Palm oil Agribusiness Strategic Policy Institute

BPDP

Journal Analysis of Palm Oil Strategic Issues

English Edition
Volume V, No. 03
July 16, 2025

ADVANTAGES AND INNOVATIONS IN THE UTILIZATION OF OIL PALM BIOMASS: TURNING "WASTE" INTO "GOLD"

By
PASPI Monitor

RESUME

The five advantages of oil palm biomass as raw material for downstream industries are: it is a joint product of palm oil, it is available throughout the year and concentrated in relatively large quantities, it is low cost, it is zero or low carbon, and it does not cause a food–fuel trade-off in its utilization. Technological innovations in processing and downstream products of oil palm biomass are relatively available, among them the Palm Oil Research Grant (*Grant Riset Sawit*/GRS) program managed by BPDP(KS), which facilitates research on innovations in the utilization of oil palm biomass. Downstreaming of oil palm biomass can increase value added by up to 8–9 times and has the potential to become a business with significant economic value while at the same time supporting a circular and sustainable economy.

INTRODUCTION

Indonesia is not only a country that has the largest oil palm plantations in the world, but also the world's largest producer of palm oil and the world's largest producer of oil palm biomass. Oil palm plantations produce biomass in the form of empty fruit bunches (EFB), oil palm fibers and shells, oil palm trunks, and oil palm fronds.

Oil palm plantations can also be regarded as "energy and carbon plantations" that connect the sun, the earth's atmosphere, and humans (PASPI, 2023). Through the photosynthesis process in oil palm plants, energy emitted from the sun and carbon dioxide from the earth's atmosphere are absorbed and stored in the form of palm oil and biomass that can be useful to meet human needs.

Each hectare of oil palm plantation can produce biomass of around 16 tons of dry matter per year (Foo-Yuen Ng, *et al*., 2011). With the area of Indonesia's oil palm plantations in 2025 being around 16.8 million hectares, the biomass production from Indonesia's oil palm plantations can reach 261.7 million tons of dry matter biomass per year. In terms of quantity, oil palm biomass production is about three times larger than the production of palm oil (CPO) as the main product of oil palm plantations.

From this oil palm biomass, various high–value–added products can be produced. Through the application of thermochemical, biological, chemical, physical conversion technologies, and/or their combinations, oil palm biomass can be processed into various high–value–added products such as bioenergy, biomaterials, biochemicals, biofertilizers, biocoal, biopellets, biochar, bioplastics, etc., which are more environmentally friendly (Naik *et al.*, 2010; Thomas *et al.*, 2021; Nabila *et al.*, 2023; Singh *et al.*, 2025).

This paper will discuss the advantages of oil palm biomass from both economic and ecological perspectives, followed by a discussion on various innovations in the utilization of oil palm biomass that have the potential to produce various products for human life.

RELATIVE ADVANTAGES OF OIL PALM BIOMASS

Oil palm plants are endowed with photosynthetic abilities that allow for the harvesting of solar energy and the absorption of carbon dioxide from the earth's atmosphere and then storing it in the form of chemical energy in palm oil and biomass. The amount of oil palm biomass produced depends on various factors, including the age of the oil palm plants.

In general, referring to the study by Foo-Yuen Ng (2011) regarding biomass production from oil palm plantations, it includes biomass from empty fruit bunches about 1.4 tons dry matter/hectare/year, biomass from oil palm fibers and shells about 2.4 tons dry matter/hectare/year, biomass from oil palm fronds/leaves about 9.3 tons dry matter/hectare/year, and biomass from oil palm trunks about 2.9 tons dry matter/hectare/year. Thus, the total production of oil palm biomass is around 16 tons of dry matter/hectare/year. With Indonesia's oil palm plantation area in 2025 covering 16.8 million hectares, it will produce around 261.7 million tons of dry matter biomass per year (Figure 1).

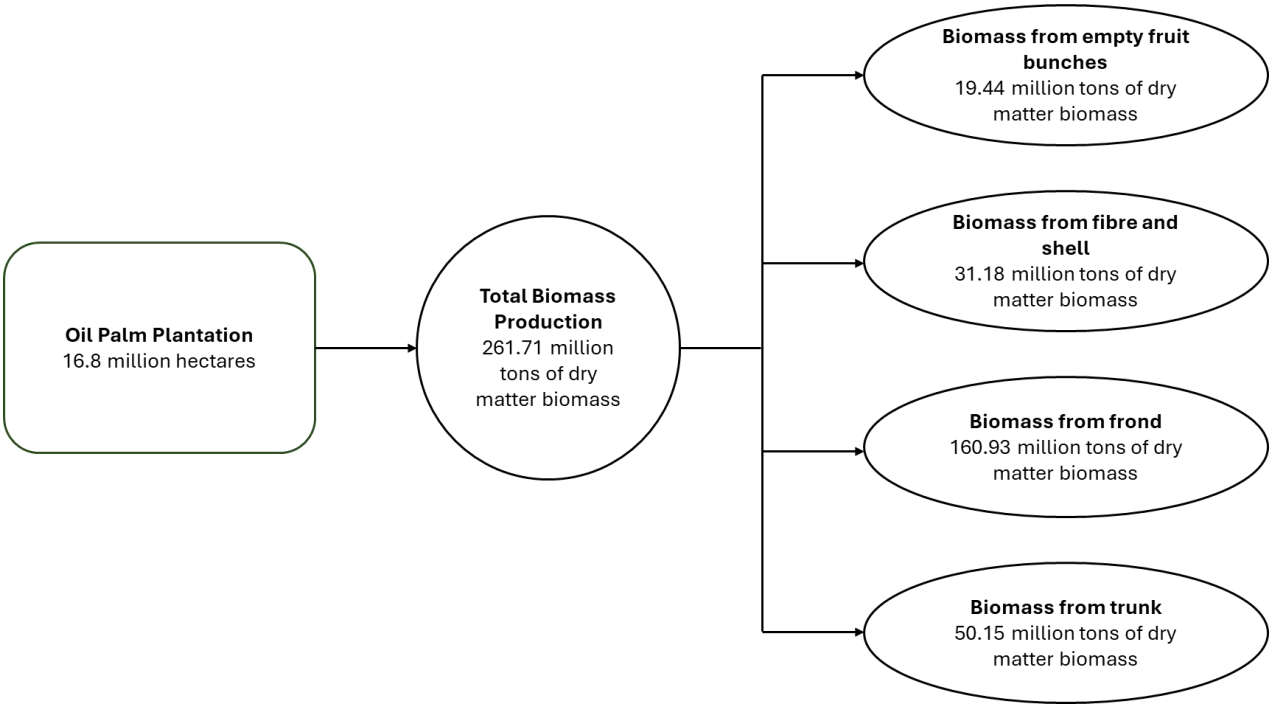

Figure 1. Biomass Production (in Dry Matter) from Indonesia's Oil Palm Plantations

Oil palm biomass has several relative advantages. ***First***, economically, oil palm biomass is produced as a joint product with the main product of oil palm plantations, namely palm oil (CPO/CPKO). In general, when palm oil production increases, biomass production also increases. Even during the Immature Period, when palm oil production is not yet available, biomass is still produced, although in smaller quantities.

Second, oil palm biomass production is available year-round in relatively large and concentrated quantities. The production process of oil palm plantations, which have a long lifespan (25–30 years), ensures that oil palm biomass production is available throughout the year. As long as the sun is still shining, the photosynthesis process in oil palm plants will continue, and biomass production will keep occurring at all times. This is different from other vegetable oil crops that are seasonal, such as soybeans, rapeseed, and sunflowers. In addition, oil palm biomass production is also relatively concentrated CPO Mill, which is generally located in the middle of the plantation, so the cost of collecting biomass is relatively cheaper.

Third, the production cost of biomass is relatively low. As a by-product/joint product of palm oil and oil palm plantations, the production cost of oil palm biomass is relatively low because it becomes

a joint cost or has already been accounted for in the production cost of palm oil. Therefore, the cost calculated as the production cost of oil palm biomass is only the collecting cost.

Fourth, ecologically, oil palm biomass is a carbon sink, where the carbon absorbed through the photosynthesis process is greater than the carbon emissions from the biomass respiration process (PASPI, 2023; PASPI Monitor, 2023[b]; 2024). The carbon balance based on the carbon footprint, for example through Life Cycle Analysis (LCA), considers biomass carbon emissions to be zero because they have already been accounted for in calculating the LCA carbon of palm oil. In other words, net oil palm biomass is a carbon sink/carbon sequestration.

Fifth, the utilization of oil palm biomass into various downstream products such as second-generation bioenergy will not create a food–fuel trade-off (PASPI Monitor, 2021), unlike the use of palm oil as raw material for first-generation bioenergy (PASPI Monitor, 2023[a]; 2025). The European Union, through its Renewable Energy Directives (RED) and the United States, through its Renewable Fuels Standard (RFS), recommend the use of second-generation biofuels such as biomass as the most sustainable energy source in the world (Naik *et al.,* 2010).

INNOVATIONS IN OIL PALM BIOMASS UTILIZATION

Oil palm biomass has long been used in oil palm plantations, though still in simple forms, for example, the use of empty fruit bunches for soil fertility or shells as boiler fuel in CPO Mills and as road hardening material in oil palm plantations. With the development of science and technology, various high–value products have been produced from oil palm biomass (Naik *et al.*, 2010; Thomas *et al.*, 2021; Hau *et al.,* 2022; Hariz *et al.,* 2023; Nabila *et al.*, 2023; Singh *et al.*, 2025), such as bioenergy (bioethanol, biocoal, briquettes, biogas from POME), biofertilizers (organic fertilizer, soil amendments), biomaterials (biocomposites, activated carbon, bioplastics, craft products and wooden furniture, biochar), animal feed, and various biochemical products.

As the world's largest producer of oil palm biomass, Indonesia is also expected to have an ecosystem to support biomass downstreaming domestically. One form of such ecosystem support is through the Palm Oil Research Grant (*Grant Riset Sawit*/GRS) program managed by the Palm Oil Fund Management Agency (*Badan Pengelola Dana Perkebunan*-BPDP or *Badan Pengelola Dana Perkebunan Kelapa Sawit*-BPDPKS, formerly). This GRS program has intensively developed research on technology/innovation of downstream products based on oil palm biomass over the past 10 years (Table 1).

Table 1. Innovations in Downstream Products Based on Oil Palm Biomass Resulting from *Grant Riset Sawit* (GRS) by BPDP(KS)

No.	Type of Biomass	Product Innovation	Researcher
A.	Empty Fruit Bunches (EFB)	1. Glucose (sugar)	Septiningrum *et al.* (2021, 2024)
		2. Mycelium leather (alternative to animal leather) for fashion products	Aditiawati *et al.* (2023, 2024)
		3. Polymer (biocomposite) for ceiling panels	Ahmad *et al.* (2024)
		4. Cellulose–based hydrogel used for wrapping (wet and dry) and absorbent pads	Susi *et al.* (2024)
		5. Wood Plastic Composite (WPC) for construction materials	Nugraha *et al.* (2024)
		6. Paper bag (polybag) for oil palm seedling nurseries	Dina *et al.* (2024)
		7. Carbon black that can be used as tire reinforcement, pigment, UV stabilizer, insulator, ink, coating, hose, and conveyor belt soap.	Kismanto (2023, 2024)

No.	Type of Biomass	Product Innovation	Researcher
		8. Viscose rayon and twisted yarn for fashion products (bags, shoes, and hats)	Nikmatin *et al.* (2022)
		9. Aerogel–based material for oil–absorbing food packaging	Masruchin *et al.* (2022)
		10. Electrode materials (activated carbon, graphene, and carbon nanotube) for supercapacitors applicable to LED lamps and dynamo drives	Prakoso *et al.* (2015, 2019, 2021)
		11. Bioplastics	Isroi *et al.* (2018, 2019)
		12. Bulletproof jackets and automotive products (car and motorcycle bumpers)	Nikmatin *et al.* (2018, 2019)
		13. Green xylitol applied in food, pharmaceutical, and chemical industries.	Setiadi *et al.* (2015, 2019)
		14. Bio–BTX (aromatic compounds benzene, toluene, and xylene)	Rasrendra *et al.* (2016, 2018; 2019)
		15. Furfural	Gozan *et al.* (2018; 2019)
		16. Oyster mushroom growing media, extraction of ligninolytic enzymes, food–grade CMC raw material, and organic fertilizer	Panji *et al.* (2016, 2018; 2019)
		17. Bio-Crude Oil (BCO)	Bindar *et al.* (2015, 2018; 2019)
		18. Cellulose Nano Crystals (CNC) applied as a support for Pt/Rh/Ce catalysts for catalytic converters	Budhi *et al.* (2016)
		19. Nano Crystalline Cellulose (NCC) applicable as reinforcing material, filler, and carrier in various medical and pharmaceutical products, packaging, wood and paper composites, and even food products.	Setyaningsih *et al.* (2016)
		20. Methanol and Dimethyl Ether	Susanto *et al.* (2015)
		21. Bioplastics (food product packaging)	Sitompul *et al.* (2015)
B.	Oil Palm Shells	1. PalmCrete® (concrete)	Astutiningsih *et al.* (2022; 2023)
		2. Electrode materials (activated carbon, graphene, and carbon nanotube) for supercapacitors applicable to LED lamps and dynamo drives	Prakoso *et al.* (2015, 2019, 2021)
		3. Carbon Nanofiber (CNF) usable as electrode material for supercapacitors and air filters	Sriyanti *et al.* (2020)
C.	Oil Palm Fronds	1. Bio-Crude Oil (BCO)	Bindar *et al.* (2015, 2018; 2019)
		2. Bio-Oil	Raksodewanto *et al.* (2015)
		3. Methanol and Dimethyl Ether	Susanto *et al.* (2015)
D.	Oil Palm Trunks	1. Laminated wood and palm sap	Erwinsyah (2019)
		2. Sugar–rich starch flour and fuel (biomass flour) for combustion systems.	Tjahjono (2019)

No.	Type of Biomass	Product Innovation	Researcher
		3. Methanol and Dimethyl Ether	Susanto *et al.* (2015)
		4. Biopellets	Wistara *et al.* (2015)

Source: BPDP(KS) (2015, 2016, 2018, 2019, 2020, 2021, 2022, 2023, 2024)

To harness the research results on oil palm biomass utilization, the Ministry of Industry (2025) has developed downstream pioneering efforts such as: (1) prototypes of new materials from oil palm fiber as alternative raw materials for oil palm nursery paper bags, artificial leather, footwear/sneakers, and even helmets and bulletproof vests; (2) processing Empty Fruit Bunches (EFB) into precursors/raw materials for the production of cellulosic bioethanol, biopolymers, bioplastics, and high–value-added organic acid raw materials; and (3) development of biofuels from cellulosic material and biofiber from biomass (shells, empty fruit bunches, and so on).

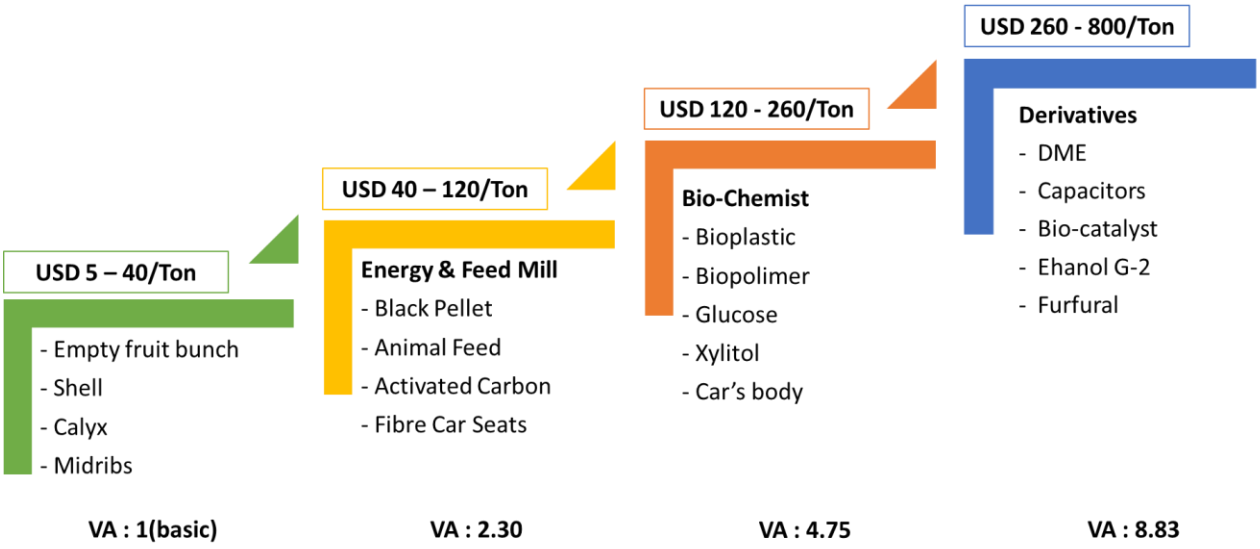

Figure 2. Increase in Value Added in Oil Palm Biomass Downstreaming (Source: Ministry of Industry, 2025)

Technological innovations in the downstreaming of oil palm biomass are intended to increase the value added of oil palm biomass (Figure 2). Processing oil palm biomass into energy and feed mill products such as block pellets, activated carbon, or car seat fiber can increase the value added of oil palm biomass by about 2.3 times. If oil palm biomass is further processed into biochemical products such as bioplastics, biopolymers, glucose, and xylitol, it can increase the value added of biomass by up to 4.75 times. The value added of oil palm biomass will increase by 8–9 times if it is processed into further downstream products such as furfural, biocatalysts, capacitors, and others.

CONCLUSION

Indonesia is not only the country with the largest oil palm plantations in the world, but also the largest producer of palm oil and the largest producer of oil palm biomass in the world. Oil palm plantations produce biomass in the form of empty fruit bunches (EFB), oil palm fibers and shells, oil palm trunks, and oil palm fronds. Referring to the study by Foo-Yuen Ng (2011), with the area of Indonesia's oil palm plantations in 2025 reaching 16.8 million hectares, oil palm biomass will produce around 261.7 million tons of dry matter biomass per year. This large biomass potential must be utilized through downstreaming to increase economic value while at the same time supporting a more environmentally friendly circular economy.

The five advantages of oil palm biomass as raw material for downstream industries are: it is a joint product of palm oil, it is available throughout the year and concentrated in relatively large quantities, it is low cost, it is zero or low carbon, and it does not cause a food–fuel trade-off in its

utilization. Technological innovations in the processing and downstream products of oil palm biomass are relatively available, one of which is produced by the *Grant Riset Sawit* (GRS) program managed by BPDP(KS), which has intensively developed research on technology/innovation for downstream products based on oil palm biomass. Downstreaming of oil palm biomass can increase value added by up to 8–9 times and has the potential to become a business with significant economic value while supporting a circular and sustainable economy.

ACKNOWLEDGEMENTS

The author extends sincere gratitude for the financial support provided by the Plantation Fund Management Agency (*Badan Pengelola Dana Perkebunan*) in the preparation of this journal article.

REFERENCES

[BPDPKS] Badan Pengelola Dana Perkebunan Kelapa Sawit. *Grant Riset Sawit 2015: Ringkasan Penelitian*. Badan Pengelola Dana Perkebunan Kelapa Sawit. https://www.bpdp.or.id/uploads/E-BOOK%20HASIL%20PENELITIAN/Buku%20Ringkasan%20GRS%202015.pdf

[BPDPKS] Badan Pengelola Dana Perkebunan Kelapa Sawit. *Grant Riset Sawit 2016: Ringkasan Penelitian*. Badan Pengelola Dana Perkebunan Kelapa Sawit. https://www.bpdp.or.id/uploads/E-BOOK%20HASIL%20PENELITIAN/Buku%20Ringkasan%20GRS%202016.pdf

[BPDPKS] Badan Pengelola Dana Perkebunan Kelapa Sawit. *Grant Riset Sawit 2018: Ringkasan Penelitian*. Badan Pengelola Dana Perkebunan Kelapa Sawit. https://www.bpdp.or.id/uploads/E-BOOK%20HASIL%20PENELITIAN/Buku%20Ringkasan%20GRS%202018.pdf

[BPDPKS] Badan Pengelola Dana Perkebunan Kelapa Sawit. *Grant Riset Sawit 2019: Ringkasan Penelitian*. Badan Pengelola Dana Perkebunan Kelapa Sawit. https://www.bpdp.or.id/uploads/E-BOOK%20HASIL%20PENELITIAN/Buku%20Ringkasan%20GRS%202019.pdf

[BPDPKS] Badan Pengelola Dana Perkebunan Kelapa Sawit. *Grant Riset Sawit 2020: Ringkasan Penelitian*. Badan Pengelola Dana Perkebunan Kelapa Sawit. https://www.bpdp.or.id/uploads/E-BOOK%20HASIL%20PENELITIAN/Buku%20Ringkasan%20GRS%202020.pdf

[BPDPKS] Badan Pengelola Dana Perkebunan Kelapa Sawit. *Grant Riset Sawit 2021: Ringkasan Penelitian*. Badan Pengelola Dana Perkebunan Kelapa Sawit. https://www.bpdp.or.id/uploads/E-BOOK%20HASIL%20PENELITIAN/Buku%20Ringkasan%20GRS%202021.pdf

[BPDPKS] Badan Pengelola Dana Perkebunan Kelapa Sawit. *Grant Riset Sawit 2022: Ringkasan Penelitian*. Badan Pengelola Dana Perkebunan Kelapa Sawit. https://www.bpdp.or.id/uploads/E-BOOK%20HASIL%20PENELITIAN/Buku%20Ringkasan%20GRS%202022.pdf

[BPDPKS] Badan Pengelola Dana Perkebunan Kelapa Sawit. *Grant Riset Sawit 2023: Ringkasan Penelitian*. Badan Pengelola Dana Perkebunan Kelapa Sawit. https://www.bpdp.or.id/uploads/E-BOOK%20HASIL%20PENELITIAN/Buku%20Ringkasan%20GRS%202023.pdf

[BPDPKS] Badan Pengelola Dana Perkebunan Kelapa Sawit. *Grant Riset Sawit 2024: Ringkasan Penelitian*. Badan Pengelola Dana Perkebunan Kelapa Sawit.

https://www.bpdp.or.id/uploads/Riset/2024%20E-Book%20-%20GRANT%20RISET%20SAWIT.pdf

[PASPI] Palm Oil Agribusiness Strategic Policy Institute. 2023. *Mitos dan Fakta Industri Minyak Sawit Indonesia dalam Isu Sosial, Ekonomi, dan Lingkungan Global*. Edisi Keempat. Bogor (ID): PASPI.

Aditiawati P, Prakoso T, Dungani R, Fitriyanti M, Priharto N, Mutsla D. 2024. *Optimasi Komposisi Substrat Fermentasi Berbasis Limbah Biomassa Tanaman Kelapa Sawit untuk Memproduksi Biomassa Miselium Sebagai Produk Biomaterial (Catalytic Esterification of Glycerol and Gondurukem for the Production of Road Marking and Adhesive Mixtures.* Grant Riset Sawit 2024: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Aditiawati P, Prakoso T, Dungani R, Fitriyanti M, Priharto N, Mutsla D. 2023. *Optimasi Komposisi Substrat Fermentasi Berbasis Limbah Biomassa Tanaman Kelapa Sawit untuk Memproduksi Biomassa Miselium Sebagai Produk Biomaterial.* Grant Riset Sawit 2023: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Ahmad, Sultan AZ, Nur R, Gustiono D, Roseno S, Rahman S. 2024. *Pengembangan Komposit Campuran (Hybrid) Serat Tandan Kosong Kelapa Sawit (TKKS) dan Glass yang Diperkuat Poliester untuk Aplikasi Plafon Rumah*. Grant Riset Sawit 2024: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Astutiningsih S, Handika N, Sentosa BOB, Adhiraga M, Dhini A, Wulandari D. 2023. *Palmcrete (Beton Sawit): Pemanfaatan (Upcycle) Cangkang Kelapa Sawit (Palm Kernel Shell) sebagai Agregat Beton Ringan Menuju Ekonomi Sirkular*. Grant Riset Sawit 2023: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Astutiningsih S, Handika N, Sentosa BOB, Adhiraga M, Dhini A, Wulandari D. 2022. *Palmcrete (Beton Sawit): Pemanfaatan (Upcycle) Cangkang Kelapa Sawit (Palm Kernel Shell) sebagai Agregat Beton Ringan Menuju Ekonomi Sirkular*. Grant Riset Sawit 2022: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Bindar Y, Zunita M, Irawan A. 2015. *Pengembangan Teknologi Produksi Minyak Mentah Nabati Pirolisis (Bio-Crude Oil) Berbahan Baku Limbah Biomassa Sawit.* Grant Riset Sawit 2015: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Bindar Y, Zunita M, Irawan A. 2018. *Pengembangan Teknologi Produksi Minyak Mentah Pirolisis Biomassa (Bio-Crude Oil), Bioa-Char, dan Bio-Pyrolysis Gas Berbahan Baku Limbah Biomassa Sawit.* Grant Riset Sawit 2018: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Bindar Y, Zunita M, Irawan A. 2019. *Pengembangan Teknologi Produksi Minyak Mentah Nabati Pirolisis (Bio-Crude Oil) Berbahan Baku Limbah Biomassa Sawit.* Grant Riset Sawit 2019: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Budhi YW, Judawisastra H, Iskandar F, Suendo V. 2016. *Pembuatan Biomaterial Maju Cellulose Nano Crystallines (CNC) dari Tandan Kelapa Sawit sebagai Material Penyangga Katalis Pt/Rh/Ce untuk Konverter Katalitik*. Grant Riset Sawit 2016: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Dimawarnita F, Suharyanto, Marsudi S, Perwitasari U. 2016. *Pemanfaatan Total Limbah Padat Kelapa Sawit dalam Rantai Industri Pertanian dan Pangan: Produksi Enzim Ligninolitik, Carboxymethyl Cellulose (CmC), Jamur Konsumsi, dan Pupuk Organik*. Grant Riset Sawit 2016: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Dina SF, Ginting TP, Hutajulu PE, Indriati L, Sitinjak M, Saragih G, Fernandez BR, Pratikha RS, Silalahi M. 2024. *Aplikasi Biodegradable Polimer Sintetik pada Pembuatan Paperbag dari Pulp Tandan Kosong Kelapa Sawit untuk Kemasan Pembibitan.* Grant Riset Sawit 2024: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Erwinsyah. 2019. *Kajian Pengembangan Pabrik Kayu Sawit Hasil Peremajaan dengan Teknologi Sandwich Laminated Lumber*. Grant Riset Sawit 2019: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Foo-Yuen N, Foong–Kheong Y, Y Basiron, K Sundram. 2011. A Renewable Future Driven with Malaysian Palm Oil-based Green Technology. *Journal of Oil Palm & The Environment*. 2:1-7.

Gozan M, Harahap AFP. 2018. *Pengembangan Konsep Biorefinery: Furfural, Asam Levulinat, dan Bioetanol Berbasis Tandan Kosong Kelapa Sawit*. Grant Riset Sawit 2018: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Gozan M, Harahap AFP. 2019. *Pengembangan Konsep Biorefinery: Furfural, Asam Levulinat, dan Bioetanol Berbasis Tandan Kosong Kelapa Sawit*. Grant Riset Sawit 2019: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Hariz HB, Zaidi SAS. Luthfi AAI, Bukhari N, Sajab MS, Markom M, Harun S, Tan JP, Ding GT, Abdul PM. Succinic Acid Production from Oil Palm Biomass: A Prospective Plastic Pollution Solution. *Fermentation*. 9(1). https://doi.org/10.3390/fermentation9010046

Hau EH, Teh SS, Yeo SK, Chua BL, Mah SH. 2022. Transformation of Oil Palm Biomass into Value-Added Components. *Reviews in Agricultural Science*. 10: 36–55. https://doi.org/10.7831/ras.10.0_36

Isroi, Cifriadi A, Saptohadi A, Panji T. 2018. *Produksi Bioplastik Berbasis Glyserol dari Minyak Sawit dan Nano-Selulosa dari Tandan Kosong Kelapa Sawit*. Grant Riset Sawit 2018: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Isroi, Rahman A, Syamsu K. 2019. *Produksi Bioplastik dari Selulosa Tandan Kosong Kelapa Sawit*. Grant Riset Sawit 2019: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Kementerian Perindustrian RI. 2025. *Kebijakan Pengembangan Industri Bahan Bakar Nabati; Siprosatu Untuk Mendukung Iklim Usaha Industri Hilir Kelapa Sawit, termasuk Industri bahan Bakar Nabati, dan Membantu lmplementasi ISPO HILIR (sesuai Perpres 16/2025)*. Presented in Seminar Peluang dan Tantangan Industri Bioenergi Menyongsong Indonesia Emas 2045 oleh APROBI (Asosiasi Produsen Biofuel Indonesia) at Jakarta on July, 17th 2025.

Kismanto A, *et.al*. 2023. *Pengembangan Teknologi Produksi Carbon Black dari Biomassa Kelapa Sawit*. Grant Riset Sawit 2023: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Kismanto A, *et.al*. 2024. *Pengembangan Teknologi Produksi Carbon Black dari Biomassa Kelapa Sawit*. Grant Riset Sawit 2024: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Masruchin N, Burhani D. 2022. *Pengembangan Nanoselulosa dari Serat Pulp Tandan Kosong Kelapa Sawit Sebagai Agen Pickering-Emulsion (Nirsurfaktan) Kemasan Pangan Aktif dan Bahan Superhidrofobik Aerogel Penyerap Minyak*. Grant Riset Sawit 2022: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Nabila R, Hidayat W, Haryanto A, Hasanuddin U, Iryani DA, Lee S, Kim S, Kim S, Chun D, Choi H, Im H, Lim J, Kim K, Jun D, Moon J, Yoo J. 2023. Oil palm biomass in Indonesia: Thermochemical upgrading and its utilization. *Renewable and Sustainable Energy Reviews*. 176: 113193. https://doi.org/10.1016/j.rser.2023.113193

Naik SN, VV Goud, PK Rout, AK Dalai. 2010. Production of First- and Second-Generation Biofuels: A Comprehensive Review. *Renewable and Sustainable Energy.* 14: 578-597. https://doi.org/10.1016/j.rser.2009.10.003

Nikmatin S, Irmansyah, Hermawan B. 2022. *Inovasi Benang dan Kain dari Biomass Sawit untuk Aplikasi Produk Industri Kreatif Fashion*. Grant Riset Sawit 2022: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Nikmatin S, Irmansyah, Irwanto DAY. 2018. *Optimasi Hingga Implementasi Pengolahan Limbah Padat Sawit sebagai Material Filler Polimer Aplikasi Komponen Otomotif dan Bahan Anti Peluru untuk*

Diversifikasi Produk. Grant Riset Sawit 2018: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Nikmatin S, Irmansyah, Irwanto DAY. 2019. *Optimasi Hingga Implementasi Pengolahan Limbah Padat Sawit sebagai Material Filler Polimer Aplikasi Komponen Otomotif dan Bahan Anti Peluru untuk Diversifikasi Produk*. Grant Riset Sawit 2019: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Nugraha AF, Chalid M, Husnil YA, Pangesty AI, Ghozali M, Faramitha Y, Dimawarnita F. 2024. *Aplikasi Wood Plastic Composite (WPC) Berbahan TKKS sebagai Bahan Konstruksi Ramah Lingkungan untuk Perumahan.* Grant Riset Sawit 2024: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Panji T, Marsudi S, Dimawarnita F, Perwitasari U, Suharyanto. 2019. *Pemanfaatan Total Limbah Padat Kelapa Sawit dalam Rantai Industri Pertanian dan Pangan: Produksi Enzim Ligninolitik, Carboxymethyl Cellulose (CmC), Jamur Konsumsi, dan Pupuk Organik*. Grant Riset Sawit 2019: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Panji T, Marsudi S, Dimawarnita F, Perwitasari U, Suharyanto. 2018. *Pemanfaatan Total Limbah Padat Kelapa Sawit dalam Rantai Industri Pertanian dan Pangan: Produksi Enzim Ligninolitik, Carboxymethyl Cellulose (CmC), Jamur Konsumsi, dan Pupuk Organik*. Grant Riset Sawit 2018: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

PASPI Monitor. 2021. Minyak Sawit dan Isu *Food-Fuel Trade Off. Palm O' Journal Analisis Isu Strategis Sawit*. 2(8): 321-326. https://palmoilina.asia/wp-content/uploads/2021/02/2.8.-MINYAK-SAWIT-DAN-ISU-FOOD-FUEL-TRADE-OFF-.pdf

PASPI Monitor. 2023a. COP-28 Dubai Summit, Emisi Energi Fosil, dan Bioenergi Sawit. *Journal of Analysis Palm Oil Strategic Issues.* 4(14): 833-840. https://palmoilina.asia/jurnal-kelapa-sawit/jalur-biofuel-complex-sawit/

PASPI Monitor. 2023b. Keunggulan Perkebunan Sawit dalam Carbon Sink & Produksi Minyak Hemat Emisi. *Journal of Analysis Palm Oil Strategic Issues.* 4(15): 841-848. https://palmoilina.asia/jurnal-kelapa-sawit/sawit-dalam-carbon-sink/

PASPI Monitor. 2024. 3 in 1: Perkebunan Sawit Produksi Minyak Nabati, Biomassa, dan Jasa Lingkungan. *Journal of Analysis Palm Oil Strategic Issues.* 4(16): 849-854. https://palmoilina.asia/jurnal-kelapa-sawit/3-in-1-minyak-sawit-biomassa/

PASPI Monitor. 2025. Inovasi Diversifikasi Bioenergi Berbasis Sawit untuk Substitusi Energi Fosil. *Journal of Analysis Palm Oil Strategic Issues.* 5(2): 9-20. https://palmoilina.asia/jurnal-kelapa-sawit/bioenergi-berbasis-sawit/

Prakoso T, Nurdin I, Devianto H, Widiatmoko P. 2015. *Pembuatan Nanokarbon Aktif untuk Superkapasitor dari Limbah Sawit.* Grant Riset Sawit 2015: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Prakoso T, Nurdin I, Devianto H, Widiatmoko P. 2019. *Peningkatan Rendemen Nanokarbon Aktif untuk Elektroda Superkapasitor dari Limbah Kelapa Sawit.* Grant Riset Sawit 2019: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Prakoso T, Nurdin I, Devianto H, Widiatmoko P. 2021. *Pembuatan Purwarupa Superkapasitor dari Limbah Kelapa Sawit.* Grant Riset Sawit 2021: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Raksodewanto A, Kismanto A, Peryoga MDSY, Wijono A, Riza, Widjatmoko KA, Nurayadi AP, Sumbogo SD, Adiarso, Dwiratna B, Nasiri SJA. 2015. *Pengembangan Industri Bahan Bakar Minyak Berbahan Baku Biomassa dari Perkebunan Kelapa Sawit.* Grant Riset Sawit 2015: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Rasrendra CB, Sasongko D, Kariem MA, Rizkiana J, Winoto HP. 2018. *Pengembangan Teknologi Produksi Bio-Aromatik dan Bio-Btx Berbahan Mentah Tandan Kosong Sawit*. Grant Riset Sawit 2018: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Rasrendra CB, Sasongko D, Kariem MA, Rizkiana J, Winoto HP. 2019. *Pengembangan Lanjut Teknologi Produksi Bio-Aromatik dan Biobtx Berbahan Mentah Tandan Kosong Sawit*. Grant Riset Sawit 2019: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Rasrendra CB, Sasongko D, Kariem MA, Rizkiana J. 2016. *Pengembangan Teknologi Produksi Bio-Aromatik dan Bio-Btx Berbahan Mentah Tandan Kosong Kelapa Sawit*. Grant Riset Sawit 2016: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Septiningrum K, Azkiya AC, Merdekawati NA, Fauzi MI, Nugroho AF, Suharman, Purwadi R, Kresnowati, Rasrendra CB. 2024. *Optimalisasi Teknologi Fraksionasi Tandan Kosong Kelapa Sawit pada Skala Pilot*. Grant Riset Sawit 2024: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Septiningrum K, Mariyana R, Azkiya AC, Nugroho Y, Antara NT, Kustanto H, Hasanah F, Nobel CH, Purwadi R, Kresnowati. 2021. *Pengembangan Teknologi Proses Produksi Pengolahan Tandan Kosong Sawit Menjadi Glukosa pada Skala Pilot dan Teknologi Proses Terintegrasi Produksi Glukosa, Xilosa, dan Lignin Skala Lab*. Grant Riset Sawit 2021: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Setiadi T, Meilany D, Kresnowati. 2015. *Rekayasa Proses Hidrolisis Tandan Kosong Sawit untuk Produksi Green Xylitol*. Grant Riset Sawit 2015: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Setiadi T, Meilany D, Kresnowati. 2019. *Rekayasa Proses Hidrolisis Tandan Kosong Sawit untuk Produksi Green Xylitol*. Grant Riset Sawit 2019: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Setyaningsih D, Uju, Muna N. 2016. *Sintesis Nano Crystalin Cellulose (NCC) Ramah Lingkungan dari Biomassa Sawit dan Aplikasinya*. Grant Riset Sawit 2016: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Singh S, Nara R, Yadav M, Sharma C, Agrawal S, Kumar A. 2025. Oil Palm Biomass: A Potential Feedstock for Lignocellulolytic Enzymes and Biofuels Production. *Environmental Science and Pollution Research*. 32(19): 11791–11814. https://doi.org/10.1007/s11356-025-36379-3

Sitompul J, Wibowo A, Rasrendra CB, Pramudita D. 2015. *Pengembangan Proses dan Produksi Biomatrial dari TKS (Tandan Kosong Sawit) untuk Bahan Pembungkus yang Ramah Lingkungan.* Riset Sawit 2015: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Sriyanti I, Jauhari J, Marlina L, Ariska M, Sajaya R, Almafie R. 2020. *Pengembangan Teknologi Dan Produksi Biomaterial Maju Carbon Nanofiber (CNF) Berkekuatan Mekanik Tinggi dari Limbah Cangkang Kelapa Sawit yang Ramah Lingkungan dan Prosfektif*. Grant Riset Sawit 2020: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Susanto H, Ardy A, Yuono, Pranobo SH, Prasetyo JL. 2015. *Konversi Limbah Padat Sawit Menjadi Metanol dan Dimetil-Eter melalui Proses Gasifikasi (Biomass to Liquid)*. Grant Riset Sawit 2015: Ringkasan Penelitian. Badan Pengelola Dana Perkebunan Kelapa Sawit.

Thomas S, Andres. 2021. Biomass from Palm Oil Waste as a Renewable Energy Source with Community Benefits. *International Journal Papier Advance and Scientific Review.* 2(1). https://doi.org/10.47667/ijpasr.v2i1.79