Review

Natural-Based Composites: A Framework for Interpreting Engineering Evidence

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Table S1A: Matrix-platform evidence map: material system, formulation, and processing descriptors. Reported: Clearly stated in the article. Partially reported: Mentioned, but incomplete, ambiguous, or lacking key detail. Not reported: Not stated in the article.

Ref.	Matrix platform	Matrix family / grade	Bio-based status / origin basis	Reinforcement or filler paired in study	Processing route	Key processing conditions reported?	Pre-conditioning / moisture state reported?	Defect state / porosity reported?
[1]	Bio-based polymer	PBS, BioPBS FZ71PB	Commercial bio-based PBS grade	Neat control	0 wt.%	Vacuum drying followed by melt blending, compression molding, and injection molding.	Reported	Reported
[1]	Bio-based polymer	PBS, BioPBS FZ71PB	Commercial bio-based PBS grade	NFC	40 wt.% NFC	Vacuum drying followed by melt blending, compression molding, and injection molding.	Reported	Reported
[1]	Bio-based polymer	PBS, BioPBS FZ71PB	Commercial bio-based PBS grade	Hybrid NFC/MCC	12 wt.% NFC with 28 wt.% MCC (40 wt.% total)	Vacuum drying followed by melt blending, compression molding, and injection molding.	Reported	Reported
[1]	Bio-based polymer	PBS, BioPBS FZ71PB	Commercial bio-based PBS grade	MCC	40 wt.% MCC	Vacuum drying followed by melt blending, compression molding, and injection molding.	Reported	Reported

[2]	Bio-based polymer	PLA	Bio-based; article states PLA is produced from beets, corn, and wheat; commercial PLA granules used	Sisal fiber	10, 20, and 30 wt.%	Compression molding	Reported	Reported
[2]	Conventional polymer matrix	Unsaturated polyester resin, grade ECMALON 4413	Conventional commercial resin; bio-based origin not reported	Sisal fiber	10, 20, and 30 wt.%	Hand lay-up	Reported	Partially reported
[3]	Bio-based polymer	PLA 4032D	Bio-based PLA; starch-derived origin stated in the article; commercial pellets supplied by NatureWorks	Short plant fibers: flax, jute, and ramie; alkali- and silane-treated, with untreated flax comparator at 40 wt.%	10–50 wt.% for flax content series; 40 wt.% for fiber-type and treatment comparison	Twin-screw extrusion with injection molding	Reported	Partially reported
[4]	Bio-based polymer	PLA, NaturePlast PLI005	Fully biodegradable PLA-based composite; commercial bio-based PLA matrix	Basket-weave flax fabric, untreated and APPT plasma-treated	60 wt.% fiber	PLA sheet pressing followed by hand lay-up and compression molding.	Reported	Reported
[5]	Bio-based polymer	PLA, NatureWorks Ingeo 3260 HP	Biodegradable PLA commercial grade	Neat control	0 wt.%	Solvent-assisted premixing with injection moulding	Reported	Partially reported

[5]	Bio-based polymer	PLA, NatureWorks Ingeo 3260 HP	Biodegradable PLA commercial grade	Flax fibres	10 wt.%	Solvent-assisted premixing with injection moulding	Reported	Partially reported
[5]	Bio-based polymer	PLA, NatureWorks Ingeo 3260 HP	Biodegradable PLA commercial grade	Sheep wool fibres	10 wt.%	Solvent-assisted premixing with injection moulding	Reported	Partially reported
[6]	Bio-based polymer	PLA, Ingeo™ 2003D (NATURAL grade)	Biodegradable/bio-based PLA matrix; lignocellulosic filler recovered from sorghum biomass	Sorghum leaf and stem fibrous fillers, milled and fractionated to <0.25 mm	5, 10, 15 wt.%	Single-screw extrusion, re-extrusion for homogenization, and injection molding	Reported	Partially reported
[7]	Bio-based polymer	PLA, Ingeo 4032D	Commercial biopolymer / biodegradable aliphatic polyester	Jute fiber	10, 20, and 30 wt.% (main comparative results reported at 30 wt.%)	Alkali treatment followed by drying, melt compounding via extrusion, and compression molding.	Reported	Reported
[7]	Bio-based polymer	PBS, Bionolle 1001	Commercial biopolymer / biodegradable aliphatic polyester	Jute fiber	10, 20, and 30 wt.% (main comparative results reported at 30 wt.%)	Alkali treatment followed by drying, melt compounding via extrusion, and compression molding.	Reported	Reported
[7]	Petroleum-based polymer	PP, H110MA	Petroleum-based thermoplastic / MA-compatibilized system	Jute fiber	10, 20, and 30 wt.% (main comparative results reported at 30 wt.%)	Alkali treatment followed by drying, melt compounding via extrusion, and compression molding.	Reported	Reported

[7]	Petroleum-based polymer	PE, HDPE 5502	Petroleum-based thermoplastic / MA-compatibilized system	Jute fiber	10, 20, and 30 wt.% (main comparative results reported at 30 wt.%)	Alkali treatment followed by drying, melt compounding via extrusion, and compression molding.	Reported	Reported
[8]	Bio-based polymer	PHBV, Enmat Y1000	Biodegradable PHA-family biopolymer from renewable/secondary sources	Hemp short fiber	30 wt.%	Drying followed by single-screw extrusion and injection molding.	Reported	Reported
[8]	Bio-based polymer	PHBV, Enmat Y1000	Biodegradable PHA-family biopolymer from renewable/secondary sources	Flax short fiber	30 wt.%	Drying followed by single-screw extrusion and injection molding.	Reported	Reported
[8]	Bio-based polymer	PHBV, Enmat Y1000	Biodegradable PHA-family biopolymer from renewable/secondary sources	Wood short fiber	30 wt.%	Drying followed by single-screw extrusion and injection molding.	Reported	Reported
[9]	Bio-based polymer	PHBV, PHI 002	Fully biodegradable bacterial polyester from the PHA family	Nettle stalk fibers	15 wt.%	Twin-screw compounding followed by injection molding.	Reported	Reported
[9]	Bio-based polymer	PHBV, PHI 002	Fully biodegradable bacterial polyester from the PHA family	Nettle leaves fibers	15 wt.%	Twin-screw compounding followed by injection molding.	Reported	Reported

[9]	Bio-based polymer	PHBV, PHI 002	Fully biodegradable bacterial polyester from the PHA family	Pine cone flour	15 wt.%	Twin-screw compounding followed by injection molding.	Reported	Reported
[9]	Bio-based polymer	PHBV, PHI 002	Fully biodegradable bacterial polyester from the PHA family	Walnut shell flour	15 wt.%	Twin-screw compounding followed by injection molding.	Reported	Reported
[10]	Bio-based polymer	PHBV (HV 14–16 wt.%), biosynthesized in lab-scale bioreactor	Biodegradable PHA-family biopolymer derived from waste vegetable oil	Neat control	0 wt.%	PHBV biosynthesis and recovery followed by compression molding.	Reported	Partially reported
[10]	Bio-based polymer	PHBV (HV 14–16 wt.%)	Biodegradable PHA-family biopolymer derived from waste vegetable oil	Untreated pistachio shell flour (S)	20, 30, and 40 wt.%	Melt mixing and compression molding.	Reported	Partially reported
[10]	Bio-based polymer	PHBV with 5 wt.% PHBV-MA compatibilized matrix	Biodegradable PHA-family biopolymer derived from waste vegetable oil; compatibilized with maleated PHBV	Untreated pistachio shell flour (S)	20, 30, and 40 wt.%	Maleated PHBV preparation, melt mixing and compression molding.	Reported	Partially reported
[10]	Bio-based polymer	PHBV with 5 wt.% PHBV-MA compatibilized matrix	Biodegradable PHA-family biopolymer derived from waste vegetable oil; compatibilized with maleated PHBV	Alkali- and silane-treated pistachio shell flour (TS).	20, 30, and 40 wt.%	Maleated PHBV prepara-tion, melt mixing and compression molding.	Reported	Partially reported

[11]	Bio-based polymer	PHBV, ENMAT PHBV resin Y1000P	Biobased and biodegradable PHA copolyester	Softwood sawdust (SD)	13 and 30 wt.%; soil burial tested at 13 wt.%	Twin-screw microcompounding and injection molding	Reported	Reported
[11]	Bio-based polymer	PHBV, ENMAT PHBV resin Y1000P	Biobased and biodegradable PHA copolyester	Chitin from shrimp shells	13 and 30 wt.%; soil burial tested at 13 wt.%	Twin-screw microcompounding and injection molding	Reported	Reported
[11]	Bio-based polymer	PHBV, ENMAT PHBV resin Y1000P	Biobased and biodegradable PHA copolyester	Human hair waste (HHW)	13 and 30 wt.%; soil burial tested at 13 wt.%	Twin-screw microcompounding and injection molding	Reported	Reported
[12]	Bio-based polymer	PHBV, ENMAT Y1000P (HB/HV 92:8)	Commercial biobased and biodegradable PHBV produced by bacterial fermentation	Diss fibers in untreated and treated forms (UNDF, ATDF, APTDF, ASTDF)	20 wt.%	Fiber treatment, melt compounding and thermocompression molding	Reported	Reported
[13]	Bio-based polymer	PHBV, EnmatY1000P	Bio-based and biodegradable PHA copolymer (HB:HV 98:2)	Regenerated cellulose fibers (RCFs)	20 wt.%	Double pultrusion, involving single-screw coating followed by twin-screw homogenization, and subsequent injection molding.	Reported	Reported

[14]	Bio-based polymer	PHBV (ENMAT Y1000P), plasticized with TBC	Bacterial polyester; renewable, biodegradable, biocompatible; described as home-compostable	Cellulose fiber (UBK pulp) with MA-g-PHBV compatibilizer	CF: 10–25 wt.%; TBC: 20 wt.%; MA-g-PHBV: 3–7 wt.%	Reactive extrusion of the compatibilizer followed by micro-extrusion and injection molding.	Reported	Reported
[15]	Bio-based polymer	PHBV, ENMAT Y1000P, 3% hydroxyvalerate	Commercial bio-based and biodegradable polyester matrix	Horchata solid residue (HSR) from tiger nut (Cyperus esculentus L.)	0, 10, 20, 30, 40 wt.%	Melt blending in internal mixer, cold grinding and compression molding	Reported	Reported
[16]	Bio-based polymer	Thermoplastic starch (TPS)	Starch-derived, renewable, biodegradable; commercial TPS supplied by Eco Chem., Technology Pvt. Ltd., India	Alkali-treated water hyacinth filler/short fibers (WHF); glyoxal and glycerol used as additives	WHF: 0–5 wt.% of TPS solid weight; glyoxal: 10 wt.%; glycerol: 10 wt.%	Twin-screw extrusion/compounding and hot-press compression molding	Reported	Reported
[17]	Bio-based polymer	Thermoplastic cornstarch (TPS)	Cornstarch-based biodegradable polymer matrix	Sisal fiber	10, 20, and 30 wt.% fiber; alkali treatment at 6, 12, and 18 wt.%	Sisal extraction followed by alkali treatment, starch gelatinization and plasticization, manual mixing, solution casting, and low-temperature drying.	Reported	Partially reported
[18]	Bio-based polymer	PHBV (Enmat Y1000)	Commercial bio-based and biodegradable PHBV of	Wood fibres, $CaCO_3$, PBAT-g-MAH (Ad1), PBAT-g-GMA	10 wt.% wood; 3 wt.% $CaCO_3$; optional 10 wt.% Ad1 or	Sieving and initial drying followed by twin-screw compounding and	Reported	Reported

			microbial origin	(Ad2), and TA.Fe-functionalised wood	Ad2	extrusion, pelletizing, redrying, injection molding, and FGF assessment.		
[19]	Biodegradable polymer blend	PHBV/PBAT (PHI 002 / PBE 006)	Hybrid biodegradable blend: PHBV is bio-based and biodegradable, while PBAT is biodegradable but not bio-based	Rice straw (RS) lignocellulosic filler	RS at 20, 30, and 40 w/w %; PHBV:PBAT ratios of 80:20, 50:50, and 20:80	Melt compounding and compression molding	Reported	Reported
[20]	Bio-based polymer	Chitosan bioresin matrix cross-linked with genipin and plasticized with sorbitol	Chitosan-based renewable biopolymer matrix	Banana short fiber	4 wt.% banana fiber; 0.2% (w/v) genipin; 40% (w/v) sorbitol	Solution preparation followed by fiber dispersion, solution casting, vacuum-oven drying and curing, and final drying at room temperature.	Reported	Reported
[21]	Biodegradable polymer	PCL	Biodegradable thermoplastic polyester; commercial grade; bio-based origin not reported	Wood fibers (WF), untreated and citric-acid-treated	5, 10, 20 wt.% WF; treated series at 10 wt.% WF with 0.05, 0.25, 1.00 M CA	Melt compounding in internal mixer and compression molding	Reported	Partially reported
[22]	Biodegradable polymer	Cellulose acetate (CA)	Semi-synthetic cellulose derivative; biodegradable/renewable cellulose-based matrix	Hydroxyapatite (HA) synthesized from chicken eggshells	0, 5, 10, 15, 20 wt% HA	Film casting and phase inversion	Reported	Not reported

[23]	Bio-based polymer	Casein-based matrix (commercial lactic casein)	Bio-based matrix derived from surplus waste milk; natural protein-based matrix	Recycled cellulose fibers from cigarette butts	50 wt.%	Manual mixing, compression moulding and oven drying	Reported	Reported
[23]	Bio-based polymer	Casein-based matrix (commercial lactic casein)	Bio-based matrix derived from surplus waste milk; natural protein-based matrix	Recycled cellulose acetate fibers from cigarette butts	50 wt.%	Manual mixing, compression moulding and oven drying	Reported	Reported
[24]	Bio-based polymer	Chitosan	Bio-based biodegradable polysaccharide matrix	Soy protein isolate nanofibers (SPIFs) with morphology varied by fibrillation time	Optimized formulation: 3% chitosan, 3% citric acid, and 15% of 2% (w/v) SPIF solution; morphology varied as W-4, W-8, W-12, W-24	SPI hydration, acidified aqueous fibrillation, blending/cross-linking with chitosan, solution casting and oven drying	Reported	Partially reported
[25]	Bio-based polymer / polysaccharide film	Chitosan	Natural polysaccharide derived from chitin	None	0 wt.% MNF	Solution casting followed by oven drying and storage in a desiccator.	Reported	Reported
[25]	Bio-based polymer	Polyvinyl alcohol (PVA)	Synthetic yet biodegradable water-soluble polymer	None	0 wt.% MNF	Solution casting followed by oven drying and storage in a desiccator.	Reported	Reported

[25]	Biodegradable synthetic polymer	CHI/PVA (1:1 blend)	Partially bio-based biodegradable blend	None	0 wt.% MNF	Solution casting followed by oven drying and storage in a desiccator.	Reported	Reported
[25]	Biopolymer/synthetic biodegradable blend	CHI/PVA/MNF	Partially bio-based biodegradable blend	Mushroom nanofibers (MNFs)	0.5 wt.% MNF	MNF extraction followed by solution casting, oven drying, and storage in a desiccator.	Reported	Reported
[25]	Biopolymer/synthetic biodegradable blend	CHI/PVA/MNF	Partially bio-based biodegradable blend	Mushroom nanofibers (MNFs)	1 wt.% MNF	MNF extraction followed by solution casting, oven drying, and storage in a desiccator.	Reported	Reported
[25]	Biopolymer/synthetic biodegradable blend	CHI/PVA/MNF	Partially bio-based biodegradable blend	Mushroom nanofibers (MNFs)	2 wt.% MNF	MNF extraction followed by solution casting, oven drying, and storage in a desiccator.	Reported	Reported
[25]	Biopolymer/synthetic biodegradable blend	CHI/PVA/MNF	Partially bio-based biodegradable blend	Mushroom nanofibers (MNFs)	5 wt.% MNF	MNF extraction followed by solution casting, oven drying, and storage in a desiccator.	Reported	Reported
[26]	Biopolymer/synthetic	Chitosan	Natural polysaccharide-based biopolymer blend	Jute fiber-free control	0 wt.% JT	Solution preparation followed by casting, air drying, and	Reported	Reported

	biodegradable blend					conditioning.		
[26]	Bio-based polymer	Chitosan	Natural polysaccharide-based biopolymer blend	NaOH-pretreated jute fiber	1 wt.% JT	Alkaline pretreatment followed by solution casting, air drying, and conditioning.	Reported	Reported
[26]	Bio-based polymer	Chitosan	Natural polysaccharide-based biopolymer blend	NaOH-pretreated jute fiber	1.25 wt.% JT	Alkaline pretreatment followed by solution casting, air drying, and conditioning.	Reported	Reported
[26]	Bio-based polymer	Chitosan	Natural polysaccharide-based biopolymer blend	NaOH-pretreated jute fiber	1.5 wt.% JT	Alkaline pretreatment followed by solution casting, air drying, and conditioning.	Reported	Reported
[27]	Bio-based polymer	PCL	Biodegradable aliphatic polyester	Bamboo powder	0 wt.%	Solvent casting followed by oven drying and compression molding.	Reported	Reported
[27]	Bio-based polymer	PCL	Biodegradable aliphatic polyester	Bamboo powder	10 wt.%	Solvent casting followed by oven drying and compression molding.	Reported	Reported
[27]	Bio-based polymer	PCL	Biodegradable aliphatic polyester	Bamboo powder	20 wt.%	Solvent casting followed by oven drying and compression molding.	Reported	Reported

[27]	Bio-based polymer	PCL	Biodegradable aliphatic polyester	Bamboo powder	30 wt.%	Solvent casting followed by oven drying and compression molding.	Reported	Reported
[27]	Bio-based polymer	PCL	Biodegradable aliphatic polyester	Bamboo powder	40 wt.%	Solvent casting; oven drying; hot pressing.	Reported	Reported

Table S1B. Matrix-platform evidence map: testing context, performance outcomes, and reporting gaps.

Ref.	Test context reported? (standard + condition)	Main property domain assessed	Main finding	Feedstock provenance reported?	Durability / retention metrics reported?	End-of-life evidence type reported?	Cross-study interpretability	Main reporting gap
[1]	Partially reported	Thermal, thermomechanical, mechanical, surface, and biodegradation	The neat PBS control showed the highest tensile strength and elongation, but lower stiffness and slower compost disintegration than cellulose-filled composites.	Partially reported	Partially reported	Reported	Moderate	No quantitative defect/porosity metrics and no retained-property data after degradation or exposure.
[1]	Partially reported	Thermal, thermomechanical, mechanical, surface, and biodegradation	The 40% NFC formulation markedly increased stiffness, but showed more voids and micropores, lower tensile strength and elongation, and faster compost disintegration than neat PBS.	Partially reported	Partially reported	Reported	Moderate	Defect description is qualitative only; quantitative porosity data and fully standardized test reporting are missing.
[1]	Partially reported	Thermal, thermomechanical, mechanical, surface, and biodegradation	The 3/7 formulation combined high stiffness, better dispersion, and the highest T5% among the composites, while also disintegrating faster than neat	Partially reported	Partially reported	Reported	Moderate	Defect evaluation remains qualitative, and retained properties after degradation were not reported.

			PBS under composting conditions.					
[1]	Partially reported	Thermal, thermomechanical, mechanical, surface, and biodegradation	The 40% MCC formulation showed better dispersion than 40% NFC, high stiffness, the highest tensile strength among the filled systems, and slightly faster compost disintegration than NFC-richer formulations.	Partially reported	Partially reported	Reported	Moderate	Porosity and interfacial coverage were not quantified, and no property-retention data after aging or composting were provided.
[2]	Reported	Water uptake and diffusion coefficient	Water uptake increased with sisal loading, followed Fickian behavior, and reached 23.36% at maximum loading, with D = 17.58 × 10^{-7} mm^2/s.	Reported	Partially reported	Not reported	Moderate	No direct porosity/void quantification; no fiber geometry/aspect ratio; no retention of mechanical properties after moisture exposure.
[2]	Reported	Water uptake and diffusion coefficient	Water uptake increased with sisal loading, followed Fickian behavior, and reached 22.39% at maximum loading, with D = 16.50 × 10^{-7} mm^2/s; moisture resistance was slightly better than sisal/PLA.	Reported	Partially reported	Not reported	Moderate	No direct porosity/void quantification; no fiber geometry/aspect ratio; incomplete moisture-state history before processing; no retention of mechanical

								properties after moisture exposure.
[3]	Reported	Tensile performance, interfacial/microstructural characterization, thermal behavior, and performance prediction	Alkali and silane treatments improved fiber–matrix adhesion and tensile performance. Flax provided the most effective reinforcement, with properties reaching their maximum at 40 wt.%. In contrast, the 10 wt.% formulation underperformed because of internal defects, whereas fiber contents above 40 wt.% led to agglomeration and a subsequent decline in performance.	Reported	Not reported	Not reported	Moderate	No durability or retention testing; no end-of-life evidence; defect/porosity reporting is only partly quantitative; full matrix moisture-conditioning history before processing is incomplete.
[4]	Partially reported	Hygrothermal durability, tensile behavior, moisture uptake, and thermal/chemical aging	Under 40 °C / 100% humidity aging up to 42 days, flax/PLA showed rapid stiffness loss and later strength degradation; APPT improved wettability and interfacial adhesion but had negligible effect on tensile-property retention.	Reported	Reported	Not reported	Moderate	No quantitative porosity/void dataset; tensile test standard not explicitly stated; no end-of-life/biodegradation evidence.

[5]	Reported	Mechanical, thermomechanical, thermal, surface, and degradation behaviour	Neat PLA showed poor UV resistance and degraded mainly under UV exposure, while it changed only slightly in the composter simulating the natural environment.	Reported	Reported	Reported	Moderate	No quantitative porosity/interfacial-defect data and no standardized long-term compost mass-loss metric.
[5]	Reported	Mechanical, thermomechanical, thermal, surface, and degradation behaviour	Flax at 10 wt.% improved flexural properties relative to neat PLA, slowed UV-driven deterioration, and moderately accelerated soil degradation.	Reported	Reported	Reported	Moderate	No quantitative porosity/interfacial-defect data and no standardized long-term compost mass-loss metric.
[5]	Reported	Mechanical, thermomechanical, thermal, surface, and degradation behaviour	Wool at 10 wt.% kept properties near or below neat PLA, slowed UV degradation, and clearly accelerated compost-like soil degradation because of its hygroscopic nature.	Reported	Reported	Reported	Moderate	No quantitative porosity/interfacial-defect data and no standardized long-term compost mass-loss metric.
[6]	Reported	Tensile, impact, thermal, thermomechanical, density, and morphology	Stem-derived filler showed a better stiffness–ductility balance, better dispersion, and better interfacial adhesion than leaf-derived filler, while all filled composites showed reduced impact strength	Reported	Not reported	Not reported	Moderate	No quantitative void/porosity dataset; conditioning history of PLA before compounding is incomplete; no durability aging or end-of-life testing.

			and thermal stability versus neat PLA.					
[7]	Reported	Mechanical, thermal, morphology, water absorption, hydrothermal aging, and biodegradability	PLA–Jute achieved moderate mechanical performance and the highest biodegradability, but also showed high water uptake and notable post-aging strength loss.	Reported	Reported	Reported	Moderate	No quantitative void/porosity analysis; some key comparisons are emphasized mainly at 30 wt.% jute.
[7]	Reported	Mechanical, thermal, morphology, water absorption, hydrothermal aging, and biodegradability	PBS–Jute showed biodegradable behavior close to PLA–Jute, but with lower mechanical robustness, lower crystallinity, and the highest moisture sensitivity among the compared systems.	Reported	Reported	Reported	Moderate	No quantitative void/porosity analysis; some key comparisons are emphasized mainly at 30 wt.% jute.
[7]	Reported	Mechanical, thermal, morphology, water absorption, hydrothermal aging, and biodegradability	PP–Jute with MA delivered the best overall mechanical performance, combining strong interfacial adhesion, low moisture uptake, and minimal biodegradation.	Reported	Reported	Reported	Moderate	No quantitative void/porosity analysis; some key comparisons are emphasized mainly at 30 wt.% jute.

[7]	Reported	Mechanical, thermal, morphology, water absorption, hydrothermal aging, and biodegradability	PE–Jute with MA exhibited the highest thermal stability and maintained strong durability under humid conditions, although its biodegradation was very limited.	Reported	Reported	Reported	Moderate	No quantitative void/porosity analysis; some key comparisons are emphasized mainly at 30 wt.% jute.
[8]	Reported	Mechanical properties, molded-part quality, and water uptake	Hemp-fiber PHBV delivered the best overall performance, with the highest tensile-property improvement, reduced shrinkage, improved molded-part quality, and increased water uptake versus neat PHBV.	Reported	Partially reported	Not reported	Moderate	No direct biodegradation experiment and only qualitative defect/porosity reporting.
[8]	Reported	Mechanical properties, molded-part quality, and water uptake	Flax-fiber PHBV substantially increased stiffness and tensile strength and reduced shrinkage, but also raised water absorption relative to neat PHBV.	Reported	Partially reported	Not reported	Moderate	No direct biodegradation experiment and only qualitative defect/porosity reporting.
[8]	Reported	Mechanical properties, molded-part quality, and water uptake	Wood-fiber PHBV increased stiffness and hardness and reduced shrinkage, but showed poorer adhesion, lower tensile strength than neat PHBV, and less favorable	Reported	Partially reported	Not reported	Moderate	No direct biodegradation experiment and only qualitative defect/porosity reporting.

			dispersion than flax- and hemp-filled systems.					
[9]	Reported	Tensile, flexural, impact, thermal, and hydrodegradation behavior	Stiffness improved while tensile strength decreased slightly; among the tested fillers, nettle stalk fibers gave the best stiffness gain and the lowest tensile-strength loss, but water uptake and property loss still increased after hydrolytic incubation.	Reported	Reported	Not reported	Moderate	No quantitative void data; only one filler loading studied; no composting or other end-of-life evidence.
[9]	Reported	Tensile, flexural, impact, thermal, and hydrodegradation behavior	Nettle leaf fibers increased stiffness but caused the largest losses in tensile and impact performance and the weakest hydrolytic retention, consistent with poorer fiber–matrix interaction.	Reported	Reported	Not reported	Moderate	No quantitative void data; only one filler loading studied; no composting or other end-of-life evidence.
[9]	Reported	Tensile, flexural, impact, thermal, and hydrodegradation behavior	Pine cone flour improved stiffness but showed the highest water uptake during hydrolytic exposure and a clear reduction in strength and thermal	Reported	Reported	Not reported	Moderate	No quantitative void data; only one filler loading studied; no composting or other end-of-life evidence.

			stability relative to neat PHBV.					
[9]	Reported	Tensile, flexural, impact, thermal, and hydrodegradation behavior	Walnut shell flour gave a modest stiffness increase and the best thermal stability among the fillers, but tensile and impact properties still decreased and hydrolytic degradation reduced retention over time.	Reported	Reported	Not reported	Moderate	No quantitative void data; only one filler loading studied; no composting or other end-of-life evidence.
[10]	Reported	Mechanical, thermal, morphology, water absorption, and soil-burial biodegradability	Neat PHBV showed the lowest stiffness and biodegradation rate among the studied formulations, while retaining structural integrity longer than the filled composites.	Reported	Reported	Reported	Moderate	No quantitative porosity/interphase metrics and incomplete processing-moisture history for all constituents.
[10]	Reported	Mechanical, thermal, morphology, water absorption, and soil-burial biodegradability	Untreated pistachio shell increased stiffness, crystallinity, water absorption, and biodegradation, but high filler loading generated voids and reduced tensile strength unless compatibilized.	Reported	Reported	Reported	Moderate	No quantitative defect analysis and limited particle-size distribution detail beyond sieve mesh.

[10]	Reported	Mechanical, thermal, morphology, water absorption, and soil-burial biodegradability	PHBV-MA improved filler wetting and interfacial adhesion, raising tensile and impact performance of untreated-shell composites while maintaining high biodegradation at high filler loadings.	Reported	Reported	Reported	Moderate	No quantitative porosity/interphase metrics and limited particle-size distribution detail beyond sieve mesh.
[10]	Reported	Mechanical, thermal, morphology, water absorption, and soil-burial biodegradability	The PHBV/PHBV-MA/TS system gave the best overall interfacial quality and the highest tensile, modulus, impact, and thermal-stability improvements, while still showing very high soil-burial biodegradation at 40 wt.% filler.	Reported	Reported	Reported	Moderate	No quantitative porosity/interphase metrics and limited particle-size distribution detail beyond sieve mesh.
[11]	Partially reported	Tensile, thermal, and soil biodegradation	Sawdust reinforced PHBV to some extent, increasing tensile strength at break at higher loading, and also accelerated soil biodegradation compared with neat PHBV.	Reported	Partially reported	Reported	Moderate	Mechanical testing conditions were given, but standards were not explicitly stated; defect state was qualitative only; biodegradation was evaluated only at 13 wt.%.
[11]	Partially reported	Tensile, thermal, and soil biodegradation	Chitin did not provide a clear reinforcing effect on tensile strength, but it	Reported	Partially reported	Reported	Moderate	Mechanical testing conditions were given, but standards were not explicitly stated;

			increased soil biodegradation relative to neat PHBV.					defect state was qualitative only; biodegradation was evaluated only at 13 wt.%.
[11]	Partially reported	Tensile, thermal, and soil biodegradation	Human hair waste did not reinforce tensile strength, but it produced the fastest soil biodegradation, with about 35% weight loss after five months.	Reported	Partially reported	Reported	Moderate	Mechanical testing conditions were given, but standards were not explicitly stated; defect state was qualitative only; biodegradation was evaluated only at 13 wt.%.
[12]	Reported	Mechanical, thermal, crystallinity, morphology, and water uptake	Alkali-silane treated Diss fiber gave the best overall balance, improving interfacial adhesion, flexural modulus, Shore D hardness, HDT, and lowering water uptake versus untreated fiber composite.	Reported	Not reported	Not reported	Moderate	No quantitative porosity/defect metrics and no durability or end-of-life validation.
[13]	Reported	Mechanical, optical, rheological, thermal, and accelerated-aging durability	RCFs strongly improved the toughness and strength of PHBV, but hydrolytic aging in water and aqueous media, especially at 70 °C, caused major property loss through surface	Reported	Reported	Not reported	Moderate	No end-of-life biodegradation evidence and no quantitative interfacial-defect/porosity metrics.

			erosion and polymer-chain degradation.					
[14]	Reported	Mechanical, rheological, thermal, and interfacial/morphological performance	At up to 25 wt.% CF, the compatibilized PHBV/TBC biocomposites showed improved interfacial adhesion and better tensile, flexural, HDT, and rheological performance than the uncompatibilized systems, with the highest-grafting MA-g-PHBV being the most effective.	Reported	Not reported	Not reported	Moderate	No quantitative porosity/void-content data, no durability retention study, and no experimental end-of-life validation despite compostability claims.
[15]	Reported	Mechanical, barrier, thermal, optical and antioxidant performance	HSR reduced tensile strength and elongation, increased opacity and water vapor permeability, and provided antioxidant activity; stiffness increased or was maintained at low filler contents (up to about 20 wt.%).	Yes	Not reported	Not reported	Moderate	No quantitative porosity/void fraction, no durability-retention study, and no end-of-life validation for the composites.
[16]	Reported	Mechanical, moisture uptake, thermal stability, biodegradation, and cytotoxicity	The TW2 formulation with 2 wt.% WHF gave the best overall balance, with strong gains in tensile and flexural performance, while higher filler contents	Reported	Partially reported	Reported	Moderate	No quantitative porosity/void-content dataset; filler geometry remains incomplete; no post-exposure

			increased brittleness, agglomeration, porosity-related defects, and moisture uptake.					mechanical retention dataset.
[17]	Reported	Tensile strength, water absorption, and biodegradability	An optimized sisal-reinforced thermoplastic cornstarch biocomposite for packaging was obtained at 30 wt.% fiber and 18 wt.% alkali treatment, combining improved tensile strength, acceptable water absorption, and high biodegradability.	Reported	Partially reported	Reported	Moderate	No quantitative defect/porosity analysis, incomplete moisture-state reporting during processing, and limited fiber-geometry detail beyond chopped length.
[18]	Reported	Thermal, mechanical, rheological, morphological, crystallinity, and processability	Wood generally reduced tensile strength and elongation, but TA.Fe-functionalised wood gave mechanical performance closest to neat PHBV with higher Young's modulus, while Ad2 gave the best thermal stability among the composite formulations.	Reported	Not reported	Not reported	Moderate	Defect state was only qualitative; no durability/retention or end-of-life testing; no quantitative porosity/void analysis.
[19]	Reported	Mechanical, barrier, thermal, microstructural,	Smaller RS particles and higher PHBV content improved homogenization and interfacial adhesion;	Reported	Not reported	Reported	Moderate	Defect/porosity state was described mainly qualitatively and only for selected

		disintegration/biodegradation, and environmental	RS increased rigidity and contact angle but generally reduced ductility, thermal stability, crystallinity, and barrier performance; only 80:20 blends met ISO 20200 disintegration requirements.					formulations; no retention/durability testing after aging or service exposure was reported.
[20]	Reported	Mechanical, thermal, moisture uptake, UV-blocking, antibacterial, and biodegradation	The CT/BF composite combined tensile strength above 10.5 MPa, improved stiffness and thermal stability, high UV-blocking, antibacterial activity, and complete biodegradability within about one month.	Reported	Partially reported	Reported	Moderate	No quantitative porosity/interfacial-defect metrics and no post-exposure retained-property analysis.
[21]	Reported	Interfacial adhesion, tensile/mechanical, water uptake, wettability, rheology, and thermal behavior	CA-treated WF/PCL composites showed improved fiber/matrix adhesion, higher yield strength, reduced water uptake, and slightly higher Vicat softening temperature than untreated WF/PCL systems.	Reported	Partially reported	Not reported	Moderate	No biodegradation or composting evidence, no quantitative porosity/void analysis, and no retained mechanical properties after water exposure.
[22]	Partially reported	Mechanical, thermal, water-vapor barrier, and antibacterial performance	HA addition improved mechanical strength, thermal stability, barrier performance, and	Reported	Not reported	Not reported	Moderate	No end-of-life/biodegradation evidence; no formal conditioning history before testing;

			antibacterial function, while CA/HA.15 provided the best overall balance for packaging applications.					pore/defect description remained qualitative or limited.
[23]	Reported	Flexural, shear, and impact mechanical performance	Recycled cellulose-reinforced casein composites outperformed cellulose acetate composites, showing higher flexural modulus/strength, shear strength, and impact strength.	Reported	Not reported	Not reported	Moderate	No quantitative void/porosity analysis; panel thickness variability due to shrinkage; no durability or biodegradation testing.
[23]	Reported	Flexural, shear, and impact mechanical performance	Recycled cellulose acetate-reinforced casein composites showed lower stiffness and strength and more brittle behavior, consistent with weaker fiber–matrix adhesion.	Reported	Not reported	Not reported	Moderate	No quantitative void/porosity analysis; panel thickness variability due to shrinkage; no durability or biodegradation testing.
[24]	Reported	Mechanical, gas selectivity/barrier, wet stability, fruit-preservation performance, degradability, and recyclability	Medium-length SPIFs produced after 12 h fibrillation yielded the best overall balance, markedly improving tensile performance and elongation while enhancing CO_2/O_2 selectivity and cherry tomato preservation.	Reported	Reported	Reported	Moderate	Defect state was only qualitatively described; filler loading was reported as solution addition rather than dry-filler wt.%; gas-selectivity mechanism still needs deeper clarification.

[25]	Reported	Mechanical, moisture/barrier, biodegradation, and food preservation	Neat CHI showed high stiffness but low tensile strength and elongation, the highest moisture absorption and WVP, and slower soil-burial disintegration than PVA.	Reported	Partially reported	Reported	Moderate	No quantitative defect/porosity data and no retained post-exposure film-property measurements.
[25]	Reported	Mechanical, moisture/barrier, biodegradation, and food preservation	Neat PVA showed the highest flexibility and the lowest WVP among the controls, but it degraded fastest during soil burial.	Reported	Partially reported	Reported	Moderate	No quantitative defect/porosity data and no retained post-exposure film-property measurements.
[25]	Reported	Mechanical, moisture/barrier, biodegradation, and food preservation	The CHI/PVA control provided a balanced tensile response with intermediate moisture absorption and WVP, serving as the baseline matrix for MNF reinforcement.	Reported	Partially reported	Reported	Moderate	No quantitative defect/porosity data and no retained post-exposure film-property measurements.
[25]	Reported	Mechanical, moisture/barrier, biodegradation, and food preservation	At 0.5 wt.% MNF, tensile strength increased strongly while high elongation was retained and both moisture absorption and WVP decreased relative to CHI/PVA.	Reported	Partially reported	Reported	Moderate	Film defects were not quantified, and post-exposure retained film properties were not measured.

[25]	Reported	Mechanical, moisture/barrier, biodegradation, and food preservation	The 1 wt.% MNF film combined high tensile strength, major stiffness enhancement, lower moisture absorption/WVP, and the best strawberry preservation up to 7 days.	Reported	Partially reported	Reported	Moderate	Film defects were not quantified, and post-exposure retained film properties were not measured.
[25]	Reported	Mechanical, moisture/barrier, biodegradation, and food preservation	At 2 wt.% MNF, stiffness and barrier performance improved further, but tensile strength and elongation decreased compared with the 0.5–1 wt.% films.	Reported	Partially reported	Reported	Moderate	Film defects were not quantified, and post-exposure retained film properties were not measured.
[25]	Reported	Mechanical, moisture/barrier, biodegradation, and food preservation	The 5 wt.% MNF film achieved the highest Young's modulus and the lowest WVP/moisture absorption, but tensile strength and elongation dropped markedly, likely because of fiber aggregation and micro-defects.	Reported	Partially reported	Reported	Moderate	Aggregation/micro-defects were only discussed qualitatively, and no retained post-exposure film properties were reported.
[26]	Reported	Mechanical, barrier, optical, antimicrobial, antioxidant, and biodegradation	The CS/GG control film showed the highest transparency and the fastest biodegradation, but lower hydrophobicity and weaker barrier/mechanical	Reported	Reported	Reported	Moderate	No quantitative porosity/interfacial-defect metrics and no post-exposure retained mechanical-property analysis.

			performance than jute-reinforced films.					
[26]	Reported	Mechanical, barrier, optical, antimicrobial, antioxidant, and biodegradation	Adding 1 wt.% jute improved tensile strength, UV-blocking, moisture resistance, antioxidant activity, and antifungal performance relative to the fiber-free control.	Reported	Reported	Reported	Moderate	No quantitative porosity/interfacial-defect metrics and no post-exposure retained mechanical-property analysis.
[26]	Reported	Mechanical, barrier, optical, antimicrobial, antioxidant, and biodegradation	The 1.25 wt.% jute film gave the best balance of performance, with the highest water contact angle, highest elongation at break, strongest antioxidant activity, and the best structural retention during soil burial.	Reported	Reported	Reported	Moderate	No quantitative porosity/interfacial-defect metrics and no post-exposure retained mechanical-property analysis.
[26]	Reported	Mechanical, barrier, optical, antimicrobial, antioxidant, and biodegradation	The 1.5 wt.% jute film achieved the highest tensile strength and lowest water vapor permeability, while maintaining strong UV-blocking, antimicrobial activity, and slower soil-burial degradation than the control.	Reported	Reported	Reported	Moderate	No quantitative porosity/interfacial-defect metrics and no post-exposure retained mechanical-property analysis.

[27]	Reported	Mechanical, thermal, wettability/porosity, and degradation	Neat PCL showed the lowest porosity and degradation rate, the highest water contact angle, and the lowest tensile, flexural, and hardness values among the studied materials.	Reported	Partially reported	Reported	Moderate	No retained mechanical-property analysis after degradation exposure.
[27]	Reported	Mechanical, thermal, wettability/porosity, and degradation	Adding 10 wt.% bamboo powder modestly improved stiffness, tensile strength, hardness, and degradability relative to neat PCL, while slightly increasing porosity and wettability.	Reported	Partially reported	Reported	Moderate	No retained mechanical-property analysis after degradation exposure.
[27]	Reported	Mechanical, thermal, wettability/porosity, and degradation	At 20 wt.% bamboo powder, the composite showed further gains in tensile/flexural performance and degradation sensitivity, together with higher porosity and lower contact angle than the neat matrix.	Reported	Partially reported	Reported	Moderate	No retained mechanical-property analysis after degradation exposure.
[27]	Reported	Mechanical, thermal, wettability/porosity, and degradation	The 30 wt.% composite combined higher tensile and flexural strength, improved thermal stability, and greater biodegradation than lower-loading	Reported	Partially reported	Reported	Moderate	No retained mechanical-property analysis after degradation exposure.

			systems, but also showed more pores and lower hydrophobicity. The 40 wt.% bamboo powder composite delivered the highest tensile strength, Young's modulus, hardness, thermal stability, porosity, and degradation rate, but the lowest water contact angle.					
[27]	Reported	Mechanical, thermal, wettability/porosity, and degradation		Reported	Partially reported	Reported	Moderate	No retained mechanical-property analysis after degradation exposure.

Table S2A. Reinforcement and bio-derived filler evidence map: filler identity, morphology, compatibility, and reporting descriptors.

References	Reinforcement / filler	Functional role	Morphology / architecture	Matrix category used in study	Surface treatment / compatibilization	Feedstock provenance reported?	Geometry reported? (length, diameter, aspect ratio)	Moisture state at processing reported?
[1]	Nanofibrillated cellulose (NFC)	Bio-derived filler with a structural reinforcement role.	Nanofibrillated cellulose, freeze-dried powder	Biobased polymer	None reported / unmodified cellulose	Reported	Partially reported	Reported
[1]	Hybrid NFC/MCC filler (28/12 wt.%)	Structural bio-derived filler / reinforcement	Hybrid micro/nano cellulose filler	Biobased polymer	None reported / unmodified cellulose	Reported	Partially reported	Reported

[1]	Hybrid NFC/MCC filler (20/20 wt.%)	Structural bio-derived filler / reinforcement	Hybrid micro/nano cellulose filler	Biobased polymer	None reported / unmodified cellulose	Reported	Partially reported	Reported
[1]	Hybrid NFC/MCC filler (12/28 wt.%)	Structural bio-derived filler / reinforcement	Hybrid micro/nano cellulose filler	Biobased polymer	None reported / unmodified cellulose	Reported	Partially reported	Reported
[1]	Microcrystalline cellulose (MCC)	Structural bio-derived filler / reinforcement	Microcrystalline particulate cellulose powder	Biobased polymer	None reported / unmodified cellulose	Reported	Partially reported	Reported
[2]	Sisal fiber	Structural fiber	Layered fiber reinforcement; exact fiber geometry not reported	Biobased polymer	Not reported	Partially reported	Not reported	Reported
[2]	Sisal fiber	Structural fiber	Layered fiber reinforcement; exact fiber geometry not reported	Conventional thermoset polymer	Not reported	Partially reported	Not reported	Not reported
[3]	Flax fiber	Structural fiber / reinforcing fiber	Short plant fiber; fewer cavities than jute; fiber length reduced after processing	Biobased polymer	Alkali and silane treatment; untreated comparator also tested.	Reported	Partially reported	Partially reported
[3]	Jute fiber	Structural fiber / reinforcing fiber	Short plant fiber; more internal cavities than the other fibers	Biobased polymer	Alkali and silane treatment; untreated comparator also tested.	Reported	Partially reported	Partially reported

[3]	Ramie fiber	Structural fiber / reinforcing fiber	Short plant fiber; intermediate reinforcement relative to flax and jute	Biobased polymer	Alkali and silane treatment; untreated comparator also tested	Reported	Partially reported	Partially reported
[4]	Flax fiber fabric	Structural fiber	Woven basket-weave (Panama weave) natural fiber fabric	Biobased polymer	None / untreated	Reported	Partially reported	Reported
[4]	Flax fiber fabric	Structural fiber	Woven basket-weave (Panama weave) natural fiber fabric	Biobased polymer	Atmospheric-pressure plasma torch (APPT) treatment	Reported	Partially reported	Reported
[5]	Flax fibres	Structural reinforcement fibre	Fibre feedstock from low-twist roving; discontinuous fibre in composite form	Biodegradable polymer	None reported	Reported	Partially reported	Not reported
[5]	Sheep wool fibres	Natural filler / degradation-promoting fibre	Short animal fibre cut into several-millimetre pieces	Biodegradable polymer	Washed with soap and water at 60 °C; no compatibilizer reported	Reported	Partially reported	Not reported
[6]	Sorghum leaf fibrous filler	Bio-derived reinforcing filler	Milled lignocellulosic fibrous filler, fraction <0.25 mm	Biobased polymer	Not reported	Reported	Partially reported	Reported
[6]	Sorghum stem fibrous filler	Bio-derived reinforcing filler	Milled lignocellulosic fibrous filler, fraction <0.25 mm	Biobased polymer	Not reported	Reported	Partially reported	Reported

[7]	Jute fiber	Structural fiber	Chopped natural lignocellulosic fiber	Biobased polymer and petroleum-based polymer	5 wt.% NaOH alkali treatment; maleic anhydride compatibilizer used in PP and PE systems	Reported	Partially reported	Reported
[7]	Flax fiber	Structural fiber	Chopped natural lignocellulosic fiber	Biobased polymer and petroleum-based polymer	5 wt.% NaOH alkali treatment; maleic anhydride compatibilizer used in PP and PE systems	Reported	Partially reported	Reported
[7]	Hemp fiber	Structural fiber	Chopped natural lignocellulosic fiber	Biobased polymer and petroleum-based polymer	5 wt.% NaOH alkali treatment; maleic anhydride compatibilizer used in PP and PE systems	Reported	Partially reported	Reported
[7]	Kenaf fiber	Structural fiber	Chopped natural lignocellulosic fiber	Biobased polymer and petroleum-based polymer	5 wt.% NaOH alkali treatment; maleic anhydride compatibilizer used in PP and PE systems	Reported	Partially reported	Reported
[8]	Flax fiber	Structural filler	Short fiber	Biobased polymer	Not reported	Reported	Reported	Reported
[8]	Wood fiber	Structural filler	Irregular short lignocellulosic fiber	Biobased polymer	Not reported	Reported	Reported	Reported

[9]	Nettle stalk fibers	Structural fiber / reinforcing filler	Short fibrillar fiber	Biobased polymer	Alkali treatment (5 wt.% NaOH, 2 h)	Reported	Reported	Reported
[9]	Nettle leaves fibers	Structural fiber / reinforcing filler	Short flake-like fiber	Biobased polymer	Alkali treatment (5 wt.% NaOH, 2 h)	Reported	Reported	Reported
[9]	Pine cone flour	Bio-derived particulate reinforcing filler	Irregular fibrous flour / bundle-like particles	Biobased polymer	Alkali treatment (5 wt.% NaOH, 2 h)	Reported	Reported	Reported
[9]	Walnut shell flour	Bio-derived particulate reinforcing filler	Flour / plate-like particulate	Biobased polymer	Alkali treatment (5 wt.% NaOH, 2 h)	Reported	Reported	Reported
[10]	Pistachio shell flour	Structural / bio-derived filler	Lignocellulosic flour / particulate filler	Biobased polymer	Untreated filler; PHBV-MA used in selected formulations	Reported	Partially reported	Partially reported
[10]	Pistachio shell flour subjected to alkali and silane treatments.	Structural / bio-derived filler	Chemically treated lignocellulosic flour / particulate filler	Biobased polymer	Alkali treatment and silanization, combined with a PHBV-MA compatibilizer.	Reported	Partially reported	Partially reported
[11]	Softwood sawdust (SD)	Bioderived reinforcing filler	Sawdust / wood particulate filler	Biobased polymer	None reported	Reported	Partially reported	Reported

[11]	Chitin from shrimp shells	Bioderived particulate filler	Fine powder / particulate filler	Biobased polymer	None reported	Reported	Partially reported	Reported
[11]	Human hair waste (HHW)	Bioderived fibrous filler	Short keratin fiber / hair fiber	Biobased polymer	None reported	Reported	Reported	Reported
[12]	Diss fiber (Ampelodesmos mauritanicus)	Structural lignocellulosic reinforcement	Short natural fiber / cut fiber ribbons	Biobased polymer	Untreated, alkali, alkali-peroxide, and alkali-silane (TMOS) treatments	Reported	Partially reported	Reported
[13]	Regenerated cellulose fibers (RCFs)	Structural fiber / toughening reinforcement	Filament-derived regenerated cellulose fiber	Biobased polymer	None reported	Reported	Partially reported	Partially reported
[14]	Cellulose fiber (CF) from unbleached northern softwood kraft pulp (UBK)	Structural reinforcement / bioderived filler	Short, ground cellulose fiber obtained from sheets using a cutting mill with 2 mm sieve	Biobased polymer (PHBV/TBC system)	No direct fiber surface treatment reported; compatibilization at composite level with MA-g-PHBV	Reported	Partially reported	Reported
[15]	Tiger nut horchata solid residue (HSR)	Bio-derived multifunctional filler; reduces polymer fraction and adds antioxidant/light-blocking functionality	Irregular lignocellulosic particulate residue with fibrous fragments, starch granules, and lipid-rich dispersed phases	Biobased polymer	No treatment or compatibilizer reported	Reported	Partially reported	Reported

[16]	Water hyacinth filler / short fiber (WHF)	Structural bio-filler / reinforce-ment	Short-fiber / powdered lignocellulosic filler from water hyacinth stem	Biobased polymer	2 wt.% NaOH alkali treatment on WHF; glyoxal used as crosslinker and glycerol as plasti-cizer in TPS	Reported	Partially reported	Reported
[17]	Sisal fiber	Structural fiber	Chopped short natural fiber	Biobased polymer	Alkali treatment (6, 12, and 18 wt.% NaOH); boric acid cross-linker used in matrix system	Reported	Partially reported	Partially re-ported
[18]	Wood fibres (in-cluding TA.Fe-functionalised wood)	Structural filler / reinforcement	Short irregular ligno-cellulosic fibres	Biobased polymer	TA/Fe functionalisa-tion of wood in one formulation; PBAT-g-MAH and PBAT-g-GMA used as compatibilizing modifiers in se-lected blends	Reported	Reported	Reported
[19]	Rice straw (RS)	Bio-derived filler / reinforcement	Milled lignocellulosic particulate filler	Biodegradable poly-mer blend	No surface treat-ment or compatibil-izer specifically ap-plied to RS	Reported	Partially reported	Reported
[20]	Banana fiber	Structural rein-forcement	Short natural fiber	Biobased polymer	None reported / un-treated fiber	Reported	Partially reported	Reported

[21]	Wood fibers (WF), untreated	Structural reinforcement / stiffness enhancer	Lignocellulosic wood fibers	Biodegradable polymer	None	Reported	Partially reported	Not reported
[21]	Citric-acid-treated wood fibers	Structural reinforcement with interfacial enhancement	Surface-etched / roughened / partially fibrillated lignocellulosic fibers	Biodegradable polymer	Citric acid treatment followed by thermal treatment, washing to neutral pH, and drying; esterification on fiber surface reported	Reported	Partially reported	Reported
[22]	Hydroxyapatite (HA) from chicken eggshells	Bio-derived antibacterial mineral filler / reinforcing filler	Particulate/crystalline mineral filler	Biobased polymer	Not reported	Reported	Not reported	Not reported
[23]	Recycled cellulose fibers	Structural reinforcing fiber	Recycled fiber flakes / short fibers	Biobased polymer	NaOH hydrolysis from recycled cellulose acetate; no additional compatibilizer reported	Reported	Reported	Not reported
[23]	Recycled cellulose acetate fibers	Structural reinforcing fiber	Recycled fiber flakes / short fibers	Biobased polymer	Green-process sterilization and water/ethanol washing; no compatibilizer reported.	Reported	Reported	Not reported

[24]	Soy protein isolate nanofibers (SPIFs)	Reinforcing nanofiber / crosslinking and filling phase / gas-selectivity modifier	Morphologically diverse protein nanofibers, ranging from short dispersed fibrils to long entangled mature fibrils	Biobased polymer / polysaccharide film	No direct surface treatment of SPIF reported; compatibilization achieved through blending with chitosan and citric-acid crosslinking	Reported	Reported	Partially reported
[25]	Mushroom nanofibers (MNFs) extracted from oyster mushroom stipes (Pleurotus spp.)	Nano-reinforcement / barrier-enhancing bio-derived filler	Linear, thread-like nanofibers	Biopolymer/synthetic biodegradable blend (CHI/PVA)	Alkaline and UV-assisted treatment; no separate compatibilizer reported.	Reported	Partially reported	Reported
[26]	NaOH-pretreated jute fiber	Structural fiber / bio-derived filler	Chopped short lignocellulosic fiber	Biobased polymer	5 wt.% NaOH alkaline pretreatment	Reported	Partially reported	Reported
[27]	Bamboo powder (BP)	Structural bio-derived filler / particulate reinforcement	Fine powder / particulate filler	Biodegradable polymer	Not reported	Reported	Partially reported	Reported

Table S2B. Reinforcement and bio-derived filler evidence map: processing, conditioning, performance claims, and reporting gaps.

References	Processing route	Defect descriptors reported?	Conditioning / exposure history reported?	Retention metrics reported?	Main result claimed by authors	Cross-study interpretability	Main reporting gap
[1]	Cellulose preparation + vacuum drying + melt blending + compression molding + injection molding	Reported	Reported	Not reported	NFC increased stiffness and storage modulus, but poor dispersion, voids, and micropores limited tensile performance and slowed cross-study ranking.	Moderate	No aspect ratio data and no quantitative interfacial-defect or porosity metrics.
[1]	Cellulose preparation + vacuum drying + melt blending + compression molding + injection molding	Reported	Reported	Not reported	The 7/3 hybrid reduced voids relative to 40% NFC and improved filler dispersion, but surface roughness and incomplete compatibility remained evident.	Moderate	No aspect ratio data and no quantitative interfacial-defect or porosity metrics.
[1]	Cellulose preparation + vacuum drying + melt blending + compression molding + injection molding	Reported	Reported	Not reported	The 5/5 hybrid showed the strongest synergistic reinforcement, highest Young's modulus, smoother fracture morphology, and improved thermo-mechanical performance.	Moderate	No aspect ratio data and no quantitative interfacial-defect or porosity metrics.
[1]	Cellulose preparation + vacuum drying + melt blending + compression	Reported	Reported	Not reported	The 3/7 hybrid combined good dispersion, high modulus, better tensile strength than NFC-richer	Moderate	No aspect ratio data and no quantitative interfacial-defect or porosity metrics.

References	Processing route	Defect descriptors reported?	Conditioning / exposure history reported?	Retention metrics reported?	Main result claimed by authors	Cross-study interpretability	Main reporting gap
	molding + injection molding				systems, and slightly faster compost disintegration.		
[1]	Cellulose preparation + vacuum drying + melt blending + compression molding + injection molding	Reported	Reported	Not reported	MCC showed the best dispersion among the single-filler systems, higher crystallinity and tensile strength than NFC-filled PBS, and slightly faster compost disintegration.	Moderate	No aspect ratio data and no quantitative interfacial-defect or porosity metrics.
[2]	Compression molding	Partially reported	re-Reported	Not reported	Sisal/PLA showed Fickian water uptake that increased with fiber loading, reaching 23.36% at 30 wt.%.	Moderate	Missing fiber geometry and direct defect characterization; no retained mechanical-property data after immersion.
[2]	Hand lay-up	Partially reported	re-Reported	Not reported	Sisal/polyester also showed Fickian water uptake that increased with fiber loading, but moisture resistance was slightly better than sisal/PLA, reaching 22.39% at 30 wt.%.	Moderate	Missing fiber geometry, pre-processing moisture history, and direct defect characterization; no retained mechanical-property data after immersion.
[3]	Fiber cutting + washing + drying + alkali treatment + neutralization +	Reported	Not reported	Not reported	Flax gave the best reinforcement effect; alkali + silane improved	Moderate	No full per-fiber post-processing geometry/aspect ratio dataset;

References	Processing route	Defect descriptors reported?	Conditioning / exposure history reported?	Retention metrics reported?	Main result claimed by authors	Cross-study interpretability	Main reporting gap
	silane treatment + twin-screw compounding + injection molding				interfacial bonding, and performance peaked at 40 wt.% before agglomeration reduced properties at higher content.		PLA moisture conditioning before processing not fully stated; no durability or retention testing.
[3]	Fiber cutting + washing + drying + alkali treatment + neutralization + silane treatment + twin-screw compounding + injection molding	Reported	Not reported	Not reported	Jute reinforced PLA less effectively than flax, likely because its fiber microstructure contained more cavities and weaker reinforcement capacity.	Moderate	No full per-fiber post-processing geometry/aspect ratio dataset; PLA moisture conditioning before processing not fully stated; no durability or retention testing.
[3]	Fiber cutting + washing + drying + alkali treatment + neutralization + silane treatment + twin-screw compounding + injection molding	Reported	Not reported	Not reported	Ramie improved PLA mechanical performance after treatment, but its reinforcement effect remained below flax under the same conditions.	Moderate	No full per-fiber post-processing geometry/aspect ratio dataset; PLA moisture conditioning before processing not fully stated; no durability or retention testing.
[4]	Drying + hand lay-up + compression molding	Reported	Reported	Reported	Untreated woven flax reinforcement in PLA showed rapid hygrothermal degradation, with stiffness dropping sharply within 24 h and strength decreasing after	Moderate	No fiber/yarn diameter or aspect ratio data and no quantitative void/interfacial-defect statistics.

References	Processing route	Defect descriptors reported?	Conditioning / exposure history reported?	Retention metrics reported?	Main result claimed by authors	Cross-study interpretability	Main reporting gap
					about three weeks due to moisture-driven matrix/interface degradation.		
[4]	APPT treatment + dry-ing + hand lay-up + compression molding	Reported	Reported	Reported	APPT treatment greatly improved flax wettability and SEM-observed fiber-matrix adhesion, but had negligible influence on tensile strength and stiffness during hygrothermal aging.	Moderate	No fiber/yarn diameter or aspect ratio data and no quantitative void/interfacial-defect statistics.
[5]	Mechanical mixing with PLA granules + solvent-assisted preparation (DCM) + injection moulding	Partially re-ported	Reported	Partially re-ported	Flax fibres improved the mechanical performance of PLA composites, slowed UV-driven deterioration, and accelerated degradation in soil/compost conditions.	Moderate	No explicit fibre length/diameter/aspect-ratio dataset, no quantitative porosity/void analysis, and no moisture state reported during processing.
[5]	Fibre cleaning/cutting + mechanical mixing with PLA + solvent-assisted preparation (DCM) + injection moulding	Partially re-ported	Reported	Partially re-ported	Wool fibres strongly accelerated soil/compost degradation due to their hygroscopicity, but high wool loading reduced the mechanical properties of PLA composites.	Moderate	No diameter/aspect-ratio data, no quantitative interfacial-defect or porosity metrics, and no processing moisture-state information.

References	Processing route	Defect descriptors reported?	Conditioning / exposure history reported?	Retention metrics reported?	Main result claimed by authors	Cross-study interpretability	Main reporting gap
[6]	Drying + milling + fractionation + single-screw extrusion + re-extrusion + injection molding	Reported	Reported	Not reported	Leaf-derived filler increased stiffness, but promoted greater brittleness, agglomeration, voids, and interfacial discontinuities, especially at higher loadings.	Moderate	No length/diameter/aspect-ratio dataset for the final filler; no quantitative defect or porosity metrics; no durability-retention testing.
[6]	Drying + milling + fractionation + single-screw extrusion + re-extrusion + injection molding	Reported	Reported	Not reported	Stem-derived filler provided a better balance between stiffness and ductility, with better dispersion and interfacial adhesion than leaf-derived filler.	Moderate	No length/diameter/aspect-ratio dataset for the final filler; no quantitative defect or porosity metrics; no durability-retention testing.
[7]	Alkali treatment + drying + melt compounding/extrusion + compression molding	Reported	Reported	Reported	Jute fiber provided the clearest performance–sustainability trade-off, with biodegradability in PLA/PBS systems and superior strength/stability in MA-compatibilized PP/PE systems. (Abstract; Results and discussion; Conclusions)	Moderate	Fiber length was reported (6–10 mm), but diameter/aspect ratio were not reported numerically, and interfacial defects were not quantified.
[7]	Alkali treatment + drying + melt compounding/extrusion + compression molding	Not reported	Not reported	Not reported	Flax fiber was the most effective reinforcement for flexural performance, with PP–Flax (+MA)	Limited	No flax-specific SEM/defect evidence, no flax-specific aging/biodegradation

References	Processing route	Defect descriptors reported?	Conditioning / exposure history reported?	Retention metrics reported?	Main result claimed by authors	Cross-study interpretability	Main reporting gap
					reaching 78.5 MPa at 30 wt.% fiber, followed by PLA–Flax at 72.0 MPa. (Results and discussion)		history, and no flax-specific retention metrics were reported.
[7]	Alkali treatment + drying + melt compounding/extrusion + compression molding	Not reported	Not reported	Not reported	Hemp fiber gave the highest impact strength in PE–Hemp (+MA) (4.7 kJ/m² at 30 wt.% fiber), while PLA–Hemp showed a marked drop in impact resistance with increasing fiber loading. (Results and discussion)	Limited	No hemp-specific SEM/defect evidence, no hemp-specific aging/biodegradation history, and no hemp-specific retention metrics were reported.
[7]	Alkali treatment + drying + melt compounding/extrusion + compression molding	Not reported	Not reported	Not reported	Not reported.	Limited	Kenaf was listed in the materials section, but no condition-specific mechanical, thermal, morphological, aging, or biodegradation results were reported.
[8]	Drying + extrusion + injection molding	Partially reported	Partially reported	Not reported	Flax fiber improved stiffness and tensile strength and reduced shrinkage, but its performance remained slightly below hemp-filled PHBV and water uptake increased versus neat PHBV.	Moderate	No treatment comparison, no quantitative porosity/interfacial metrics, and no retention or direct biodegradation test.

References	Processing route	Defect descriptors reported?	Conditioning / exposure history reported?	Retention metrics reported?	Main result claimed by authors	Cross-study interpretability	Main reporting gap
[8]	Drying + extrusion + injection molding	Partially reported	Partially reported	Not reported	Wood fiber increased stiffness and hardness and reduced shrinkage, but irregular geometry, poorer dispersion, and interfacial gaps limited strength performance.	Moderate	No treatment comparison, no quantitative porosity/interfacial metrics, and no retention or direct biodegradation test.
[9]	Washing + drying + alkali treatment + twin-screw compounding + injection molding	Reported	Reported	Reported	Strength decreased slightly, stiffness improved the most among fillers, and hydrolytic degradation still reduced mechanical properties after immersion.	Moderate	No post-processing fiber geometry or aspect ratio; no quantitative void analysis.
[9]	Washing + drying + alkali treatment + twin-screw compounding + injection molding	Reported	Reported	Reported	Stiffness improved, but tensile strength, impact strength, and hydrolytic retention were the poorest among the fillers because of weaker interfacial interaction.	Moderate	No post-processing fiber geometry or aspect ratio; no quantitative void analysis.
[9]	Washing + drying + alkali treatment + twin-screw compounding + injection molding	Reported	Reported	Reported	Stiffness increased, but pine cone flour showed the highest water uptake and weaker hydrolytic durability than the better-performing fillers.	Moderate	No post-processing particle geometry distribution; no quantitative void analysis.

References	Processing route	Defect descriptors reported?	Conditioning / exposure history reported?	Retention metrics reported?	Main result claimed by authors	Cross-study interpretability	Main reporting gap
[9]	Washing + drying + alkali treatment + twin-screw compounding + injection molding	Reported	Reported	Reported	Walnut shell flour improved stiffness modestly and showed the best thermal stability among the fillers, but strength and impact resistance still dropped and water exposure reduced retention.	Moderate	No post-processing particle geometry distribution; no quantitative void analysis.
[10]	Melt mixing + compression molding	Partially reported	Reported	Reported	Untreated pistachio shell acted as an effective nucleating and stiffening filler and strongly accelerated soil-burial biodegradation, but without treatment it showed weaker interfacial adhesion and more void-related defects.	Moderate	No full particle-size distribution or aspect ratio data and no quantitative porosity/interphase measurements.
[10]	Melt mixing + compression molding	Partially reported	Reported	Reported	Treated pistachio shell combined with PHBV-MA produced the best wetting and adhesion, the highest tensile/modulus/impact gains, and slightly lower water uptake than untreated shell at the same high filler loading.	Moderate	No full particle-size distribution or aspect ratio data and no quantitative porosity/interphase measurements.

References	Processing route	Defect descriptors reported?	Conditioning / exposure history reported?	Retention metrics reported?	Main result claimed by authors	Cross-study interpretability	Main reporting gap
[11]	Twin-screw compounding + injection molding	Reported	Reported	Not reported	Sawdust improved tensile strength at break at higher loading and promoted faster soil biodegradation than neat PHBV.	Moderate	Filler geometry was only loosely described; no quantitative interfacial defect metrics; no mechanical retention after soil burial.
[11]	Twin-screw compounding + injection molding	Reported	Reported	Not reported	Chitin showed little or no reinforcing effect on tensile strength, but it increased biodegradation versus neat PHBV.	Moderate	Particle geometry was not quantified in detail; no quantitative interfacial defect metrics; no mechanical retention after soil burial.
[11]	Twin-screw compounding + injection molding	Reported	Reported	Not reported	Human hair waste did not reinforce tensile strength, but gave the strongest biodegradation response among the fillers.	Moderate	Fiber geometry was reported, but no compatibilization was used and no quantitative interfacial defect metrics or mechanical retention data were provided.
[12]	Fiber extraction + chemical treatment + melt compounding + thermo-compression molding	Partially reported	Partially reported	Not reported	Surface treatment, especially alkali-silane, improved fiber–matrix adhesion and dispersion, increased crystallinity and stiffness-related properties, and reduced water absorption relative to	Moderate	Missing diameter/aspect ratio and quantitative defect metrics; no retention or aging-performance data.

References	Processing route	Defect descriptors reported?	Conditioning / exposure history reported?	Retention metrics reported?	Main result claimed by authors	Cross-study interpretability	Main reporting gap
					untreated Diss fiber composite.		
[13]	Double pultrusion + injection molding	Reported	Reported	Reported	RCFs greatly increased PHBV impact strength and improved tensile strength, but weak fiber-matrix adhesion and hydrolytic aging in aqueous media limited long-term durability.	Moderate	Final fiber geometry/orientation after processing was not quantified, and no end-of-life biodegradation evidence was reported.
[14]	Cutting/milling + drying + melt compounding/micro-extrusion + injection molding	Partially reported	Partially reported	Not reported	CF compensated part of the stiffness loss caused by TBC, and when combined with highly grafted MA-g-PHBV it produced the best fiber–matrix adhesion and the strongest improvements in tensile and flexural behavior.	Moderate	Missing quantitative fiber geometry, missing quantitative defect metrics, and no retention/aging dataset for comparing long-term reinforcement performance.
[15]	Drying + milling + sieving + melt blending +compression molding	Partially reported	Partially reported	Not reported	HSR improved antioxidant activity and light blocking, but reduced tensile strength and elongation and worsened water vapor barrier performance; low contents could maintain or improve stiffness	Moderate	No full particle size/aspect ratio characterization, no quantitative void/defect metric, and no durability-retention analysis after conditioning or aging

References	Processing route	Defect descriptors reported?	Conditioning / exposure history reported?	Retention metrics reported?	Main result claimed by authors	Cross-study interpretability	Main reporting gap
[16]	Alkali treatment + drying + grinding/sieving + twin-screw compounding + hot pressing	Partially reported	Partially reported	Partially reported	Alkali-treated WHF at 2 wt.% improved tensile, flexural, impact, and hardness performance through better matrix–filler interaction, whereas higher loadings promoted agglomeration, pore formation, and performance loss.	Moderate	Missing diameter and aspect ratio; no quantitative porosity/void analysis; no property-retention dataset after aging or degradation.
[17]	Sisal extraction + alkali treatment + manual mixing with TPS + solution casting + drying	Partially reported	Reported	Not reported	Sisal fiber improved the reinforcement efficiency of thermoplastic cornstarch, and the best overall packaging-oriented performance was achieved at 30 wt.% fiber with 18 wt.% alkali treatment.	Moderate	No diameter/aspect-ratio data, no quantitative defect microscopy, and no retention metrics after post-exposure mechanical testing.
[18]	Sieving + drying + optional TA/Fe functionalisation + compounding/extrusion + pelletising + injection moulding + FGF assessment	Partially reported	Partially reported	Not reported	Untreated wood led to poorer fibre–matrix adhesion and lower tensile performance, while TA.Fe-functionalised wood improved adhesion-related response and produced tensile	Moderate	No quantitative pull-out/void statistics, no durability or retention study, and no isolated long-term assessment of the functionalised filler.

References	Processing route	Defect descriptors reported?	Conditioning / exposure history reported?	Retention metrics reported?	Main result claimed by authors	Cross-study interpretability	Main reporting gap
					properties close to neat PHBV with higher stiffness.		
[19]	Drying + melt compounding + compression molding	Partially reported	re-Reported	Not reported	RS acted as a reinforcing filler that increased stiffness and surface hydrophobicity, with smaller particles giving better dispersion and stronger reinforcement effects, although RS also promoted permeability increase and reduced thermal stability and crystallization.	Moderate	Particle size classes were reported, but not full particle geometry such as length, diameter, or aspect ratio after processing; interfacial defects were not quantified; no retention metrics were reported.
[20]	Fiber cleaning + oven drying + hand cutting + dispersion in chitosan matrix solution + solution casting + vacuum-oven drying + room-temperature drying	Partially reported	re-Reported	Not reported	Banana short fibers were uniformly embedded in the chitosan matrix, improving tensile strength, elongation, modulus, and thermal resistance while maintaining rapid biodegradation.	Moderate	No fiber diameter or aspect-ratio data and no quantitative defect/interphase statistics.
[21]	Melt compounding + compression molding	Partially reported	re-Partially reported	re-Not reported	Untreated WFs increased modulus and Vicat temperature, but reduced yield strength and increased water uptake	Moderate	No direct fiber length/diameter dataset, no quantitative void content, and no retained-property dataset

References	Processing route	Defect descriptors reported?	Conditioning / exposure history reported?	Retention metrics reported?	Main result claimed by authors	Cross-study interpretability	Main reporting gap
					because of limited fiber/matrix adhesion.		after environmental exposure.
[21]	Fiber treatment + melt compounding + compression molding	Partially reported	Partially reported	Not reported	CA-treated WFs improved wetting and reduced pull-out, increasing yield strength and reducing water uptake and surface hydrophilicity versus untreated WF composites.	Moderate	No quantitative interfacial strength metric, no biodegradation evidence, and incomplete geometry descriptors beyond aspect ratio.
[22]	Hydrothermal HA synthesis + film casting + phase inversion	Partially reported	Reported	Not reported	HA incorporation activated antibacterial activity and improved strength, thermal stability, and water-vapor barrier performance, with 15 wt% HA giving the best overall film balance.	Moderate	No particle size/aspect ratio data; no moisture-state reporting during processing; no retention metrics after environmental exposure.
[23]	Cigarette-butt collection + sterilization + water/ethanol washing + NaOH hydrolysis + mixing with casein matrix + compression moulding	Reported	Partially reported	Not reported	Recycled cellulose showed better fiber–matrix adhesion and superior flexural, shear, and impact performance than recycled cellulose acetate.	Moderate	No moisture-state data for fibers before mixing; no quantitative interfacial/void metrics; no durability testing.
[23]	Cigarette-butt collection + sterilization + water/ethanol washing + mixing with casein	Reported	Partially reported	Not reported	Recycled cellulose acetate produced more brittle behavior and pull-out fracture, indicating poorer	Moderate	No moisture-state data for fibers before mixing; no quantitative

References	Processing route	Defect descriptors reported?	Conditioning / exposure history reported?	Retention metrics reported?	Main result claimed by authors	Cross-study interpretability	Main reporting gap
	matrix + compression moulding				adhesion to the casein matrix.		interfacial/void metrics; no durability testing.
[24]	SPI dissolution + overnight hydration + pH 2 conditioning + hydrothermal fibrillation + blending with CH/citric acid/glycerol + casting + drying	Partially reported	re-Reported	Reported	SPIF morphology strongly controlled film performance, and the W-12 condition (~1.5 μm medium-length fibrils) delivered the best combination of strength, flexibility, gas selectivity, and tomato-preservation efficacy.	Moderate	Defects and aggregation were described qualitatively but not quantified; no standardized porosity metric was reported; the mechanism behind selective gas transport remains incompletely resolved.
[25]	Alkaline treatment + H_2O_2 bleaching + UV irradiation + high-speed homogenization + dialysis + solution casting + oven drying	Partially reported	re-Reported	Not reported	MNFs improved CHI/PVA film strength, stiffness, moisture barrier properties, biodegradability, and strawberry shelf life, with 1 wt.% giving the best preservation performance and 5 wt.% giving the lowest WVP. (Abstract; Materials and Methods; Results; Conclusions)	Moderate	Aspect ratio was not explicitly reported, direct film defect/dispersion imaging across loadings was not provided, and retained post-exposure film properties were not measured.
[26]	Size reduction + alkaline pretreatment + drying + incorporation by solution casting + air drying	Reported	Reported	Reported	Pretreated jute fiber effectively reinforced the chitosan/guar gum matrix, improving tensile	Moderate	Aspect ratio was not explicitly reported, and defect/void evidence was qualitative rather

References	Processing route	Defect descriptors reported?	Conditioning / exposure history reported?	Retention metrics reported?	Main result claimed by authors	Cross-study interpretability	Main reporting gap
					strength, hydrophobicity, UV-blocking, water-vapor barrier, and antimicrobial/antioxidant functionality while slowing soil-burial mass loss.		than quantitatively measured.
[27]	Grinding + oven drying + solvent casting + oven drying + compression moulding	Reported	Reported	Not reported	Bamboo powder was uniformly dispersed in the PCL matrix and increased tensile strength, flexural strength, hardness, thermal stability, porosity, wettability, and degradation as filler loading increased, with the strongest overall effect at 40 wt.% BP.	Moderate	Particle size range was reported, but aspect ratio was not reported, and retained post-exposure mechanical properties were not measured.

Table S3. Proposed minimum reporting checklist for natural-based composite studies.

Category	Minimum descriptor	Recommended measurement or reporting method
Feedstock and pre-conditioning	Fiber source and grade; moisture content at processing; storage duration and conditions; pre-drying protocol.	Report supplier and lot; quantify moisture content at processing using an appropriate standardized method where applicable; report drying temperature, duration, and handling details [28].
Architecture and composition	Reinforcement format; target and measured reinforcement fraction (volume fraction and, when relevant, mass fraction).	Specify UD, woven, mat, short fiber, or particulate form; report target and measured fractions and how they were confirmed (for example burn-off, density-based methods, or image analysis).
Interface treatment strategy	Full compatibilization or surface modification protocol.	Report reagent identity, concentration, temperature, treatment duration, and post-treatment washing and drying or conditioning steps [29,30].
Process history and defect metrics	Key compounding, molding, or printing parameters; quantitative void content when relevant.	Report temperatures, pressures, residence times, layup or consolidation conditions, and print parameters; quantify porosity or voids using a suitable method (for example microscopy, density-based methods, or microcomputed tomography).
Durability conditioning	Explicit exposure history prior to testing.	Report environment, temperature, relative humidity or immersion medium, exposure duration, and cycling details; track specimen mass during conditioning when moisture-driven trends are expected [31,32].
End-of-life evidence type	Basis for any sustainability or end-of-life claim.	State whether evidence is based on composition (including measured bio-based content), standardized biodegradation testing under defined conditions, recyclability demonstration, or scenario-based assessment aligned with circular design criteria and life cycle analysis [33,34].

Table S4. Context-qualified quantitative performance comparisons extracted from the mapped evidence

References	Material system / matched comparison	Reported quantitative evidence	Derived quantitative change	Engineering interpretation / limitation
[1]	PBS vs. PBS/40 wt.% NFC	TS: 30.9 → 12.9 MPa; E: 271 → 561 MPa	TS −58.3%; E +107.0%	Stiffness increased substantially while tensile strength decreased.
[6]	PLA vs. PLA/15 wt.% sorghum leaf	TS: 44.0 → 30.0 MPa; E: 4163 → 5340 MPa; EAB: 2.40 → 0.86%; impact: 10.46 → 6.98 kJ m^{-2}	TS −31.8%; E +28.3%; EAB −64.2%; impact −33.3%	Increased stiffness was accompanied by lower strength, ductility, and impact resistance.
[12]	Untreated PHBV/Diss vs. alkali/silane-treated PHBV/Diss	Maximum stress: 20.17 ± 1.1 → 31.50 ± 2.5 MPa; E: 3382 ± 32 → 3736 ± 21 MPa	Stress +56.2%; E +10.5%	Treatment improved mechanical response; interfacial evidence remained mainly morphological.
[14]	PHBV/cellulose without compatibilizer vs. compatibilized system	TS: 21.1 → 30.4 MPa; flexural strength: 33.92 → 44.06 MPa; E: 2231 → 2611 MPa	TS +44.1%; flexural strength +29.9%; E +17.0%	Compatibilization improved several mechanical responses.
[18]	PHBV/wood/$CaCO_3$ base formulation vs. selected additive formulation	UTS: 17.68 → 25.62 MPa; EAB: 1.75 → 3.69%; E: 960.6 → 981.8 MPa	UTS +44.9%; EAB +110.9%; E +2.2%	Large strength and ductility increases occurred with only a modest modulus change.
[21]	PCL/10 wt.% wood fiber, untreated vs. citric-acid-treated	Yield strength at 0 °C: 19 → 26 MPa; 90-d water uptake: 7.44 → 3.22%	Yield +36.8%; water uptake −56.7%	Treatment improved mechanical response while substantially reducing moisture uptake.
[27]	PCL vs. PCL/40 wt.% bamboo powder	UTS: 25.82 → 37.27 MPa; porosity: 0.41 → 3.25%	UTS +44.3%; porosity increased from 0.41 to 3.25%	Higher tensile strength did not correspond to a lower defect state.
[2]	PLA/sisal vs. unsaturated polyester/sisal, 30 wt.%	Water uptake: 23.36 vs. 22.39%	Polyester/sisal: −4.15% relative to PLA/sisal	Difference is descriptive because matrix chemistry and processing route differ.

Note: Derived percentage changes were calculated only from matched numerical values reported within the same study using $\Delta P(\%) = [(P_2 - P_1)/P_1] \times 100$. These calculations are context-specific and are not intended to establish universal material rankings. Reported values retain the formulation and experimental context of the respective primary studies.

Table S5. Context-qualified durability and retained-performance evidence.

Study	Material system	Exposure condition	Property / endpoint	Initial → post-exposure evidence	Retention	Engineering interpretation / limitation
[4]	Woven flax/PLA	42 d, 40 °C, 100% RH	Tensile strength	Reported reduction = 31%	**69%**	Strength was better retained than stiffness under the same exposure.
[4]	Woven flax/PLA	42 d, 40 °C, 100% RH	Stiffness	Reported reduction = 72%	**28%**	Stiffness was highly sensitive to hygrothermal aging.
[5]	Neat PLA	12 d UV-A/UV-B, humid environment	Reported modulus	2.39 ± 0.08 → 1.09 ± 0.12 GPa	**45.6%**	Supporting evidence only; property labels in the source should be retained exactly as reported.
[5]	PLA/20 wt.% flax	Same exposure	Reported modulus	3.73 ± 0.37 → 3.37 ± 0.50 GPa	**90.3%**	Flax-containing PLA retained more of the reported modulus under the reported exposure.
[9]	Neat PHBV	14 d, 2% NaCl, 38 °C	Tensile strength	38.4 ± 2.50 → 36.7 ± 1.68 MPa	**95.6%**	Relatively limited strength loss.
[9]	PHBV/15SN	Same exposure	Tensile strength	32.8 ± 1.23 → 15.4 ± 0.71 MPa	**47.0%**	Initial reinforcement did not ensure high retained performance.
[9]	PHBV/15LN	Same exposure	Tensile strength	25.9 ± 1.30 → 15.3 ± 0.54 MPa	**59.1%**	Retention differed according to filler type.
[9]	PHBV/15C	Same exposure	Tensile strength	31.0 ± 1.89 → 17.2 ± 0.47 MPa	**55.5%**	Environmental sensitivity remained formulation-dependent.
[9]	PHBV/15WN	Same exposure	Tensile strength	29.7 ± 1.34 → 23.6 ± 1.01 MPa	**79.5%**	Higher retained strength among the filled formulations evaluated in that study.
[13]	PHBV/20 wt.% regenerated cellulose	21 d water, 70 °C	Tensile strength	Reported reduction = 69.49%	**30.51%**	Severe hydrolytic deterioration of tensile response.
[13]	Same system	Same exposure	Impact strength	Reported reduction = 28.68%	**71.32%**	The same exposure affected impact performance less severely than tensile performance.

Note: Property retention was calculated only when sufficiently matched initial and post-exposure values or explicitly reported property losses were available within the same study. NR = not reported; NC = not calculable from sufficiently matched numerical evidence.

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