Grant proposal

Title of project: Production of D-Limonene from Nigerian Citrus Waste: The Nigerian Limonene Waste to Wealth Initiative (NL2WI)

Project team members

S/N	Name	Affiliation	Qualification	Contribution to project
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1.0 Executive summary

The Nigerian Limonene Waste to Wealth Initiative (NL2WI) is a strategic agro-industrial project designed to address two pervasive national resource constraints simultaneously: the immense post-harvest citrus waste burden on the environment and the chronic dependence on high-cost importation of limonene. This proposal details a robust commercial plan for extracting D-Limonene, a high-value terpene, from discarded citrus peel waste across Nigeria major citrus producing States namely; Benue, Nassarawa, Kogi, Ogun, Oyo, Osun, Ebonyi, Kaduna, Taraba, Ekiti, Imo, Anambra, Kwara, Edo and Delta (UNCTAD, 2007).

Limonene, a natural plant essential oils which has a pleasant and citrus-like odor (Park *et al.*, 2024), is mainly dominated by D-limonene. It is the main monoterpene widely found in the peels of citrus and other fruits. Limonene is a biomarker compound in citrus peel with a content ranging from 85 % up to 93 % (Chen *et al.*, 2020; Lin *et al.*, 2024, Park *et al.*, 2024). It is classified as "generally recognized as safe" (GRAS) by the U.S. Food and Drug Administration and is widely used in the food, pharmaceutical, chemical and cosmetic industries (Vieira *et al*., 2018). Growing consumer interest towards natural essential oil has fuel the demand for citrus

peel oil. Food and Beverages, Pharmaceuticals and Cosmetics industries in Nigeria depend on imports to meet the essential oils requirement. D-Limonene is a biodegradable, high-value terpene used as a solvent, fragrance/flavor precursor, cleaner, and specialty chemical feedstock. The Nigerian Limonene Waste to Wealth Initiative (NL2WI) when implemented will not only limit importation of limonene but will make Nigeria a limonene exporting nation with a net foreign exchange earnings. The project also has the potential for huge job creation and grass-root engagement for socioeconomic development, which aligns well with the Renewed Hope Agenda of the current administration.

This project proposes a green-chemical operation to collect citrus peel waste from orange processors/farmers across major producing states, optimize the extraction and refining of d-limonene for economic production and USP grades, respectively, for identified local industries and export markets. This project converts an inexpensive agro-waste into an exportable and import-substituting chemical, creating jobs and improving post-harvest value chains. It demonstrates the commercial viability of local production of pharmaceutical raw material which aligns with the presidential initiative for unlocking the healthcare value chain (PVAC) as enshrine in the Renewed Hope Agenda.

The project is estimated to cost one-time investment of about N240,000,000.00, (N240m) over an implementation period of 24 months. The economic value of the impact of the project over the next 10 years' post-implementation is estimated at exceeding N60,000,000,000.00 (N60b).

1.1 Statement of the Problem

Citrus fruits are highly consumed worldwide as fresh produce and juice but a significant portion of the fruit, about 40 – 60 % is non-edible and discarded as waste (Manthey and Grohmann, 2001). Nigeria Citrus Production has been on a steady increase of 1.7 % year on year since 2014 (Olife and Mohammed 2021). With a production of 4,114,676 tonnes in 2019, Nigeria was ranked 9th among Citrus Producing countries in the world (FAOSTAT, 2020). Citrus consumption/processing generates high volumes of co-products namely, peel and pulp, and the peel makes up approximately 25 % of total weight of the fruit. Since Nigeria produces about 4.1 million tonnes of citrus fruits annually, it is estimated that Nigeria generate over 1 million tonnes of citrus peels annually (Olife and Mohammed 2021). The Nigerian Limonene Waste to Wealth Initiative (NL2WI) will harness the huge volume of citrus waste and turn into wealth, especially when global commercial production is still through extraction from citrus fruits.

Nigeria high citrus production level stands in stark contrast to the underdeveloped state of the processing sector. The lack of formalized processing infrastructure leads directly to significant inefficiencies and huge economic loss. Post-harvest losses, particularly in major producing regions like Benue State, are conservatively estimated to range from 21% to 30%. This translates into thousands of tons of perfectly usable organic material that is discarded or improperly handled. The sheer volume of discarded citrus peel waste represents a major environmental liability. When this organic waste is improperly managed, it contributes significantly to littering, general environmental degradation, and pollution. The Nigerian limonene waste to wealth initiative (NL2WI) provides a sustainable, profit-driven mechanism to actively manage this specific high-volume waste stream.

In a study by (Akpan et al., 2021), it is reported that Nigeria has the potential of producing between 233,859 – 485,554 kg of citrus peel oil per annum, with a possibility of tripling this values. Despites Nigeria's limonene production potentials, the Nigeria Customs Service reported that a total of 183,607 kg of essential oils of citrus worth ₦244.84 million was imported into Nigeria from 2016 to 2020 (Olife and Mohammed 2021). This amount to about 90% of limonene used by manufacturing companies in Nigeria. Whilst Nigeria is among top citrus producing nation, the nation still solely relies on imported limonene a co-product of citrus waste. At the moment Limonene is not produced in Nigerian, although companies like Silverline chemicals, kelvin natural mint pvt. Ltd claims online to manufacture limonene in Nigeria, these claim are misleading as they are all Indian companies with no know affiliation with any local company. Reporting as far back as 2015 indicated that investment in citrus processing in Nigeria was minimal, despite clear evidence that such investment offers good economic returns. The lack of domestic agro-processing capability leads directly to economic leakage through import dependency. While tons of orange peels are being wasted domestically, local industries requiring citrus derivatives must rely on expensive foreign supplies. The high average import price for peels of citrus fruit essential oil, representing a significant expansion and a record high. This data point exposes a critical national economic contradiction: the country is effectively paying half a million dollars per ton to import processed citrus derivatives while discarding the zero-cost raw material needed to produce them locally. This high import valuation provides overwhelming financial justification for immediate domestic import substitution through the Nigerian Limonene Waste to Wealth Initiative (NL2WI). By supporting local raw material production, the project also contributes to the strategy for local medicine security through the presidential initiative for unlocking the healthcare value chain (PVAC) as enshrine in the Renewed Hope Agenda.

1.2 Project Justification

The project supports the PVAC strategy for local medicine security and other socioeconomic development framework in the Renewed Hope Agenda. The project is scientifically sound and commercially validated. Limonene is an essential oil with wide-ranging applications in industrial, pharmaceutical, cosmetic, and domestic domains, including use as food flavoring and industrial solvents. The processing of citrus peels into essential oils is the most definitive way to transform a potential environmental pollutant into a resource with significant economic potential. By tackling the existing barrier of "little investment" in processing, the Nigerian limonene waste to wealth initiative (NL2WI) provides a direct path toward securing economic prosperity and achieving public health benefits from a healthier, safer environment derived from effective waste management.

Business opportunities in the Nigerian limonene waste to wealth initiative (NL2WI) value chain ranges from collection, drying, packaging for local and export market. The collection stage involves very little capital and therefore ideal for people with low start-up capital. This project will harness the economic potentials of citrus peel, producing industrial raw material from it, thereby saving millions of naira. The strategy of value addition on citrus waste provides ample opportunity for revenue generation, employment generation and effective post-harvest management.

Conversely, the raw material cost is nearly zero. The utilization of orange peel waste that would otherwise be discarded as an environmental pollutant means that the acquisition cost of the feedstock is essentially limited to logistics and collection overhead. This dramatic reduction in

feedstock cost is the fundamental mechanism that allows the project to maintain superior profitability.

1.3 Objectives

Project objectives are;

1. To reduce organic waste, lowers methane from uncontrolled peel decomposition, and provides a biodegradable solvent alternative, which align with national sustainability goals.
2. To produce 60,300 kg of limonene from citrus wastes produced in North-Central, parts of South-South, and South-West geopolitical zones of Nigeria for use in the industry.
3. To demonstrate commercial viability of local production of Limonene to reduce import dependence, strengthen local value addition to pharmaceutical raw materials, and support the Presidential Initiative for unlocking the healthcare value chain (PVAC).
4. To promote environmental sustainability and youth socioeconomic empowerment through waste to wealth initiative of the economic production of limonene from citrus waste.

2.0 Methodology

2.1 Extraction technology and operational model

Steam distillation is a proven and highly effective means of extracting pure, high-quality essential oils, resulting in clear oils with complex aromas. This method is critical for meeting the strict purity standards required for access to the fastest-growing market segments. The extraction process involved stages of size reduction, heating, an extractor tank, gas and steam piping, a condenser, and a decanter as described by (da Costa *et al.* 2022). The optimization process will require repeated batch operations to establish optimum operational procedures/parameters for scalable commercial production and viability. The steam distillation facility of NIPRD will be used for this project.

2.2 Phased Equipment Scaling and Plant Design

The commercialization timeline integrates a necessary pilot phase for validation and compliance.

2.2.1 Pilot Phase Necessity

A preliminary budget allocation is dedicated to procuring pilot-scale equipment, A 300 L essential oil extraction kits. This pilot unit is mandatory for confirming local yield rates, establishing robust Standard Operating Procedures (SOPs), and, most critically, generating the product samples and detailed process data required for submission to the National Agency for Food and Drug Administration and Control (NAFDAC) for regulatory approvals.

2.2.2 Commercial Scale

A scalable commercial facility will be designed around a medium-scale chemical processing plant, targeting extraction capabilities in the range of 5 to 10 tons per day of raw material input.

This specialized factory design will be anticipate utilizing reinforced concrete and steel structures from local inputs and skills, falling within the higher end of industrial construction costs to ensure durability, safety, and compliance with Good Manufacturing Practice (GMP) standards.

2.3 Rural & SME empowerment through Citrus value chain development

In order to fully harness citrus value chain, and for sustainability of the project, citrus peel collection hub will be established in 7 priority states, namely FCT, Benue, Nassarawa, Niger, Kaduna, Edo and Kogi State. This hub will be an aggregation of small groups of women and youths in cooperative societies. Five collectors per state will undergo a three (3) day sensitization and training on best practices for citrus peel collection, sorting and drying methods. To mitigate the risk of inconsistency in feedstock supply, and also ensure steady supply of premium grade peel, the collection center will be provided with a locally fabricated GMP compliant drying unit. This strategy of value addition on citrus waste will provides ample opportunity for revenue generation and employment to a lot of Nigerian.

3.0 ESTIMATED BUDGET

3.1 Cost of training, sensitization and establishment of citrus peel processing hubs; toward citrus value chain development and socioeconomic empowerments for project sustainability and job creation (Creation of citrus peel collection hubs and training of selected collectors on GMP in citrus peel collection, sorting, drying and, packaging).

S/No	Description of item	Quantity	Unit Cost	Amount (N)
1	Rent of collection hub across the Nation (35 hubs)	N300,000 per year	35	10,500,000
2	**Sensitization/awareness creation/training** Creation of citrus peel collection hubs and training of selected collectors on GMP in citrus peel collection, sorting, drying and, packaging.	a. Honorarium for 5 participants from 7 priority states b. Honorarium for Facilitators	N50,000/day for 3 days =N150,000/ person for 5 persons from 7 state = (150,000 x5 x7) =N5,250,000 N 120,000/day for 3 day = N360,000 for three person = N1,080,000 for seven state = 7,560,000	12,810,000
3	Fabrication of GMP compliant drying trays for all collection hubs (Electric/gas oven)- Temp; 40^{O}c to 100 ^{O}C, 340x280x235 cm (lxwxh) dimension	35	900,000	31,500,000
			Subtotal	**54,810,000**

3.2 Cost of repair and maintenance of the existing 500-liter capacity steam distillation equipment and other apparatus.

S/No	Item Description	Quantity	Unit cost (N)	Amount (N)
1a.	30 KVA power diesel generator	1 complete set	18,000,000	18,000,000
1b.	12 mm electric cable	30 meters	255,000.00	255,000
1c.	Change over switch	1	160,000.00	160,000
1d.	Installation/logistics	1	585,000.00	585,000
2a.	Procurement of Cooling tower fan motor (2 KW).	1 set	400,000.00	400,000
2b.	Starter switch contactor for Fan electric motor	3	50,000.00	150,000
	Three Phase electrical impreventer			

2c.		3	25,000.00	75,000
3a.	Steam boiler: Burner contactor (100A)	2	80,000.00	160,000
3b.	2.5 mm electric cable	30 m	3,000.00	90,000
4a.	Stainless steel steam pipes – (16 lengths of 2")	16 lengths of 2" diameter	295,000.00 / length	4,720,000
4b.	Stainless steel water pipes – (8 lengths of 1 3/4")	8 lengths of 1 3/4"	275,000 / length	2,220,000
4c.	Stainless steel water pipes – (5 lengths of 1 1/2")	5 lengths of 1 1/2"	245,000 / length	1,225,000
	Stainless steel water pipes - 11	11 lengths of 2"	295,000 / length	

4d.	lengths of 2"			3,245,000
		16 lengths of		
	Glass wool fiber for lagging of	2” diameter	115,000/	
4e.	Steam line		length	1,840,000
	Pipe fittings/accessories		1,350,000.00	
4f.				1,350,000
	Glass wool fiber blanket		1,000,000.00	
	For Extractor/Reboiler			1,000,000
	Workmanship for welders		2,700,000.00	
	And procurement of Argon gas			2,700,000
	Logistics for Technicians and		850,000.00	
	Pipes/fittings/accessories			850,000
5.	Automatic Polarimeter for Optical Rotation. Model – Veidt INESA WXG-4	1 unit	800,000.00	800,000

6.	Digital Viscometer (10 - 100,000 mPa's) Specification - *Digital lab rotation viscosity meter ± 3% accuracy fluidity meter tester with 4 rotors and temperature probe (110-240v) NDJ-5S* *Features; Compact design, variable spindle/rotor speed, Data storage, Versatility, Accuracy and repeatability, Digital display, Temperature measurement, Integrated time, Spindle set.*	1 unit	1,200,000.00	1,200,000
7.	Tabletop digital refractometer (BRIX ABBE) Model name/number; BNWYA-2S/3S 0-100% Features. 1. Sapphire prism, temperature control, 8-inch color touch screen. 2. Brix: 0-100%, high resolution: Brix: 0.01%	1 unit	1,700,000.00	1,700,000

Estimated freight charges, insurance, tax on items to be imported:		950,000
	Subtotal	**43,675,000**

3.3 ***List of materials needed for the project***

S/No	Description of item	Quantity	Unit Cost (N)	Amount (N)
1	Collection of Citrus peel from collection hubs	100 tonnes	N200 / kg of 100 tonnes =(200 x 100,000)	20,000,000
2	Packaging, Labeling and Cartons (30 ml essential oil bottles, and other storage vessels)	10,000 units	1,500	15,000,000
3	Transport of feed stock from the various collection hub to	100 trips	120,000	12,000,000

	extraction site (NIPRD Abuja	(1tonnes/ trip)		
4	Labour for Ad-Hoc staff for the proposed 12 weeks duration (Exaction and purification of Limonene from Citrus peel essential oil)	900 hrs.,	8334.00/hr	7,500,600
	Purchase of a 200L standalone pilot scale essential oil extraction machine to complement NIPRD facility as a back-up.	200L capacity extraction stainless steel vessel, Operating temp -5oc to 100 ^{o}c, With vacuum pump, 35m2 condenser, circulating pump	1 unit	35,956,700
			Subtotal -	**90,457,300**

3.4 ***List of daily running costs for production during the proposed 12 weeks duration***

S/No	Description of item	Quantity	Unit Cost	Amount (N)
1	Diesel fuel for running generator (14.62L/hr)	10526 liters	1368/hr	14,400,115
2	Diesel fuel for running the steam generator boiler (12.5L/hr)	9000 liters	1368/hr	12,312,000
3	Charges for the use of water supplied	750 hrs.	4000/hr	3,000,000

	Subtotal	**29,712,000**

3.5 ***List and cost of glassware needed for the project***

S/N	Item description	Quantity	Unit Price (Naira)	Amount (Naira)
1.	TLC glass plates GF 254 (5cm x 10cm) / plate, 40 plates/pack. (Qingdao HaiYang Chemical Company, China)	10 cartons	7000 /pack 70,000 / carton	700,000.00
2.	TLC glass tanks – (10 x 20 cm) / set	4 sets	30,145.00	120,580.00
3.	Glass rod 8 x 500mm	10 sets	180.50	1,805.00
4.	Forceps – 30cm, 20cm long	15 pcs	210.00	3,150.00
5.	Glass pipettes – 15cm long 30cm long	 500 pcs 500 pcs	 90.50 120.00	 45,250.00 60,000.00
6.	Glass pipettes rubber fillers (2ml)	20 pcs	90.00	1,800.00
7.	Glass Separating funnel	250 ml (5pcs) 500 ml (5pcs) 1 liter (10pcs) 3 liters (2 pcs) 5 liters (2 pcs)	2,500.00 5,200.00 7,000.00 10,000.00 15,000.00	12,500.00 26,000.00 70,000.00 20,000.00 30000.00
8.	Glass pycnometer	50ml (5pcs) 25ml (5pcs) 10ml (5pcs)	8000.00 5000.00 3000.00	40,000.00 25,000.00 15,000.00

9.	Glass round bottom flasks (various sizes)	10ml (50pcs),	950.50	47,525.00
		25ml (20pcs),	1000.00	20,000.00
		50ml (20pcs),	1500.00	30,000.00
		250ml (20pcs),	2500.00	2,500.00
		500ml (10pcs),	4000.00	80,000.00
		1L (10pcs),	6000.00	6,000.00
		2L (10pcs)	8000.00	80,000.00
10.	Glass round bottom flasks connector mouth	29/24 (3 sets)	5,000.00	15,000.00
		29/19 (3 sets)	5,000.00	15,000.00
11.	Glass measuring cylinders	5ml (30pcs)	1,011.00	30,330.00
		10ml (20pcs)	1,013.00	20,260.00
		250ml (20pcs),	1197.00	23,940.00
		500ml (10pcs),	33,277.00	332,770.00
		1L (10pcs),	21,408.00	214,080.00
		2L (10pcs)	71,677.00	716,770.00
12.	Glass beakers	5ml (30pcs)	6,062.00	181,860.00
		10ml (20pcs)	6,029.00	120,580.00
		250ml (20pcs),	11,759.00	235,180.00
		500ml (10pcs),	14,518.00	145,180.00
		1L (10pcs),	29,996.00	299,960.00
		3L (10 pcs)	35,000.00	350,000.00
		5L (10pcs)	40,000.00	400,000.00
13.	Melting point Capillary tubes	40 pks	5,000.00	20,000.00
14.	Glass desiccator (30cm diameter) with desiccant	1 set	40,000.00	40,000.00
15.	Densitometer for volatile oil	1 set	35,800.00	35,800.00
	Estimated freight charges, insurance,			950,000.00

	tax for items to be imported:			
			Subtotal -	**₦6,426,550.00**

3.6 C*ost of* Quality Control / Lab Test of products

16.	TLC/ GCMS analysis	100 batches	30,000	3,000,000
			Subtotal -	**3,000,000**

3.7 *List and cost of solvents, chemicals and reagents needed for the project*

19.	Sodium hypochlorite (99% Sigma-Aldrich or BDC)	20 x 500g	30,000	600,000
20.	D limonene (99% Reference standard) CAS number - 470-82-6	2 x 100 mg	400,000	800,000
21.	Hydrochloric acid (analar)	2.5L x 20	40,000	800,000
22.	Hexane (Analar grade 99%) Sigma-Aldrich	2.5L x 12	40,000	480,000
23.	Standard distilled water (Sigma)	2.5L x 12L	30,000	360,000.00
24.	Silica Gel			
	60-80 micron	10 cartons	45,000/carton	450,000.00
	100-200 micron	10 cartons	45,000/carton	450,000.00
	300-400 micron	10 cartons	55,000/carton	550,000.00
25.	Sephadex LH-20			
	a. 100g (China)	2 pack x 100g	200,000.00	400,000.00
	b. 500g (China)	3 pack x 500g	900,000.00	2,700,000.00

26.	5ml syringe	10 boxes	10,000.00	100,000.00
27.	Parafilm roll – (10cm x 38 cm roll)	2 sets	32,900.00	65,800.00
	Estimated freight charges, insurance, tax for items to be imported:			350,000.00
			Sub-total:	**N7,305,800.00**

3.8 Literature, documentation, information

S/N	Item description	Quantity	Unit Cost (N)	Amount (N)
1.	NAFDAC documentation and product listing			1,200,000
2.	Stationeries for results, reports and filing (3 cartons of A-4 paper)	3 ctns	10,000	30,000
3.	3-in-1 Hp Lazer-jet black & white Printer (A4 paper size)	1 unit	800,000	800,000
4	Marketing & Distribution			1,500,000
			Sub-total:	**3,530,000**
			Grand Total:	**238,916,650.00**

Grand Total = Two hundred and thirty-eight million, Nine hundred and sixteen thousand, six hundred and fifty naira only (N238,916,650.00)

3.1 Phased Execution Schedule

The project is structured into two interlocking phases designed to manage regulatory timelines and capital deployment efficiently.

3.1.1 Phase 1 (Months 1-12): Preparation & Pilot Construction & Procurement

This phase focuses on foundational activities: securing locations for collection hub, selection and training aggregated group of collectors in the selected states, Design, and fabrication of GMP compliant drying unit, procurement and delivery of the Pilot-scale essential oil extraction unit (300L capacity), Repair/Renovation of NIPRD essential oil extraction facility, and, most importantly, the installation of the specialized utility infrastructure, Crucially, NAFDAC documentation and product sample submission will occur within this phase, initiating the longest regulatory cycles necessary for final commercial certification. The financial schedule for this phase is N 202,674,650

3.1.2 Phase 2 (Months 12-24): Operations & Export

Following equipment commissioning and NAFDAC clearance, commercial operations will commence. Initial sales will focus on the local market for Technical Grade D-limonene (solvents, degreasers) to generate immediate revenue. This will be rapidly followed by export operations targeting Asia-Pacific and North America for the higher-margin Food and Cosmetic Grades upon the final grant of NAFDAC certification. The financial schedule for this phase is N 36,242,000

4.0 Timeline

S/N	Category	Time line
1	**Sensitization/awareness creation/training** Creation of citrus peel collection hubs and training of selected collectors on GMP in citrus peel collection, sorting, drying and, packaging for local and export market,	Four months
2	Collection of Citrus peel from collection hubs	Three Months
3	Transport of feed stock from the various collection hub to extraction site (NIPRD Abuja)	One week
4	Fabrication of GMP compliant drying trays for all collection hubs	Five months
5	Repair of NIPRD essential oil facility	Two month
6	Purchase and delivery of a 300L standalone essential oil extraction machine to complement NIPRD facility	Four Month
7	Extraction and isolation of Limonene	Fifteen months
8	Packaging Bottles	Three week
9	Labeling & Cartons	One week
10	Quality Control / Lab Test GCMS/TLC analysis of each batch of products	As might be required
11	Rent of collection hub	Three weeks
12	Marketing & Distribution	Three months
13	NAFDAC documentation and product listing	Six month

5.0 Risk Management

Personnel and equipment risks will be mitigated through observance of precautions set out in approved operational protocols and SOPs. Additional care will be taken through adequate sensitization, and training of personnel and staff involved in the project. Experts scientists at NIPRD and industry will be consulted at every stage of the project. Hazards will be treated with utmost sense of urgency for medical attention.

6.0 Price and revenue context

Feedstock: 100 tonnes citrus peel at 0.7 % oil yield = 70,000 kg oil. if 90% limonene = then 60,300 kg limonene will be produced from 100 tonne peel. This quantity of limonene can be generate per 100 tonnes peel processed. The established baseline price of industrial-grade limonene, is at approximately $35.40 /kg, shows the high potential revenue stream. Therefore, 6,300kg of limonene can generate a revenue of $2,134,620 which is equivalent to about 3.2 billion Naira. This mean that even modest production volumes have attractive revenue potential if quality and logistics are controlled.

7.0 Project sustainability, Nigeria supply potential and feedstock availability

Nigeria produces substantial quantities of oranges and other citrus; estimates and studies indicate that Nigeria generates about 1 million tonne of orange and other citrus peel volumes (studies have reported combined citrus/peel production estimates in the hundreds of thousands of liters of peel oil potential annually). This raw material is currently under-utilized or becomes waste, offering consistent feedstock for local limonene extraction. Establishing peel collection hubs near processing markets will secure steady supply.

8.0 Market channels and go-to-market

Domestic: Pharmaceutical manufacturers, cleaning/industrial solvent producers, detergents, paints & coatings, cosmetics, food flavor houses, and agrochemical formulators (biopesticides). Limonene as a greener solvent is attractive to manufacturers seeking to reduce petrochemical solvent use.

Export: Regional West African buyers and international buyers (food/cosmetic grade) — build export contracts as capacity and quality certifications (ISO, GRAS/USP where applicable) are achieved.

9.0 Expected benefit of product to Nigeria economy

The project expects to

1. Generate foreign exchange earnings through aggressive export activities, and contributing directly to Nigeria's Gross Domestic Product (GDP).
2. Limit economic leakage through import dependency. It is reported that ₦244.84 million is spent to imported citrus oil into Nigeria from 2016 to 2020
3. Develop value chain, create jobs, and bring economic prosperity to small citrus processing hubs, which will earn extra revenue by selling dried citrus waste peels.

4. Generate new revenue stream; by transforming waste into marketable commodity. Businesses can create new sources of income.
5. Encourages development of downstream industries (biobased cleaning products, pharmaceuticals, flavors, cosmetics), strengthening Nigeria's chemical manufacturing base.

Conclusion

Commercial limonene production from citrus peel is a practical, green, and economically attractive opportunity for Nigeria: it monetizes agro-waste, supports rural incomes, substitutes imported solvents, and feeds growing global demand for biodegradable terpenes. With a conservative pilot, modular scaling, and targeted market development, the Nigerian Limonene Waste to Wealth Initiative (NL2WI) can be cash-positive and catalyze a new biochemicals cluster in the country.

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