate change and environmental problems. Safety and Health Policy (OSHA) 1994, Employment Act 1955, Factories and Machineries (Noise Exposure) Regulations 1989, and worker Minimum Standard of Housing and Amenities Act 1990 are the policies and law that the organizations have to follow. However, implementing food safety and HACCP policy as per ISO 22000 as the best advanced practice for the palm oil industry is useful for public and customer welfare (Mohd-Lair *et al.* 2012). The palm oil industry is a key source of employment and extensively eradicates poverty among the poor people in developing countries, creates jobs, offers a better standard of living, provides infrastructural facilities and contributes to social stability (MPOC 2007a).

Factors in Malaysian palm oil suistainability

This research paper used open-ended (semi-structured) interview to explore Malaysian sustainability on palm oil, there are six participants. The participants age grade started from 40 to 50 year-old. They are professionally educated participant one is holder of Master degree, and Deputy Director-General Services, Malaysian Palm Oil Board (MPOB), Ministry of Primary Industry. Participant two is a Master degree holder, and he is Manager Research Development from FELDA Global Ventures Holdings Berhad (FGV Holdings Berhad), Malaysia. The third participant is a Master holder and Director, PROFES LIPID SDN BHD, Malaysia. Participant four holds Master's degree, and he is Head of Marketing from OLIQ TRADE SDN BHD, Malaysia. The participant five is Professor and Dean Faculty of Social Sciences from University of Sultan Zainal Abidin, Terengganu, Malaysia. Participant six is an Associate Professor, Faculty of Bio-resources and Food Industry, from University of Sultan Zainal Abidin, Malaysia. This is selected based on the participants' knowledge and will of participating in this research paper.

The Figure 2 above shows the Malaysian sustainability on palm. First participant from MPOB said that, Malaysia sustained on palm oil due to government seriousness on good agricultural practices with global standard. The second participant explained that, Malaysian palm oil is one of the leading palm oil in the world in terms of sustainability, technology and government enforcement activity. Third participant stated that, Malaysian sustainability on palm oil is achieved due to government conservation of the primary forest for inhabitants and bio-diversity. This primary forest is untouchable and well conserved for the RSPO principles. The participant four highlighted that, Malaysia achieved sustainability on palm oil due to market contention. The participant five confirmed that, Malaysia sustained on palm oil based on the three key factors that included environmental consciousness, economic escalation and social commitment. The participant six exposed that, Malaysia achieved sustainability on palm oil due to environmental issue, economic issue, and social issue. The participants confirmed that, Malaysia sustained on palm oil due to these factors mentioned above Interview research findings.

A Comparative Study between Nigeria and Malaysia on Palm Oil

According to a study by PIND (2011) the Nigeria palm oil industry has a significant and prospective expectation of recovering its competitive chances; this is very challenging for Nigeria to have competition while its industries are not transformed globally. Domestic demand is the direct goal for meeting up the target. Nigeria has a market for palm oil; it has to emphasize standard global production. When it accomplished this, it would better

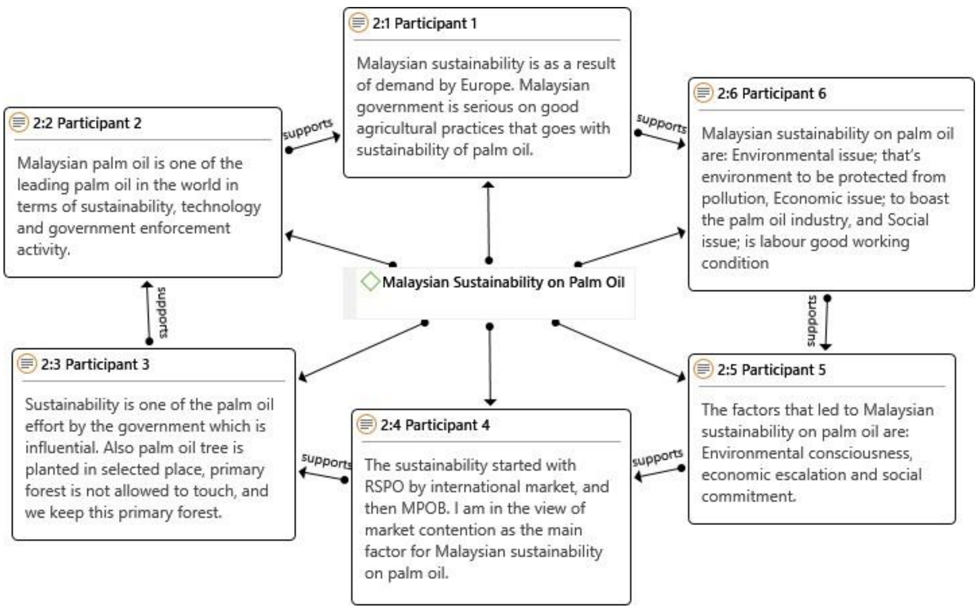

Figure 2 Malaysia sustainability on palm oil.

make the best use of its chances to compete efficiently. An additional concern to be considered is the level of high free fatty acid (FFA) consumed in palm oil locally. However, oil that contains high FFA is the local people's first choice due to its taste and odour. This increases health concerns and risks on the consumers; then, there is a need to enlighten about the hazards complicated with FFAs. The low-quality palm oil has the content of high iron and machine residues; it similarly puts in danger the public health of those that consume available oils with the lowest quality standard (PIND 2011).

The figure below presents the challenges facing the palm oil industry in Nigeria, specifically if compared with that of the Malaysian palm oil industry. Comparison between Nigeria and Malaysia on Palm Oil Industry (PIND 2011). Going by the previous research as indicated in this figure above; this study cannot compare and contrast between Nigeria and Malaysia. Malaysia is far better than Nigeria in palm oil production; it has already achieved global recognition due to its sustainability. This study has just used Malaysia as a lesson for Nigeria to learn from Malaysian strategies on palm oil industry and not compete with it.

CONCLUSION

The paper discussed on Nigerian decline on palm oil production due to some factors which include: oil boom and negligence of agriculture, Nigerian civil war, and traditional system of oil palm production. These factors are findings from documents. On the other hand, the paper presented other findings from six participants from Nigeria which is based on semi-structured interview. All the six participants from Nigeria agreed that, there are factors that led to Nigerian decline on palm oil. This paper discussed on the Malaysian sustainability on palm oil which are: environmental consciousness, economic escalation, and social commitment, these factors contributed to it sustainability and it achieved global recognition despite the facts of other challenges it encountered on the global economy of palm. All the six participants from Malaysia ascertained that, Malaysia achieved sustainability due to these factors. Nigeria has to learn from Malaysian sustainability on palm oil such as: environmental consciousness, economic escalation and social commitment in order to solve its problems on oil palm production and revive its past glory on oil palm production. The contribution of this study explored the necessitating factors that led to Nigerian decline on palm oil, and the contributing factors to Malaysian sustainability on palm oil. Methodologically, this paper applied qualitative method to collect data, while most of the studies in this area are based on quantitative method. This study contributed to the body of knowledge by presenting the findings, both from documents and interview to assist the two countries to improve their palm oil production. For Malaysia, to continue improving its sustainability, while for Nigeria to learn an experience from Malaysian sustainability to recover from decline, and revive its past glory on palm oil.

ACKNOWLEDGEMENTS

I would like to express my special gratitude to my supervisor and UniSZA. This research has been conducted based on self-sponsor, the research has neither scholarship, fellowship, nor grants. The research faced a serious challenge of Covid-19 in Malaysia, and currency devaluation (Nigerian Naira) from Nigeria.

REFERENCES

Alban M and Cardenas H. 2007. Biofuels trade and sustainable development: The case of Ecuador’s palm oil biodiesel. IIED. p. 1–58.

Ayodele T, Eshalomi MO. 2010. African case study: Palm oil and economic development in Nigeria and Ghana. IPPA. p.1–12.

Chin M. 2011. *Biofuels in Malaysia: An*

Analysis of The Legal and Institutional Framework. Bogor (ID): CIFOR Publication.

Cleveland DA. 1998. Balancing on the planet: Towards an agricultural anthropology for the twenty-first century. Hum Ecol. 26(2): 323–340.

Cohen L, Manion L, Morrison K. 2007. *Research Method in Education 6th Edition.* New York (US): Routledge.

Cresswell JW. 2012. *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research. Fourth Edition.* University of Nebraska-Lincoln (US): Pearson.

Douglas A Phillips. 2004. *Nigeria.* Philadelphia (US): Chelsea House Publisher.

Drabble JH. 1973. *Rubber in Malaya 1876–1922: The Genesis of the Industry.* Kuala Lumpur (MY): Oxford University Press.

Drabble JH. 1991. *Malayan Rubber: The Interwar Years*. London (UK): Palgrave Macmillan.

Drabble JH. 2000. *An Economic History of Malaysia. c.1800–1990 (The Transition to Modern Economic Growth)*. London (UK): Palgrave Macmillan.

Hassan MA, Yee LN, Yee PL, Ariffin H, Raha AR, Shirai Y, Sudesh K. 2013. Sustainable production of polyhydroxyalkanoates from renewable oil-palm biomass. Biomass Bioenergy. 50(1): 1–9.

Hashim M, Teoh Ch, Kamarudzaman A and Ali MA. 1993. Zero burning an environmentally friendly replanting technique. In: Jalani BS, Arifin D, Rajanaidu N, Mohd TD, Paranjothy K, Mohd BW, Henson IE, Chang KC, editor. Proc. PORIM Int Palm Oil Congress. Kuala Lumpur (MY): Palm Oil Research Institute of Malaysia. p.185–194.

International Financial Statistics. 2018. *International Financial Statistics*. Washington (US): International Monetary Fund.

Ismail. 2013. The effect of labour shortage in the supply and demand of palm oil in Malaysia. OPIEJ. 13:15–26.

Kolko J. 1988. *Restructuring the World Economy.* New York (US): Pantheon Books.

Korieh CJ. 2018. The Nigeria-Biafra war, oil and the political economy of state induced development strategy in Eastern Nigeria, 1967–1995. Soc Evol Hist. 17(1): 76–107.

Lee KH, Farzipoor R. 2012. Measuring corporate sustainability management: A data envelopment analysis approach. Int J Prod Econ. 140(1): 219–226.

Malaysia-German Chamber of Commerce and Industry (MGCC). 2017. *Palm Oil: Awareness and Sustainability; A Global Perspective*. Kuala Lumpur (MY): EU-Malaysia Chamber of Commerce and Industry (EUMCCI).

Malaysian Palm Oil Council (MPOC). 2007a). MPOC Annual Report 2007. Selangor (MY): Malaysian Palm Oil Council.

Mohd-Lair NA, Lee JFM, Liew WYH and Sarbatly R. 2012. Simulation based process improvement in palm oil industry: A case study at palm kernel department. In: Business Engineering and Industrial Applications Colloquium (BEIAC). Kuala Lumpur (MY): IEEE. p. 12–15.

Morgan WB, Solarz JA. 1994. Agricultural crisis in sub-saharan Africa: development constraints and policy problems. J Geogr. 160 (1): 57–73.

Myers GW. 1990. This is Not Your Land: An Analysis of the Impact of the Land Use Act in Southeast Nigeria. [Dissertation]. University of Wisconsin-Madison.

Okolie A. 1995. Oil Revenues, International Credits and Food in Nigeria, 1970–1992. [Thesis]. Sociology Department, University of Toronto.

Patthanaissaranukool W, PolpraSert C, and Englande AJ. 2013. Potential reduction of carbon emissions from crude palm oil production based on energy and carbon balances. Appl Energy. 102: 710–717.

Rist L, Feintrenie L, Levang P. 2010. The livelihood impacts of oil palm: smallholders in Indonesia. Biodivers Conserv. 19:1009–1024

Teoh CH. 2002. *The Palm Oil Industry in Malaysia: From Seed to Frying Pan*. Selangor (MY): Malaysian Palm Oil Council.

Watson-Manheim MB, Chudubo K, Crowston K. 2002. Discontinuities and continuities: a new way to understand virtual work. Inform Technol Peopl. 15(3): 191–209.

Watts M. 1983. *Silent Violence, Food, Famine, and Peasantry in Northern Nigeria.* Berkeley (US): Berkeley University of California Press.

Watts M, Lubeck P. 1983. The Popular Classes and the Oil Boom: A political economy of rural and urban poverty. In Zartman WI, editor. The political economy of Nigeria. New York (US): Praeger. p. 105–144.

WK and Koh CB. 2011. Farmed fish as biological agents for extracting residual palm oil refining industry. J Oil Palm Res. 23(1): 953–957.

Zhang Y and Wildemuth BM. 2009. Qualitative analysis of content. In: Wildemuth BM, editor. Application of social research methods to questions in information and library science. Westport (US): Bloomsbury Publishing.

INTERNATIONAL JOURNAL of OIL PALM

Volume 6, Number 2, 2023
Page 13–24
DOI: 10.35876/ijop.v6i2.108

ISSN: 2599-3496 print
ISSN: 2614-2376 online

Highly Efficient Clay Based Degumming Aid for Phosphorous Removal from Crude Palm Oil

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ABSTRACT

The removal of phosphorous from crude oil is a complex and necessary step to enhance the oxidative stability and shelf life of edible oil. In this aspect, the current work proposed clay based degumming aid for the removal of phosphorous from the crude palm oil during the bleaching process. The state of art qualitative and quantitative techniques was adopted for the study of physical and chemical properties of different raw materials and oil. A profound study on the stability of the degumming aid is based on the assessment of phosphorous removal efficiency with time (up to 6 months) and bleachability. The results of current work revealed that clay based degumming aid is highly effective in removing phosphorous up to 96%. Additionally, the bleaching performance of clay-based aid is also palpable (around 45%), which influences the deodorization process of the crude palm oil positively. The clay based degumming aid eliminate separate degumming process with acids, which directly impact the oil processing time and cost. Overall, proposed clay based degumming aid is highly efficient, stable for long time and cost effective as well, for the removal of undesired phosphorous from the crude palm oil during the bleaching process.

Keywords: Bleaching, clay minerals, deodorization, edible oil

INTRODUCTION

The market of edible oil is very wide and numbers of vegetable oils are produced, transported and consumed everywhere in the world. The global market of palm oil was reported to grow from 88.8 million tons to 111 million tons with the rate of 5% in the coming three years (Majiz *et al*. 2021). Indonesia, India and China are the top three palm oil consumer countries. Interestingly, Indonesia and Malaysia are the two major countries which produce around 85% of the world's palm oil (Rudy *et al*. 2022 and Hamidi *et al*. 2022). Palm oil is largely consumed in food, beverages, cosmetics and pharmaceuticals. Nevertheless, it is a rich source of vitamins A and E, and low cost along with trans fatty acids response during heating and frying made it more valuable and preferable than other vegetable oils (Tripathi *et al*. 2022).

The health benefits and adverse impact both revolves around the type and quality of consumed edible oil. Crude vegetable oil is consisted of required nutri-

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tion and unhealthy components as well. This undesired part from crude oil is partly separated by variety of processes to enhance oxidative stability and shelf life of oil (Chew *et al*. 2021). The removal of undesired phosphatides, trans fatty acid and gum while minimizing the oil loss during the process is the focus of degumming route (Carr *et al*. 1978). Although, degumming process passes through many steps and requires sophisticated facilities and raw materials as well.

The degumming of palm oil is crucial before processing for refining. In current era, a number of degumming routes are available and adopted by oil refining industries (Gharbi *et al*. 2022). Each and every degumming process influences the quality of processed oil and production cost as well. Some of the popular degumming routes include water degumming, enzymatic degumming, acid degumming, modified acid degumming and membrane filter degumming (Dijkstra *et al*. 2010 and Manjuka *et al*. 2007). Acid degumming is one of the oldest and convenient routes for removing phosphatides from the crude palm oil. The orthophosphoric acid, citric acid, nitric acid and some other edible grade acids are being used for the degumming purpose (Ohlsol *et al*. 1976). These acids were added in the barrel of oil to chelate with the gum to make complexes and settle down gum in the bottom of the barrel. The settling down phosphatides takes more than 8 hours. This degummed oil from top of the barrel is transferred for the further refining process.

The oil is treated with clay at ~110 °C to remove the colouring pigments. So, in the current work, authors have developed a novel product which will do degumming and bleaching at the same time in a single step. This product will save energy, time and resources to produce final refined palm oil which will benefit the oil refineries and ultimately the consumers in terms of price of product. In the consideration of degumming materials, clay is one of the best choices in terms of availability, cost, nontoxicity and ease of processing. Combination of selected clay minerals was chosen in current work to produce degumming aid (named as ABA-degumming aid) for phosphorous removal. The chemical composition of clays received from different sources was critically analysed and used for performance check with different types of oil.

MATERIALS AND METHODS

Materials

Clay minerals were mined from the mines located in southern part of India. After processing and characterization of materials extracted from mines, silica, palygorskite and montmorillonite minerals were selected to prepare ABA-degumming aid. Crude palm oil was purchased from a renowned company located in Gujarat, India. All reagent grade chemicals like hydrochloric acid (37%, Merck), zinc oxide (99.99%, Finar), potassium hydroxide (99.9%, Merck), sulfuric acid (99%, Merck), sodium molybdate (99.9%, Merck), hydrazine sulphate (99.9%, Merck), cyclohexane and dihydrogen potassium phosphate (99.9%, Merck) were used in current study.

A number of apparatus like silicon oil bath with stirring at 250 rpm and heating up to temperature 110 °C, deodorization set up with vacuum pump, heating element and thermometer, hot plate with operating temperature up to 250 °C and muffle furnace with operating temperature up to 1100 °C were needed in the present work.

Methods

ABA-degumming aid for palm oil was prepared using the existing facility in plant by raw material selection, sampling, sizing, surface modification, and blending process respectively. The adopted processing steps of clay-based ABA-degumming aid were described in Figure 1. The selected clay raw materials goes to the acid activation to improve the surface area and adsorptive performance then ground to create homogeneous powder with average size 12.7 µm. Subsequently, clay powder was blended with additive in ribbon blender and test samples from different sections of blender were taken out, mixed together and analysed. After performance evaluation of all test samples, product was discharged and stored in bags with liners.

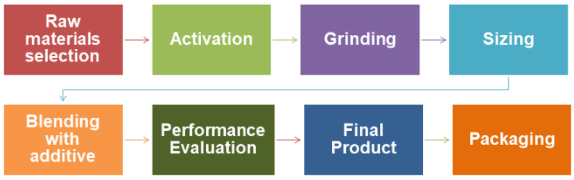

Figure 1 Process flow of preparation of ABA-degumming aid for edible oil.

Bleachability Testing and Degumming of Oil

In order to conduct the bleachability testing of the oil, 40 g melted crude palm oil was poured in a glass cuvette and 1.4% (w/w) ABA-degumming aid was added and kept in the pre-heated oil bath at 105 °C for 30 min with stirring speed of 250 rpm. Subsequently, hot oil and ABA-degumming aid mixture was filtered with Whatman No-1 filter paper. The colour analysis (using red scale values) which corresponds to the transmittance of light through the oil was carried out at room temperature with 1-inch quartz cuvette for crude, bleached in Lovibond tintometer and bleachability was calculated as per given formula (Bayram *et al*. 2021).

$$\text{Bleachability (\%)} = \frac{\text{Red crude oil} - \text{Red treated oil}}{\text{Red crude oil}} \times 100$$

Deodorization

After bleaching process, filtered oil was deodorized at 260 °C under 740-760 mmHg vacuum and without stirring for 45 minutes. The colour analysis (using red scale values) was carried out at room temperature with 1-inch quartz cuvette for crude and deodorized oil in Lovibond tintometer and bleachability (colour improvement after deodorization) was calculated by formula used above for bleachability calculation.

Phosphorous Analysis

Phosphorous analysis of edible oil was performed by following ISO standard AOCS CA 12-55. In order to conduct the phosphorous analysis; crude palm oil was bleached with ABA-degumming aids and filtered. Afterwards 0.5 g ZnO was added to 10 g bleached oil and kept for charring in silica crucible on preheated hot plate at 250 °C for more than 24 hours. Furthermore, charred oil (black mass) was converted into ash at 600 °C temperature with 2 hours soaking time. Then hydrochloric acid was poured on the ash of the oil and immediately double distilled water was added. Samples were boiled on hot plate for 5 minutes then filtered and washed 5 times. As per the protocol, potassium hydroxide solution was added to turbid the solutions then precipitates were dissolved by addition of hydrochloric acid. All these solutions were prepared in 100 mL volumetric flask. Subsequently, 10 mL solution of this 100 mL solution was taken and hydrazine sulphate and sodium molybdate solutions were used for colour development in hot water bath. All test solutions along with fresh standard solutions (0, 2.5, 5, 10 and 20 ppm) of phosphorous were analysed in UV-Visible spectrophotometer at 650 nm wavelength.

Free Fatty Acid and Acid Value Analysis

Free fatty acid (FFA) and acid value analysis (AV) of palm oil was performed as per ISO standard (ISO 660:2009 (EN)). Briefly, 10 g oil sample was taken in a flask and 2–3 drops of phenolphthalein indicator was added. Further 50 mL absolute ethanol was mixed to this solution at 65 °C temperature and allowed to cool down. Finally, this solution was titrated with 0.1 N KOH solution and Acid Value and FFA was calculated according to below formula:

$$\text{Acid Value} = \frac{\text{Concentration of KOH} * \text{Volume of KOH} * 56.1}{\text{Weight of oil sample}}$$

$$\text{FFA} = \frac{\text{Volume KOH} * \text{Normality KOH} * \text{Molecular weight FFA}}{56.1 * 10 * \text{Weight oil sample}}$$

Carotenoids Content Analysis

Carotenoid analysis of oil was performed as per British standard BS684: section 2.20:1977. Briefly, in order to determine the carotenoid content in oil, 1 g oil sample was dissolved in a 100 mL flask with cyclohexane. The absorbance of such solution is measured at 446 nm in 10 mm path length quartz cuvette and carotenoid content is calculated according to below formula:

$$\text{Carotenoids (ppm)} = \frac{383 \times \text{Absorbance}}{\text{Path length} \times \text{Concentration of solution}}$$

Deterioration of Bleaching Index

Deterioration of bleachalability index (DOBI) analysis of oil was performed as per British standard BS-684:section 2.20:1977. Briefly, in order to determine the carotenoids content in oil, 1 g oil sample was dissolved in a 100 mL volumetric flask with cyclohexane. The absorbance of such solution is measured at 446 and 269 nm in 10 mm path length quartz cuvette and DOBI content is calculated according to below formula (Ifa *et al*. 2021).

$$\text{DOBI value} = \frac{\text{Absorbance at 446 nm}}{\text{Absorbance at 269 nm}}$$

In the current work, all experiments were repeated at least four times and always triplicate of sample were analysed.

Characterizations of Clay Minerals

A chemical composition of the materials was studied by wavelength dispersive X-ray fluorescence technique (WD-XRF, Rigaku Primus Ⅲ+) having as excitation source a miniaturized 30 KV X-ray tube. Mineralogy of clay samples was analysed by X-ray diffraction technique (XRD, Shimadzu Lab X6000). The 200-mesh pass (74-micron particle size) blend was scanned at 1°/min scan rate at 30 mA current and 40 KV voltage. For the quantification of phases, Siroquant software with Rietveld method was used. The image of gold coated ABA-degumming aid was scanned by table top scanning electron microscopy (SEM, JEOL 6510) operated at 20 KV with Tungsten electron source. To measure the absorbance at 650, 446 and 299 nm UV-Visible Spectrophotometer (Specord 200 Plus Germany) was used. The red and yellow colour analysis of oil was conducted on Lovibond Colorimeter (PFX-i Series) and Tintometer (Lovibond Colorimeter model-F) at 1 and 10 inch path lengths. Particle size of degumming aid was analysed by Malvern particle size analyser (Mastersizer 2000) in wet system with sonication for 2 minutes at 12.5 Hz along with 1800-2200 rpm of hydro pump (Hydro 2000 MU) at room temperature. Brunauer-Emmett-Teller (BET, Quantachrome) was used to analyse surface area and pore volume.

RESULTS AND DISCUSSION

The current study was started from the critical analysis of raw materials to formulate the most efficient product without compromising with the quality of obtained oil. The ABA-degumming aid was prepared by selection of specific clay minerals along with one additive in specific quantity. Figure 2 presents the mineralogical analysis of the ABA-degumming aid. Critical analysis of the diffraction pattern revealed the presence of montmorillonite and silica phases as a major constituent of the ABA-degumming aid. However, palygorskite, hematite, and calcite, phases were also detected in significant quantity. The characteristics peak of montmorillonite, palygorskite, hematite, quartz, and calcite was detected at 2θ value 6°, 8.5°, 35.6°, 26.6° and 29.22° respectively. The presence of these minerals is very crucial for the degumming/bleaching of edible oil. The clay used to produce ABA-degumming aid is consisted of group of minerals, presented in Table 1. The quantification analysis shows that 86% of total aid is constituted by montmorillonite, palygorskite and silica minerals and rest 14% is occupied by calcite and hematite minerals. The quantitative analysis of chemical composition of the ABA-degumming aid reveals the presence of silica, alumina,

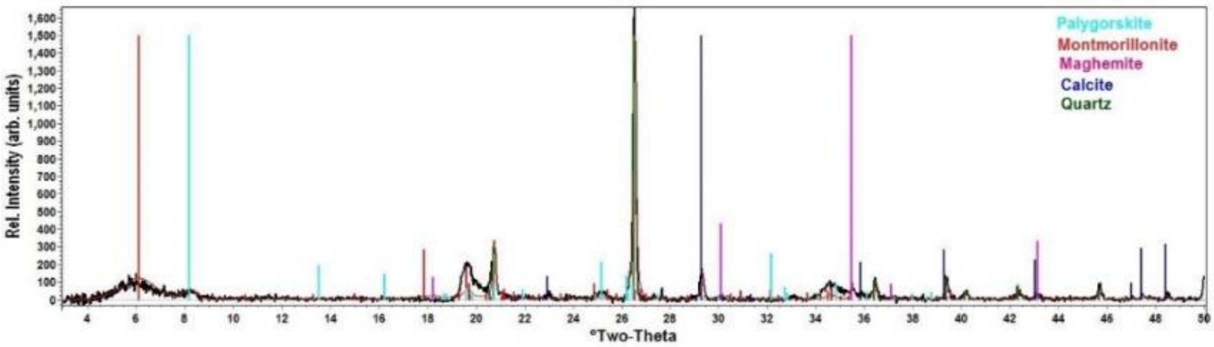

Figure 2 XRD pattern of the ABA-degumming aid.

iron oxide, calcium oxide, magnesium oxide and potassium oxide as significantly constituting chemicals of the ABA-degumming aid, which justified the mineralogical analysis well.

Table 1 Minerological composition of ABA-degumming aid

Phases	Quantification (%)
Palygorskite	16.0
Montmorillonite	49.0
Hematite	6.0
Silica	20.0
Calcite	9.0

Figure 3 shows the scanning electron microscopy image of the ABA-degumming aid. In order to ensure the uniform mixing of all constituents, five samples from different portion of the ribbon blender were drawn and images were captured by scanning electron microscope. The micrograph showed the uniform distribution of the raw materials and non-agglomeration. That confirms the physical blending of all raw materials is uniform. The uniform mixing of all constituents is a key factor to produce a quality product with consistent performance.

Certain physical parameters like bulk density, moisture and fineness directly impact the quality and cost of product. The ABA-degumming aid (phosphorous adsorbent) have 5.88% moisture which is very common in clay mineral based products. The fineness value plays important role in adsorption of colouring pigments present in oil and ABA-phosphorous adsorbent have 90% product of less than 90 μm size. Sieve method was adopted for fineness analysis of the product. The loose bulk density of the product is 0.7 g/mL, which indicates that product, is in the free flow form and has high surface area (145 m^2/g). Table 2 presents the surface area and pH value of natural attapulgite and ABA-degumming aid. The product has slightly acidic pH (5.8) value, which is the result of additive and surface treatment. This acidic pH favours the phosphorous removal from edible oil.

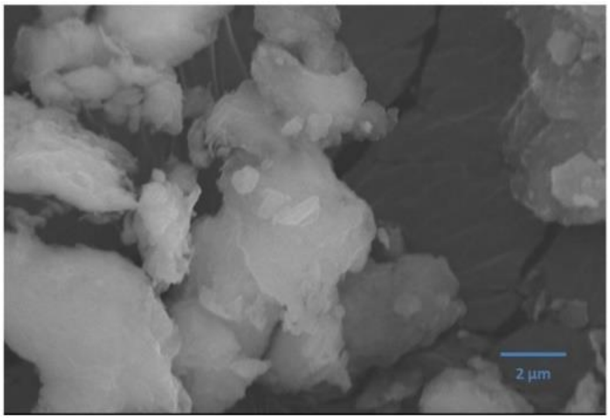

Figure 3 Scanning electron microscopy image of ABA-degumming aid.

Figure 4 shows the dose dependent response of ABA-degumming aid in terms of removal of phosphorous from the crude palm oil. The clay based degumming aid was analysed in a range of dose of aid and the higher value of phosphorous removed was set as a base to decide final dose. The dose of aid in edible oil should be in affordable range and it should not adversely alter the oil in terms of quality and nutrients. In the current study, 1.4% dose was found to reduce phosphorous up to 96% and this dose was set as a benchmark for the further studies.

Figure 5 presents the response of ABA-degumming aid on crude palm and rice brane oil (RBO). The performance of ABA-degumming aid was found to be dependent on the type of oil. The dose of degumming aid is also very crucial and higher dose will also enhance the processing cost of the oil. The degumming aid dose 1.4% was observed to be effective in palm oil but 3% dose of same degumming aid was not so effective in RBO oil. So, on the basis of current results, different types of oil requires different types of degumming process, aid and dose also. Appreciably the 1.4% dose of ABA-degumming aid removed 96% phosphorous from the crude palm oil while 3% dose in RBO oil removed only 10% phosphorous. The degumming of RBO is critical and complex mechanism. RBO contains high free fatty Acid (FFA) and crude gums of RBO contains oil, phospholipids, and wax (Senger et al. 2014). Phosphorus content in the RBO oil (55 ppm) is almost 2.5 timesthan that of the palm oil (22 ppm) (Figure 5). This all makes it complicated and sometime it requires two stage degumming to get the desired phosphorus content.

Figure 6 presents the percentage bleachability of bleached and deodorized palm oil. The results depicts that 45% bleachability at bleaching stage was achieved with proposed degumming aid, which is good and support that ABA-degumming aid is as good as other degumming process. As far as the deodorization response is concerned, 95% colour improvement at deodorization stage was reasonability good but further scope of improvement still exists.

Table 3 presents some important parameters of edible oil to judge quality and suitability in products. The ABA-degumming aid showed remarkable reduction in certain harmful organic substances at bleaching stage. Deodorization is the final step of the oil refining process which removes all undesired free fatty acids (FFA) and carotenoids and reduce colour.

Table 2 Surface area and pH analysis of natural clay and ABA-degumming aid

Quality Parameter	Unit	Natural Clay (before processing)	ABA-Degumming Aid (after processing)
Specific BET Surface area	m^2/g	90.0	145.0
pH	–	9.5	5.8

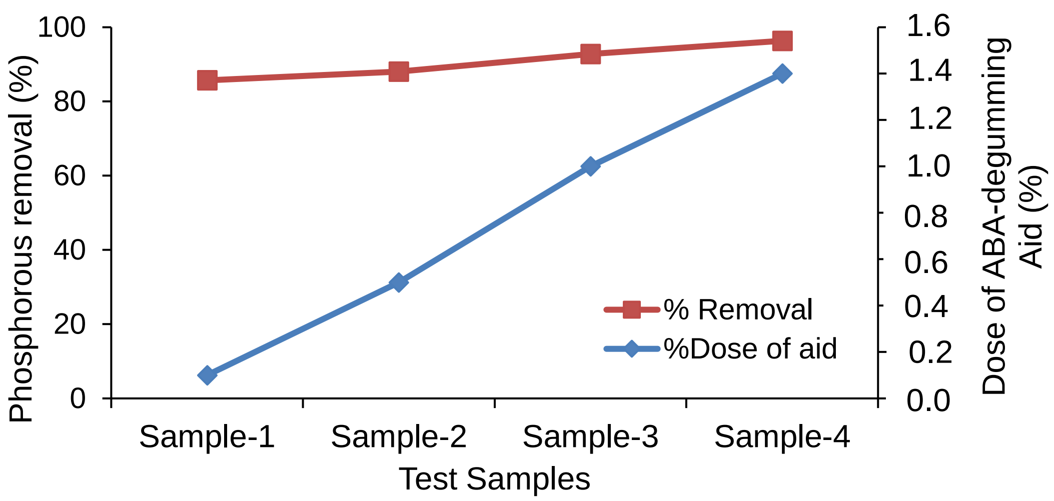

Figure 4 Response of degumming aid with respect to dose in crude palm oil.

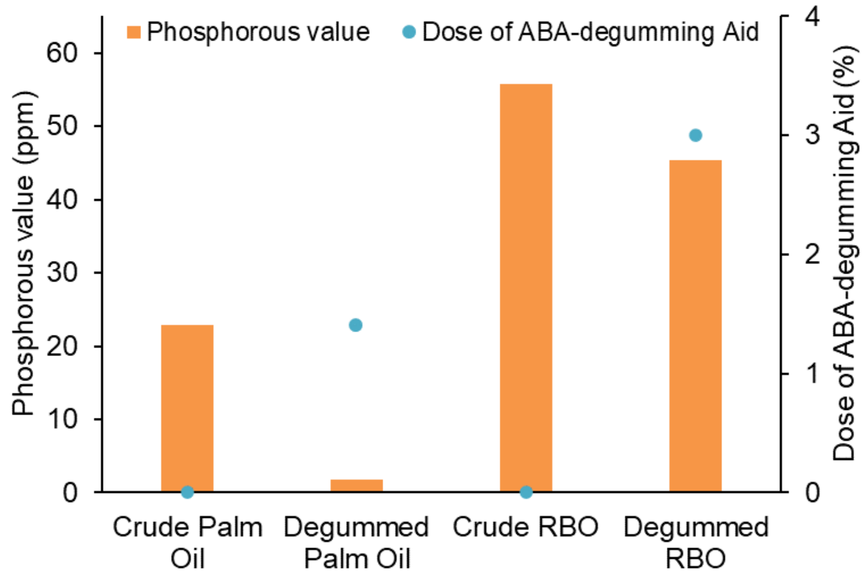

Figure 5 Response of degumming aid on crude palm and rice bran oil.

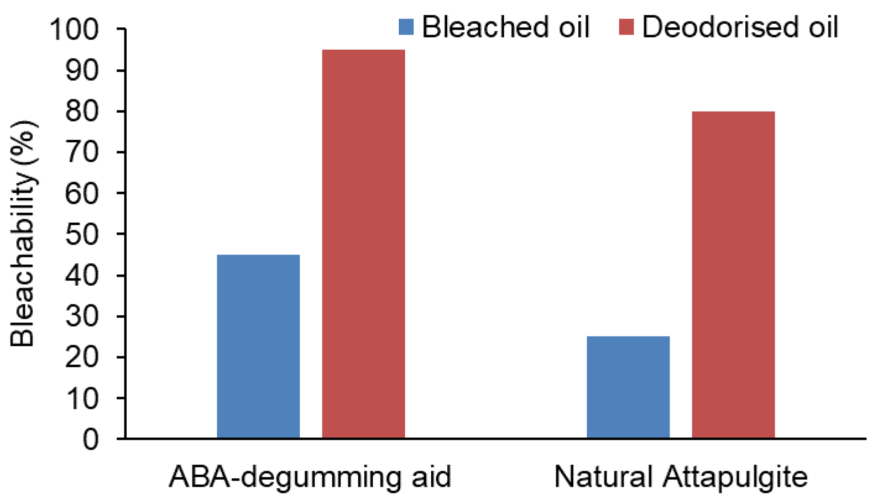

Figure 6 Bleachability at bleaching stage and deodorization stage of crude palm oil with ABA-degumming aid and natural attapulgite.

Table 3 Oil parameters of crude oil and refined with ABA-degumming aid

Oil	β Carotenoids (mg/kg)	FFA (%)	Acid Value (mg KOH/g of substance)	DOBI Value	Colour (Red in 1-inch path length)
Crude Oil	400–600	4.0–6.0	8.0–12.0	1.8–2.2	20
Bleached Oil	40–60	4.0–6.0	8.0–120	–	12
Deodorized Oil	<5.0	<0.1	<0.2	–	1

The FFA, acid value, and carotenoids results shows the non-toxicity of ABA-degumming aid for the palm oil and colour values of the deodorized oil are remarkable which are much better than only attapulgite bleached palm oil as presented in Figure 6. The removal of carotene is essential because β-carotene can react through cation, forming an alkyl radical (Krinsky *et al*. 2003 and Sarier *et al.* 1988). Figure 7 presents the stability results of the ABA-degumming aid. In the current work, ABA-degumming aid was stored in a bag to conduct stability response up to six months. Each time, test sample was drawn from the bag and bag was again tightly sealed. Every time samples were tested for phosphorous removal and bleachability. The samples were found to show consistent performance up to six months. Each time 18 crude oil was found to comprise different phosphorous value.

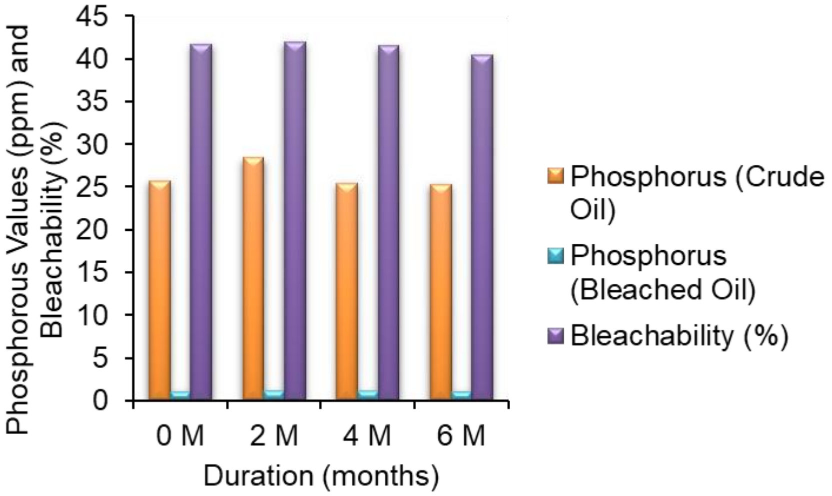

Figure 7 Stability analysis of ABA-degumming aid up to 6 months from manufacturing day (0 months), M stands for month.

In general degumming does not take place during bleaching process however it requires separate step like acid treatment, enzymatic treatment, water degumming, membrane filter degumming and many more ways. Degumming along with bleaching step is the main advantage of the ABA-degumming aid. This two in one utilization reduces time to refine oil, additional infrastructure, facilities, materials and waste management as well. The compilation of all these major steps directly impacts the selling price of edible palm oil which benefits the consumers. Most of the commercial oil refining companies use orthophosphoric acid (0.02–0.5% at 90–110 °C for 10–30 min) for the removal of phosphorous from the crude palm oil (Ebuna *et al*. 2007, Nur *et al.* 2021 and Irvan *et al*. 2020). This step is sophisticated and expensive as well, despite of low required dose. A number of products have been reported to lighten the colour of palm oil in bleaching process (Silva *et al.*1992, Zschau *et al.* 2001, and Boki *et al.* 1992). Attapulgite is the main clay which is commercially used for the bleaching of palm oil and surface modification by thermal/acid activation or carbon modification creates more pores on the surface of clay which helps in removing by trapping and adsorbing the colouring pigments from the palm oil (Gaugyan *et al.* 2018). As per the available literature 1 to 3% dose of attapulgite was reported to be used for bleaching of palm oil. But for degumming process acid is used. In contrast, in the present work only 1.4% dose bleached the crude palm oil and degummed as well. Comparison between major steps of oil refining process with phosphoric acid and ABA-degumming aid were presented in Figure 8.

The presence of phosphorous directly reduces the oxidative stability of the refined oil. ABA-degumming aid removed 96% phosphorous from the crude palm oil. The mechanism behind the phosphorous removal by ABA-degumming aid is the additive used along with modified clay make metal complex with the impurities (phosphorous, iron, heavy metals) present in the crude oil and as after the bleaching process, oil is filtered then phosphorous presented in gum was attached on aid, is separated out from the oil. Figure 9 presented the representative model of the removal of phosphorous (gums), colouring pigments and other impurities from the crude palm oil by using developed ABA-degumming aid. The optimum combination of clays and additive, with intercalation and positive charge on the surface and structure as well, are supposed to be directly responsible for removing the gums, colouring pigments and other types of impurities associated with the oil.

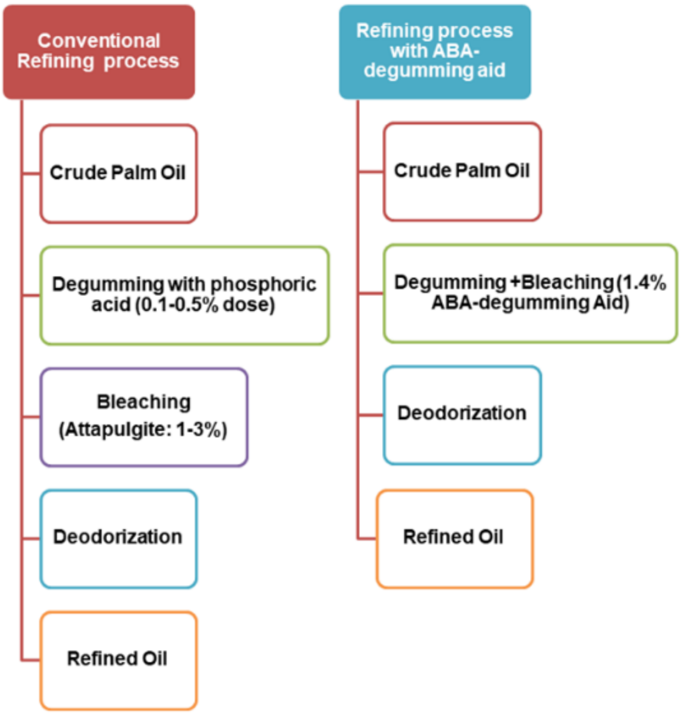

Figure 8 Comparative representation between oil refining process with phosphoric acid and ABA-degumming aid.

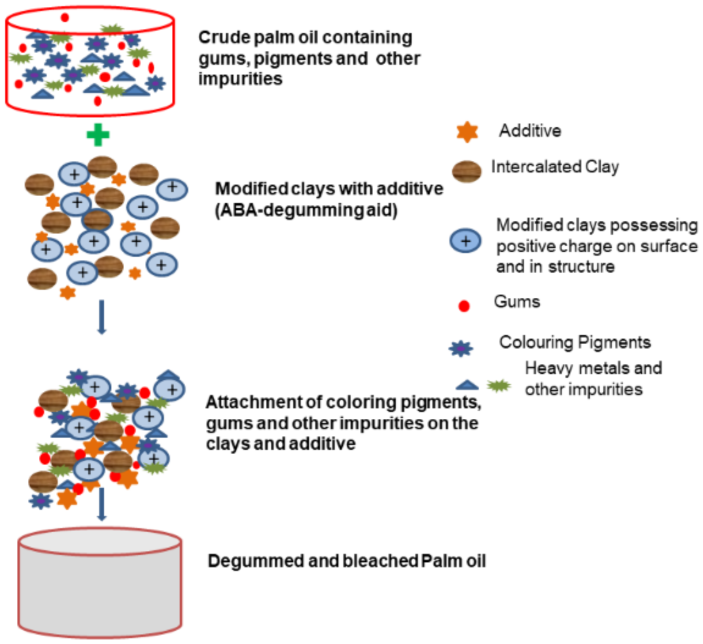

Figure 9 Representative model of bleaching along with degumming of palm oil by using ABA-degumming aid.

Clay minerals are abundant on earth and has been used as a bleaching clay adsorbent for the refining of edible oil like palm oil, soybean oil, sunflower oil etc. (Lin *et al.* 2007). Clays like palygorskite and montmorillonite poss-ess surface area which allows the researcher to use it as adsorbent. This surface area is further enhanced by doing the acid activation which in results helps to promote the adsorption of carotenoids and phospho-rous from palm oil (Wie *et al*. 2004). The acid activated clays gives good bleaching performance but fails to give the good phosphorus removal at the bleaching stage (Silva *et al.* 2013).

To overcome these issues, authors have modified the bleaching clay with additive, which helps to removed up to 96% phosphorous along with the bleachability at bleaching stage (105 °C). The additive is intercalated with the high surface area clay (Table 2). The additive act as chelating agent which helps to remove the phosphorous and high surface area clay act as a bleaching clay which helps to remove the carotenoids. The pH of ABA-degumming aid is lightly acid which creates the favourable condition for phosphorous and carote-noids removal.

The nonhydratable phosphatides are present in the form of calcium or magnesium salt of phosphatides (Vintila 2009). The adsorbent ABA-degumming aid forms a complex with calcium and magnesium. Calcium and magnesium salts of phosphatides get adsorbed on the surface of ABA-degumming aid. The high surface area of ABA-degumming aid adsorbed the carotenoids and gives the bleaching performance. Both the adsor-bed contaminants (phosphatide complex and carotenoids) are removed at the filtration stage.

Conventional degumming process of CPO takes around 10–12 hours to settle the gums in the bottom after the reaction in hot condition while bleaching requires only 0.5 hour. Additionally, settled gum carry 10% oil (with respect to weight of gum) which is considered as processing loss. Therefore, conducting degumming and bleaching in a single step by using ABA-degumming aid will reduce oil loss and processing time. Moreover, additional infrastructure for degumming will not be required. In the conventional process, phosphoric acid is used to remove the non-hydratable phosphatide in the dose of 0.1–0.5% (Lin *et al.* 2007). The average price of phosphoric acid varies in range of 75–95 Indian Rupees (INR), whereas the cost of ABA-degumming aid is 30–40% of the phosphoric acid. In the conventional process (Figure 8) degumming with phosphoric acid and Bleaching is done in two separate stages, whereas ABA-degumming aid completes both the process in a single stage. The proposed process by authors saved the asset cost of degumming tank, processing cost and energy cost of agitation, storage, and addition of phosphoric acid. Save the occupied space of degumming tank. The conventional degumming requires min 10–12 hours, whereas in the proposed process by authors the degumming is completed with bleaching only, so does not ask for separate time. Overall, eliminating separate degumming step will help to maintain quality, enhance yield, save time and reduce cost of production.

CONCLUSION

The ABA-degumming aid for the removal of phosphorous from the crude palm oil was prepared successfully. This product is economically suitable for refining of crude palm oil. The ABA-degumming aid suppressed separate degumming step while degumming and bleaching was done simultaneously in a single step. The response of ABA-degumming aid was not much prominent in RBO oil, it was only useful for the palm oil. The bleachability of bleached palm oil and deodorized palm oil was around 45% and 95% respectively, which is also an advantage with the proposed degumming aid. On the basis of conducted experiments and analysis, ABA-degumming aid is a good quality product which is useful and economic for the palm oil refining industries.

ACKNOWLEDGEMENT

This work was funded and supported by the Ashapura Group of Industries, R&D division. We are grateful to our Chairman Shri. Chetan N. Shah and Director Shri Manan C. Shah for their unconditional support. The authors are also grateful to Analytical Department for the testing and characterization of the product.

REFERENCES

Boki K, Kubo M, Wada T, Tamura T. 1992. Bleaching of alkali-refined vegetable-oils with clay-minerals. J Am Oil Chem Soc. 69:232–236.

Chew SC, Ali MA. 2021. Recent advances in ultrasound technology applications. of vegetable oil refining. Trends Food Sci. Technol. 116:468–479.

Dijkstra AJ. 2010. Enzymatic degumming. Eur J Lipid Sci and Technol. 112:1178–1189.

Egbuna SO, Aneke NA, Chime GTO. 2007. Evaluation of the effects of degumming on the quality and stability of physically refined palm oil. J Appl Eng Sci. 3:102–107.

Guangyan T, Wenbo W, Yongfeng Z, Li Z, Yuru K, Aiqin W. 2018. Carbon/attapulgite composites as recycled palm oil-decoloring and dye adsorbents. J Mater. 11:1–16.

Gharby S. 2022. Refining Vegetable oils: chemical and physical refining. Sci World J. 1(2): 275–281. DOI: 10.1155/2022/6627013.

Hale B, Gokce U, Müşerref O, Yüksel S. 2021. Optimization of bleaching power by sulfuric acid activation of bentonite. Clay Miner. 56: 148–155.

Hamidi HNA, Khalid O, Zainuddin MRKV. 2022. Technical efficiency and export potential of the world palm oil market. Agriculture. 12:1918-1927.

Ifa L, Wiyani L, Nurdjannah N, Ghalib AMT, Ramadhaniar S, Kusuma HS. 2021. Analysis of bentonite performance on the quality of refined crude palm oil's color, free fatty acid and carotene: the effect of bentonite concentration and contact time. Heliyon. 7:230–240.

Irvan, Trisakti B, Sidabutar R, Situmeang CW, Siregar FMR. 2020. Comparison of mass balance and oil quality in plant refinery I and IV. Mater Sci Eng. 801: 20–33.

Krinsky NI, Yeum KJ. 2003. Carotenoideradical interactions. Biochem Biophys Res Commun. 305:754–760.

Lin S W, Yoo CK. 2007. Optimization of degumming with attapulgite and acid activated clays in refining palm oil. J Oil Palm Res. 19:373–380.

Manjula S. 2007. Membrane technology in degumming, dewaxing, deacidifying, and decolorizing edible oils. Crit Rev Food Sci Nutrition. 46:569– 592.

Majid NA, Zaimah R, Sarmila MS, and Abd HA. 2021. Sustainable palm oil certification scheme frameworks and impacts: a systematic literature review. Sustainability. 13:32–44.

Nur SAW, Harrison LNL, Nabilah KM, Azreena IN. 2020. Production of refined red palm-pressed fibre oil from physical refining pilot plant. CSCEE. 2:100035.

Ohlson R, Svensson C. 1976. Comparison of oxalic acid and phosphoric acid as degumming agents for vegetable oils. J Am Oil Chem Soc. 53:1–10.

Pramono HLSR, Christiawan R. 2022. The need for global green marketing for the palm oil industry in Indonesia. Sustainability. 14:8621.

Roy AC. 1978. Refining and degumming systems for edible fats and oils. J Am Oil Chem Soc. 55:765–771.

Sarier N, Guler C. 1988. Beta-carotene adsorption on acid-activated mont-morillonite. J Am Oil Chem Soc. 65:776–779.

Silva SM, Sampaio KA, Ceriani R, Verhe R, Stevens C, Greyt WD, Antonio JAM. 2014. Effect of type of bleaching earth on the final color of refined palm oil. J Food Sci Technol. 59:1258–1264.

Serrano-Bermúdez LM, Monroy-Pena CA, Morenoc DA A, Anderson DI, Nino CAMR, Gustavo BH, Paulo CNR. 2021. Kinetic models for degumming and bleaching of phospholipids from crude palm oil using citric acid and Super Flo B80® and Tonsil. Food Bioprod Process. 129:75–83.

Sengar G, Kaushal P, Sharma HK, Kaur M. 2024. Degumming of rice bran oil. Rev Chem Eng. 30:183–198.

Tripathi P, Gupta E, Purwar S, Pandey TA. 2022. Processing induced trans fatty acid quantification analysis of selected edible oils and their probable outcome. Curr Sci. 123:1455–1461.

Zschau W, Grp GSFSS. 2001. Bleaching of edible fats and oils cooperative work of the German Society for Fat Science (DGF). Eur J Lipid Sci and Technol. 103:505–550.

INTERNATIONAL JOURNAL of OIL PALM

Volume 6, Number 2, 2023
Page 25–34
DOI: 10.35876/ijop.v6i2.111

ISSN: 2599-3496 print
ISSN: 2614-2376 online

Identification of *Curvularia eragrostidis* (Henn.) J.A.Mey. The Leaf Spot Pathogen of Oil Palm (*Elaeis guineensis* Jacq.) and Its Control by False Elder (*Peronema canescens* Jack) Leaf Extract

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ABSTRACT

Oil palm is the main vegetable oil-producing crop in Indonesia. Leaf spot disease is one of the major diseases that attacks oil palm seedlings at all seedling stages. In Indonesia, leaf spot disease in oil palm nurseries is most commonly caused by the genus *Curvularia* with an infection intensity of up to 60–70%. The control of leaf spot disease usually uses chemical fungicides but its continuous use can cause the development of resistant pathogen fungi and have a long-term negative impact on the environment. False elder (*Peronema canescens* Jack*)* leaves have bioactivity as an antimicrobial control disease caused by fungal infections. In this study, *Curvularia* was isolated from oil palm seedlings infected with leaf spot disease from oil palm nurseries in South Sumatra. Effectiveness testing of *P. canescens* leaves conducted by a Completely Randomized Design method with five treatments and three replications. The fungi that caused leaf spot disease in oil palm were identified as *Curvularia eragrostidis*. *P. canescens* leaf water extract at 25% concentration was very ineffective to quite effective in controlling disease severity based on the average number of spots and diameter of spots in oil palm with the values 36.25–59.50% and 12.50–27.78%. *P. canescens* leaf water extract could reduce the average number of spots and diameter of spots started on day 30 after being sprayed three times with *P. canescens* leaf water extract so that it could be used as an alternative to control *C. eragrostidis* leaf spot disease in oil palm that is more friendly to the environment.

Keywords: *Curvularia eragrostidis,* disease, false elder, leaf spot, oil palm

INTRODUCTION

Oil palm is a leading crop producing the main vegetable oil in Indonesia and becoming the largest source of foreign exchange for the export of the agricultural sector. Total Indonesian crude palm oil exports in 2019 up to 36.17 million tons. Oil palm becomes a raw material for a variety of food products, oleochemicals, pharmaceuticals and health products, household products, and industrial products even about 16% of the world's oil palm is used as biodiesel (Goh *et al.* 2017). Therefore,

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keeping the quality and productivity of oil palm crops to grow to the maximum and profitable becomes important to pay attention. One problem that needs to be solved is overcoming infectious diseases that can decrease the quality of oil palm crops.

Leaf spot disease is one of the major diseases in oil palm cultivation. This disease infects oil palm seedlings at all seedling stages, both pre-nursery and main nursery (Priwiratama and Widiyatmoko 2022). The genus *Curvularia* is the genus most often found as the cause of leaf spot disease in oil palm nurseries in Indonesia (Priwiratama 2017). Leaf spots caused by *Curvularia* in oil palm nurseries have the highest severity of disease (Pornsuriya *et al.* 2013). If not properly controlled, the damage caused by *Curvularia* leaf spot on oil palm seedlings can reach 60–70%. Several pathogenic fungi that have been reported to cause oil palm leaf spots are *Curvularia lunata, C. eragrostidis, C. oryzae,* and *Cochliobolus carbonum* (Corley dan Tinker 2015; Susanto & Prasetyo 2013). Although *Curvularia* has been known to be a pathogen that causes leaf spot disease, but the species of *Curvularia* that infects oil palm leaves has not been clearly identified.

Today, chemical fungicides are still often used as the primary option in disease control, but continuous use of chemical fungicides can cause the development of resistant pathogen fungi and have a long-term negative impact on the environment such as contamination of cultivated land due to chemical residues (Zubrod *et al*. 2019). One way of controlling diseases that are friendly to the environment and can effectively control diseases is to use a natural fungicide derived from a plant, one of which is *P. canescens* leaf water extract. Secondary metabolite content in *P. canescens* leaf water extract could be one of the better alternatives because it is known to have minimal impacts on the environmental and humans compared to chemical fungicides. *P. canescens* leaves contain secondary metabolite compounds such as alkaloids, flavonoids, saponins, tannins, steroids, and terpenoids (Emilia *et al.* 2023). In previous research conducted by Zarafi and Moumoudou (2010), the application of *Azadirachta indica* leaf extract which contained the same secondary metabolites as *P. canescens* leaves at 20% concentration could control *C. eragrostidis* infection by reducing the severity of the disease from initial 0.78% to 0.21%. The antifungal activity of *P. canescens* leaf water extract against *Curvularia* has never been studied and data related to *P. canescens* leaves an antifungal was still limited, so this research was important to carry out.

The aimed of this study was to identify the species of *Curvularia* that caused leaf spot disease in oil palms, and to analyze the effect of *P. canescens* leaf water extract on *Curvularia* infection in oil palms.

MATERIALS AND METHODS

Isolation of *Curvularia*

Samples of pathogenic fungi were taken from leaves of Costa Rica and D x P Bah Lias varieties oil palm seedlings infected with leaf spot disease in the oil palm nursery in Marga Baru Village, Muara Lakitan, Musi Rawas, South Sumatra, Indonesia. Isolation procedures adapted from Agustina *et al*. (2019). The infected leaves were cut in sizes of 0.5 x 0.5 cm^2. The cut leaf sections were disinfected with a chlorine solution (0.5%) for 2 minutes, then rinsed with sterile distilled water for 5 minutes 3 times, and then dried on sterile tissue paper. The leaf sections were then placed in PDA media in a petri dish and incubated for 7 days at room temperature. Colonies of *Curvularia* are characterized by brown, gray, or black of subcultures to identify the species (Sivanesan 1987).

Identification of *Curvularia*

Identification of morphological characteristics (Sivanesan 1987) was obtained by making semi-permanent slides. The slides were prepared with the surface of an object glass dripped glycerol, then placed a pure culture of fungal mycelial using an ose needle, then applied trypan blue or taken fungal mycelial used tape and then placed on the surface of the object glass. The slides were covered with a cover glass and observed under a microscope with 400x magnification.

Preparation of *Peronema canescens* Leaf Water Extract

Preparation of *the* extract was made using the maceration method (Sari and Listiani 2022). *Peronema canescens* leaves were selected from mature leaves, and third to fifth leaves from shoots that showed no symptoms of disease. Two kg of *P. canescens* leaves were washed and then dried at 50 °C in the oven for 24 hours, then mashed with a blender. The leaf powder was then filtered using a 60-mesh filter. *P. canescens* leaf water extract with a concentration of 25% was made by weighing 25 g of leaf powder and then extracting it by macerating it with 100 mL of sterile distilled water. Maceration was conducted for 3 days. The macerated *P. canescens* leaves were then filtered to obtain the filtrate.

Effectiveness of *Peronema canescens* Leaf Water Extract against Leaf Spot Disease in Oil Palm

The effectiveness of *P. canescens* leaf water extract was adapted from Agustina *et al.* (2019) and Qaisar *et al*. (2023). The experiment was conducted by Completely Randomized Design method, with 5 treatments and 3 replications of each treatment. The treatments were negative control (Control), positive control 1 (infected with *C. eragrostidis* 1 with application of sterile distilled water) (C1S0), positive control 2 (infected with *C. eragrostidis* 2 with application of sterile distilled water) (C2S0), infection of *C. eragrostidis* 1 with application of *P. canescens* leaf water extract 25% concentration (C1S25), and infection of *C. eragrostidis* 2 with application of *P. canescens* leaf water extract 25% concentration (C2S25). The oil palm seedlings used five-month-old varieties of D x P Bah Lias.

Inoculation of *C. eragrostidis* was done by 1 x 1 cm^2 mycelial plug attached to the sterile abaxial side of oil palm leaves which had previously been wounded. The inoculation point was wrapped with sterile gauze then covered with plastic wrap and then covered with a transparent plastic bag for 48 hours. After 48 hours, the plastic bag and gauze were removed, and then the oil palm seedlings were kept in the greenhouse and observed every day for 7 days until symptoms of leaf spot appeared. Spraying was done after 14 days symptoms appeared and repeated every 7 days for 7 weeks in the afternoon. Observations were done every day by measuring the number of spots and the diameter of the spots on the leaves of oil palm seedlings in each treatment.

Data Analysis

Disease severity was calculated by assessing the percentage of the disease severity index. The disease severity index was measured using a modified score table from Kittimorakul *et al*. (2019), as seen in Table 1.

Table 1 Disease severity score

Score	Disease Severity
0	No disease symptoms
1	Some pinpoint brown spots on the leaf without any rotten tissues
2	Spot Diameter of 1 – <3 mm
3	Spot Diameter of 3 – <4 mm
4	Spot Diameter of 4 – <5 mm
5	Spot Diameter of ≥ 5 mm

After assessing the disease severity score, the disease severity index (DSI) was calculated (Izzati and Abdullah 2008):

$$\text{DSI (\%)} = \frac{\Sigma(Ax0)+(Bx1)+(Cx2)\ldots\ldots (Fx5)}{\Sigma A+B+C\ldots\ldots F \times 5} \times 100\%$$

where A, B, C and F are the number of plants to be multiplied by the 0–5 score.

The effectiveness of *P. canescens* was calculated using a formula modified from Stevic *et al*. (2017):

$$\text{Effectiveness (\%)} = \frac{X-Y}{X} \times 100\%$$

where X was the average number or diameter of leaf spots in controls and Y was the average number or diameter of leaf spots in the treatment. Category of effectiveness of *P. canescens*:

Ineffective	= 0
Very Ineffective	= 0 – 20%
Less Effective	= 20 – 40%
Quite Effective	= 40 – 60%
Effective	= 60 – 80%
Very Effective	= >80%

Statistical analysis was carried out using an analysis of variance (ANOVA) at the 5% level and Duncans Multiple Range Test (DMRT) at the 5% level.

RESULTS AND DISCUSSION

Isolation and Identification of Leaf Spot Disease in Oil Palm

Isolation of leaf spots on D x P Bah Lias variety of oil palm seedling resulted in isolate C1 (Figure 1) and leaf spots on the Costa Rica variety of oil palm seedling resulted in isolate C2 (Figure 2). Symptoms of leaf spot disease caused by C1 which come from oil palm seedling leaves of the D x P Bah Lias variety and C2 which come from Costa Rica variety were round spots that were initially light brown and then changed to dark brown with the edges surrounded by a yellowish halo (Figure 1a and Figure 2a). This was aligned with Priwiratama *et al*. (2017) who stated that the symptoms of oil palm seedling leaves infected with *Curvularia* leaf spot disease begun with the appearance of brownish spots which over time become dark brown necrotic spots with yellowish edges. Generally, the center of the spot was dark. The spots could combine to cause the leaves to dry out when the severity of the disease is very high. Pandey *et al*. (2014) also stated that the symptoms of oil palm seedling leaves infected with *C. eragrostidis* leaf spot disease begun with the appearance of small dark spots, then over time these spots enlarge and developed into irregular black necrotic spots that form extended along the edge of the leaf or several spots form on the leaf, and could unite to form a large spot surrounded by a yellow halo. The spots could merge to cause the leaves to become dry when the severity of the disease was very high.

The results of isolation from leaf spot resulted in colonies of grayish black or black and the texture of the colonies was hairy or cottony. According to Sivanesan (1987), the colony of *Curvularia* when grown on PDA media has colonies of brown, gray, or black, and texture of the colonies was hairy, cottony, or velvety (Figure 1b–c and Figure 2b–c). The two isolates had similar morphological characteristics except for the shape and size of the conidia and the rate of colony growth (Figure 1g–h and 2g–h). When compared with the literature, the two isolates have morphological characteristics that were similar to *C. eragrostidis* but were not similar to *C. lunata, C. oryzae,* and *C. carbonum* (Table 2). According to Sivanesan (1987), *C. eragrostidis* has hyphae septate, branched, subhyaline to brown. Conidiophores septate, branched, simple, straight or curved, brown to light brown. Conidia ellipsoidal or barrel-shaped, 3-distoseptate, end cells paler, central cells brown to dark brown. Turner (1971) reported that *C. eragrostidis* was the causal agent of leaf spot disease in oil palm nurseries in Sumatra.

Effectiveness of *Peronema canescens* Leaf Water Extract in Reducing Leaf Spot Disease in Oil Palm

Based on Table 3, inoculation of *C. eragrostidis* 2 significantly showed higher disease severity than *C. eragrostidis* 1. After application of a 25% concentration of *P. canescens* leaf water extract, it could reduce the severity of disease caused by *C. eragrostidis* 1 and *C. eragrostidis* 2. On day 10, the severity of the disease was not reduced significantly and on days 30 and 50, the severity of the disease started to reduce but not significantly. The effectiveness of *P. canescens* leaf water extract against *C. eragrostidis* 1 and 2 on disease

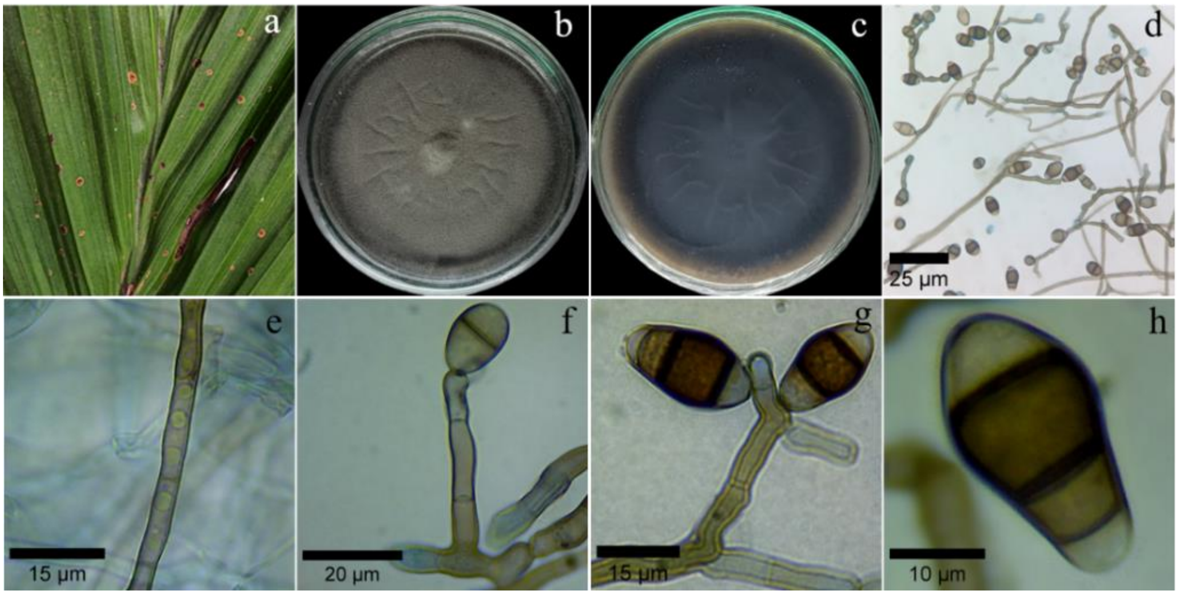

Figure 1 Symptoms and cultural characteristics of *Curvularia* isolate C1: a. Symptoms of leaf spot disease on D x P Bah Lias variety, b-c. Colonies isolate 1 on PDA after day 26, d. Hyphae and conidia e. Septate hyphae, f. Young conidia, g-h. Conidia.

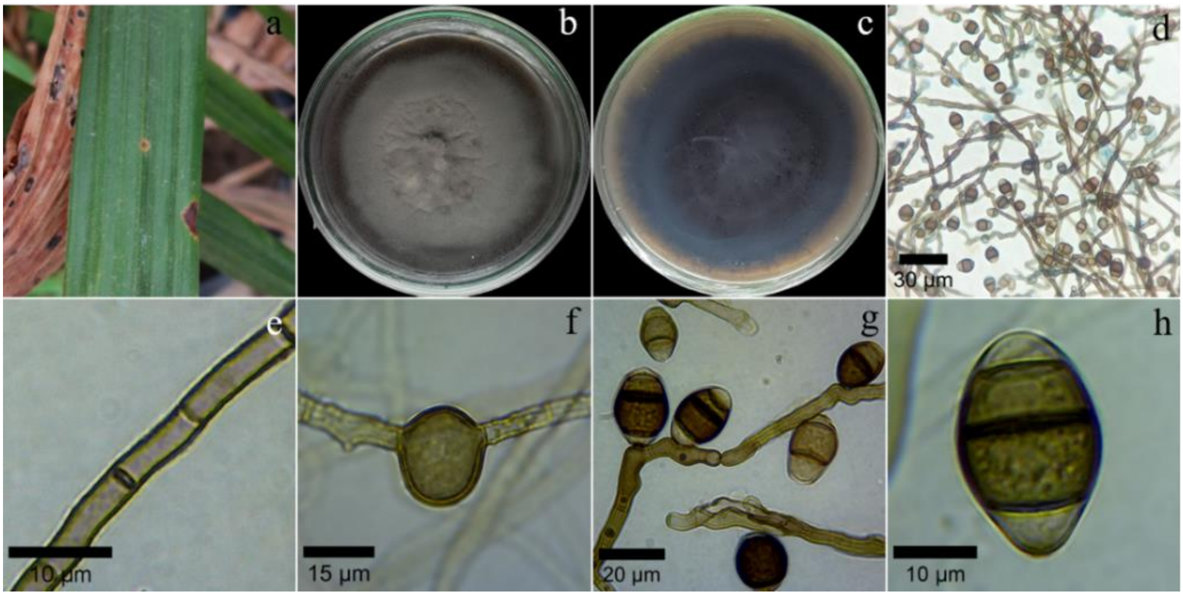

Figure 2 Symptoms and cultural characteristics of *Curvularia* isolate C2: a. Symptoms of leaf spot disease on Costa Rica variety, b-c. Colonies isolate 2 on PDA after day 26, d. Hyphae and conidia, e. Septate hyphae, f. Chlamydospores, g-h. Conidia.

Table 2 Morphological characteristics of *Curvularia* isolate C1 and C2 in comparison to *Curvularia* species references

No	Character	Isolate C1	Isolate C2	Reference *Curvularia lunata*: (Sivanesan 1987*; Salleh *et al.* 1996**)	Reference *Curvularia eragrostidis* (Sivanesan 1987*; Subramanian, 1953**; Salleh *et al.* 1996***)	Reference *Curvularia oryzae* (Sivanesan 1987*; Marin-Felix *et al.* 2020**)	Reference *Cochliobolus carbonum* (Sivanesan, 1987*, Elshafey *et al.* 2018**)
1	Septation of Hyphae	Septate	Septate	Septate*	Septate*	Septate*	Septate*
2	Branch of Hyphae	Branched	Branched	Branched*	Branched*	Branched*	Branched*
3	Pigmentation	Brownish	Brownish	Subhyaline-Brown*	Subhyaline-Brown*	Hyaline-Pale brown*	Hyaline-Brown*
4	Branch of Conidiophores	Branched	Branched	Simple/Branched*	Branched*	Simple/Branched*	Branched*
5	Shape of Conidiophores	Straight, Curved, Wavy	Straight, Curved, Wavy	Straight/Flexuous*	Simple, Erect, Straight**/Curved*	Straight/Flexuous*	Straight /Flexuous*
6	Septation of Conidiophores	Septate	Septate	Septate*	Septate*	Septate*	Septate*
7	Color of Conidiophore	Brown	Brown	Pale brown-Brown*	Brown-Light brown*	Brown/Dark brown*	Dark brown*
8	Shape of Conidia	Ellipsoidal/Barrel-shaped, Obclavate	Ellipsoidal/Barrel-shaped	Straight-Curved, Ellipsoidal, Obovoid/Clavate*	Ellipsoidal (Oval)/Barrel-shaped*	Straight, Ovoid, Obclavate/Elliptical *	Curved/Straigh, Cylindrical but broader in the middle & tapering toward the rounded end*
9	Size of Conidia	19–36 x 10–16 µm	18–25 x 8–18 µm	18–32 x 9,0–15 µm*	18–37 x 11–20 µm*, 17–26 x 11–16 µm**	24–40 x 12–22 µm*, 20–37,5 x 11–21,5 µm**	30–100 x 12–18 µm*
10	Septation of Conidia	Septate	Septate	Septate*	Septate*	Septate*	Septate*
11	Number of Septa Conidia	3 Septate	3 Septate	3/4-distoseptate*	3-distoseptate*	3-distoseptate*	7-8-distoseptate*
12	Color of Conidia	Brown (end cells paler, central cells brown)	Brown (end cells paler, central cells light-dark brown)	End cells pale brown, central cells brown/dark brown*	End cells paler, central cells brown-dark brown*	End cells paler, central cells brown/dark brown*	Dark brown*
13	Growth Rate	0.25–0.55 cm after day 4 or 0.1–0.45 cm after day 8	0.4–0.45 cm after day 4 or 0.4–0.5 cm after day 8	6.0–7.6 cm after day 4**	5.7–6.4 cm after day 4***	-	5.4 cm after day 8 **

severity based on the average number of spots has a value of 36.25–59.50%, whereas if based on the average diameter of the spots was 12.50–27.78% (Tables 4 and 5). According to Sugama and Rochjadi (1989) in Elfina *et al.* 2015), the percentage of effectiveness included the category of very ineffective to quite effective. The ineffective application of *P. canescens* leaf water extract in reducing leaf spot disease in oil palm seedlings because the application time was not appropriate namely after the spots appeared due to infection by *C. eragrostidis* 1 and *C. eragrostidis* 2. This was supported by research conducted by Zarafi and Moumoudou (2010) who reported that the application of cold water *Azadirachta indica* leaf extract 2 days before inoculation and 2 days after inoculation resulted in a significant reduction in the incidence and severity of spot disease caused by *C. eragrostidis* compared to the application at the time of appearance symptom.

Table 3 Average disease severity score and average disease severity index from *in vivo* test

Treatment	Average Disease Severity Score (Day)				Average Disease Severity Index (Day)			
	0	10	30	50	0	10	30	50
Control	0^{a}	0^{a}	0^{a}	0^{a}	0^{a}	0^{a}	0^{a}	0^{a}
C1S0	0^{a}	2^{b}	2.3^{b}	2.3^{b}	0^{a}	40^{b}	46.7^{b}	46.7^{b}
C1S25	0^{a}	2^{b}	2^{b}	2^{b}	0^{a}	40^{b}	40^{b}	40^{b}
C2S0	0^{a}	2.3^{b}	3^{bc}	3.7^{c}	0^{a}	46.7^{b}	60^{bc}	73.3^{c}
C2S25	0^{a}	2^{b}	2.7^{bc}	2.7^{bc}	0^{a}	40^{b}	53.3^{bc}	53.3^{bc}

Value in the average disease severity score and average disease severity index that are not significantly different ($p < 0.05$) have the same superscript letters ($N = 3$).
0 = No disease symptoms; 1 = Some pin-point brown spots on the leaf without any rotten tissues; 2 = Spot Diameter of 1 – <3 mm; 3 = Spot Diameter of 3 – <4 mm; 4 = Spot Diameter of 4 – <5 mm; 5 = Spot Diameter of ≥ 5 mm (Modified from Kittimorakul *et al.* 2019).

Based on Table 4, the application of *P. canescens* leaf water extract could reduce the average number of spots but not significantly. On day 10, the number of spots still increased and began to reduce but not significantly on day 30 after sprayed 3 times with *P. canescens* leaf water extract. On day 50, the inoculation treatment with *C. eragrostidis* 1 had the same average number of spots as on day 30 whereas in the inoculation treatment with *C. eragrostidis* 2, the average number of spots reduced but not significantly. Inoculation with *C. eragrostidis* 1 had a higher average number of spots than *C. eragrostidis* 2. Spot infection on positive control oil palm seedlings and those applied with *P. canescens* leaf water extract was spread in the area around the inoculation *C. eragrostidis*. This type of spot infection was a local type of infection. The local type of infection was an infection that caused physiological or structural changed within a limited period of time in the host tissue around the site of infection (Sharma 2023).

Based on Table 5, application of *P. canescens* leaf water extract could reduce the average diameter of spots but not significantly. On day 10, the diameter of the spots still increased in size and began to reduce but not significantly on day 30 after sprayed 3 times with *P. canescens* leaf water extract and the value remained the same on day 50. Inoculation with *C. eragrostidis* 1 had a smaller average diameter of spots than *C. eragrostidis* 2. There was an average reduction in the number and diameter of spots oil palm seedling leaves given the *P. canescens* leaf water extract indicating the presence of antifungal activity in *P. canescens* leaf water extract. That activity was caused by antifungal compounds contained in *P. canescens* leaf water extract. *P. canescens* leaves contain secondary metabolite compounds such as alkaloids, flavonoids, saponins, tannins, steroids, and terpenoids (Emilia *et al.* 2023). According to Utami *et al*. (2022), plants that contain secondary metabolite compounds such as steroids, alkaloids, saponins, tannins, phenolics, flavonoids, and triterpenoids could function as antifungals, namely substances that could inhibit and kill fungal growth so they could be used to control leaf spot disease caused by *C. eragrostidis.*

Table 4 Average number of leaf spots on oil palm seedlings after application of *P. canescens* leaf water extract concentration of 25%

Treatment	Average Number of Leaf Spots			Effectiveness on Day 50 (%)	Category
	10	30	50		
Control	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	-	-
C1S0	17.33 ± 2.30^{def}	24.00 ± 8.67^{ef}	26.67 ± 10.79^{f}	-	-
C1S25	15.33 ± 8.14^{cde}	17.00 ± 7.81^{cdef}	17.00 ± 7.81^{cdef}	36.25	Less Effective
C2S0	12.00 ± 5.29^{bcd}	13.00 ± 7.00^{bcde}	14.00 ± 7.54^{bcde}	-	-
C2S25	3.00 ± 2.00^{ab}	6.00 ± 2.64^{abcd}	5.67 ± 2.30^{abc}	59.50	Quite Effective

Value in each column and row that are not significantly different (p<0.05) have the same superscript letters (N = 3).

Table 5 Average diameter of leaf spots on oil palm seedlings after application of *P. canescens* leaf water extract concentration of 25%

Treatment	Average Diameter of Leaf Spots			Effectiveness on Day 50 (%)	Category
	10	30	50		
Control	0.00 ± 000^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	-	-
C1S0	1.33 ± 0.58^{ab}	2.40 ± 1.01^{bc}	2.40 ± 1.01^{bc}	-	-
C1S25	1.00 ± 0.00^{ab}	2.07 ± 0.92^{bc}	2.07 ± 0.92^{bc}	12.50	Very Ineffective
C2S0	1.83 ± 1.04^{abc}	3.30 ± 1.63^{c}	3.57 ± 1.70^{c}	-	-
C2S25	1.00 ± 0.00^{ab}	2.63 ± 1.50^{bc}	2.63 ± 1.50^{bc}	27.78	Less Effective

Value in each column and row that are not significantly different (p<0.05) have the same superscript letters (N = 3).

CONCLUSION

The fungi that caused leaf spot disease in oil palm were identified as *Curvularia eragrostidis*. False elder (*Peronema canescens* Jack) leaf water extract at 25% concentration was very ineffective to quite effective in controlling disease severity based on the average number of spots and diameter of spots in oil palm with the value of 36.25–59.50% and 12.50–27.78%. *P. canescens* leaf water extract could reduce the average number of spots and diameter of spots started on day 30 after sprayed 3 times with *P. canescens* leaf water extract.

ACKNOWLEDGEMENTS

The authors thank the staffs of the Laboratory of Plant Systematics and Sawitsari Research Station, Faculty of Biology Universitas Gadjah Mada for providing the facilities and helping with the experiments. This article is part of AVF under the supervision of RSK.

REFERENCES

Agustina D, Prihatna C, Suwanto A. 2019. Rapid inoculation technique and biological control of leaf spot disease in oil palm. Int. J of Oil Palm. 2(1):1–11. DOI: 10.35876/ijop.v2i1.24.

Corley R and Tinker P. 2015. *The Oil Palm, 5th Edition.* New York (US): Wiley-Blackwell.

Direktorat Jenderal Perkebunan. 2020. Statistik Perkebunan Unggulan Nasional 2019–2021. Jakarta (ID): Sekretariat Direktorat Jenderal Perkebunan.

Elfina YE, Muhammad Ali, Lilis Aryanti. 2015. Uji beberapa konsentrasi ekstrak tepung daun sirih hutan (*Piper aduncum* L.) untuk mengendalikan penyakit antraknosa pada buah cabai merah pasca panen. J Sagu. 14(2):18–27.

El-Shafey RA, Attia KA, Mostafa FA and Elamawi RM. 2018. Incidence and molecular identification of *Cochliobolus carbonum* as causal organism of rice seedling blight. J Basic Appl Sci. 7(4):652–662.

Emilia I, Setiawan AA, Novianti D, Mutiara D, Rangga R. 2023. Skrining fitokimia ekstrak daun sungkai (*Peronema canescens* Jack.) secara infundasi dan maserasi. Indobiosains. 5(2):95–102.

Goh KJ, Wong CK, Ng PHC. 2017. Oil Palm. In: Brian Thomas, Brian G. Murray, dan Denis J. Murphy, editors. Encyclopedia of Applied Plant Sciences. MA: Academic Press. p. 382–390.

Izzati MZNA, Abdullah F. 2008. Disease suppression in ganoderma-infected oil palm seedlings treated with *Trichoderma harzianum*. Plant Protect Sci. 44(3):101–107.

Kittimorakul J, Sunpapao A, Duangpan S, Anothai J, Eksomtramage T. 2019. Screening of oil palm (*Elaeis guineensis* Jacq.) varieties for resistance to *Curvularia* leaf spot disease. Aust J Crop Sci. 13(4):507–512.

Marin-Felix Y, Hernandez-Restrepo M, and Crous PW. 2020. Multi-locus phylogeny of the genus *Curvularia* and description of ten new species. Mycol Prog. 19:559–588. DOI: 10.1007/s11557-020-01576-6.

Pandey S, Kumar R, Rishi R, Giri K, Mishra G. 2014. First report of *Curvularia malucans* causing severe leaf necrosis of *Curculigo orchoides* in India. J Biol Earth Sci. 4(2):176–178.

Pornsuriya C, Sunpapao A, Srihanant N, Worapattamasri K, Kittimorakul J, Phithakkit S, Petcharat V. 2013. A survey of diseases and disorders in oil palms of Southern Thailand. Plant Pathol J. 12(4):169–175.

Priwiratama H. 2017. Gejala, faktor pencetus dan penanganan bercak daun *Culvularia* dan antraknosa di pembibitan kelapa sawit. Warta PPKS. 23(1):25–34.

Priwiratama H, Widiyatmoko B. 2022. Potensi teknologi iradiasi energi foton untuk pengendalian penyakit bercak daun *Curvularia* sp. pada tanaman kelapa sawit. Warta PPKS. 27(3):134–145.

Qaisar MH, Rajput NA, Atiq M, Rehman A, Kachelo GA, Ahmed H, Zafar H, Shaheen HMU, Rani HK. 2023. Inhibitory effect of polygram df and *Capsicum annum* on leaf spot of rose caused by *Curvularia lunata in vitro* and in planta. Plant Sci Today. 10(3):188–196.

Salleh BSB, Safinat A, Julia L, Teo CH. 1996. Brown spot caused by *Curvularia* spp., a new disease of asparagus. Biotropia. 9:26–37.

Sari DRAP, Listiani PAR. 2022. Perbandingan kadar flavonoid total ekstrak etanol daun ungu (*Graptophyllum pictum* l. Griff) berdasarkan perbedaan metode pengeringan. Media Farm. 18(1):91–96. DOI: 10.32382/mf.v18i1.2525.

Sivanesan A. 1987. *Graminicolous Species of Bipolaris, Curvularia, Drechslera, Exserohilum and Their Teleomorphs*. United Kingdom: C.A.B. International.

Subramanian. 1953. Fungi imperfecti from Madras: *Curvularia.* Indian Acad Sci. 38(1):27–39.

Susanto A, Prasetyo AE. 2013. Respons *Curvularia lunata* penyebab penyakit bercak daun kelapa sawit terhadap berbagai fungisida. JFI. 9(6):165–165. DOI: 10.14692/jfi.9.6.165.

Sharma MK. 2023. *Diversity of Microbes and Cryptogams (Thallophyta) Vol.1*. Chhattisgarh (IN): Insta Publishing.

Stević M, Pavlović B, Tanović B. 2017. Efficacy of Fungicides with different modes of action in raspberry spur blight (*Didymella applanata*) control. Pestic Fitomed. 32(1):25–32.

Turner PD. 1971. Recent survey of oil palm diseases in Indonesia. FAO Plant Prot Bull.19:49–56.

Utami N, Auliah A, Dini I. 2022. Studi kandungan senyawa metabolit sekunder beberapa ekstrak anging (*Usnea* sp.) dan uji bioaktivitasnya terhadap (*Candida albicans*). Chemica. 23(1):90–98.

Zarafi AB, Moumoudou U. 2010. *In vitro* and *in vivo* control of pearl millet midrib spot using plant extracts. J Appl Biosci. 35:2287–2293.

Zubrod JP, Bundschuh M, Arts G, Brühl CA, Imfeld G, Knäbel A, Payraudeau S, Rasmussen JJ, Rohr J, Scharmüller A, Smalling K. 2019. Fungicides: an overlooked pesticide class?. Environ Sci Technol. 53(7):3347–3365. DOI: 10.1021/acs.est.8b04392.

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Otegui MS. 2007.Endosperm: development and molecular biology. In: Olson OA, editor. Endosperm cell walls: formation, composition, and functions. Heidelberg (DE): Springer. p. 159-178.

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