Supplemental Report for ISO Conformant Life Cycle Assessment for Pactiv Evergreen

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Executive Summary

Pactiv Evergreen commissioned the Life Cycle Assessment (LCA) of various meat tray materials, including varying post-consumer recycled (PCR) content. The meat trays included: foam polystyrene (PS), foam PS with 30% PCR, polyethylene terephthalate (PET) with 30% PCR, foam PET with 30% PCR, foam PET, foam polypropylene (PP) and wood molded fiber. Trayak, as the practitioner of the LCA, reviewed the various meat trays modeled by Pactiv Evergreen within Trayak's screening LCA software, EcoImpact-COMPASS and the LCA was conducted using the COMPASS 2022 methodology consisting of eight environmental indicators. These indicators include fossil fuel use, greenhouse gas (GHG) emissions, water use, freshwater ecotoxicity, GHG emissions with carbon dioxide uptake, human impact, mineral resource use, and freshwater eutrophication.

The results showed the tray with the best environmental footprint was the foam PS with 30% PCR.
As compared to the wood molded fiber tray, the foam PS with 30% PCR tray had an average reduction across all eight environmental indicators of 80%, with the greatest reductions in freshwater eutrophication at 98% reduction, mineral resource use at 91% reduction, and freshwater ecotoxicity at 90% reduction. The option with the second-best environmental footprint is the foam PS tray, which is currently the most used meat tray type, based on data from the Foodservice Packaging Institute. The foam PS tray when compared to the wood molded fiber tray had an average reduction of 76% across all environmental indicators.

When the foam PS tray is compared to the foam PS tray with 30% PCR, the foam PS tray with 30% PCR has an average reduction of 2% across all the indicators. However, if freshwater eutrophication is not considered, there is an average reduction of 12% across the remaining seven indicators.

This report details the results of the comparison between the various meat trays, the breakdown of the LCA phases for some of the indicators, sustainability attribute considerations, data mapping, sensitivity analysis, and recommendations. With all of these breakdowns, the foam PS with 30% PCR tray shows the best environmental footprint in nearly all the indicators.

Project Background

Pactiv Evergreen commissioned the Life Cycle Assessment comparing meat trays made of foam polystyrene (PS), foam PS with 30% PCR, polyethylene terephthalate (PET) with 30% PCR, foam PET with 30% PCR, foam PET, foam polypropylene (PP) and wood molded fiber. Trayak, as the practitioner, used EcoImpact-COMPASS to review the packaging systems modeled by Pactiv Evergreen and conduct the life cycle analysis (LCA) according to the requirements of International Standard ISO 14044.

Goal

The Life Cycle Assessment is intended to evaluate meat trays for environmental impact (fossil fuel use, greenhouse gas emissions (with and without CO_2 uptake), water use, human impact, freshwater eutrophication, freshwater ecotoxicity, and mineral resource use) with a 3P tray dimension across various weights and materials. All of the meat tray designs are Pactiv Evergreen products except for the molded fiber tray, which is a comparable market sample. This report is for the purpose of detailing models, assumptions, and results of the LCA conducted through Trayak's EcoImpact-COMPASS software. This report is intended to support an ISO 14044 conformant LCA in order to make comparative assertions among the designs. The target audience for this report is the general public, including those who are interested in Pactiv Evergreen products and services and those who are interested in the environmental impacts of their meat tray choices.

Scope

In order to conduct a reliable and comparable LCA, a specific scope for the project needs to be defined. This involves establishing a comparable functional unit, defining the boundary conditions, detailing assumptions and limitations of the LCA, data quality requirements and impact assessment methodology, allocation procedure, impact assessment, and documentation of the data used throughout the LCA. This section will detail the scope and will also be accompanied by other documentation detailing the data modeling specifications.

Packaging Systems

This report details the results of the LCA conducted for meat trays made of foam PS, foam PS with 30% PCR, PET with 30% PCR, foam PET with 30% PCR, foam PET, foam PP and wood molded fiber. Only primary packaging is compared.

Functional Unit

The functional unit of the LCA designates the comparable unit that will be used throughout the study defining the quantity, quality, and useful life of the package/product. The functional unit for this comparison is one item count. In this comparison, one item count denotes one 3P meat

tray. 3P represents the size of a meat tray. 3P meat trays are approximately 8.6” X 6.6” X 1.3” in size; however, there can be a scale of ± 0.05 inches. This comparison assumes each tray can hold the same amount of product (typically approximately one pound), protect and deliver the product to meet all processed meat packaging regulations and requirements. Due to differences in material characteristics such as melt strength and viscoelasticity, pure PS, PET, and PP have different capacities for foaming[1,2]. This leads to weight differences between the trays, with the PS trays able to achieve lower weights.

Boundary Conditions

The LCAs conducted by the EcoImpact-COMPASS platform are cradle-to-grave including impacts for raw material extraction, manufacturing of the various components, transportation throughout the supply chain, and average end-of-life impact for the components. This LCA is conducted using the US for the manufacturing and US for the end-of-life (EOL) region. Below is a summary table of the system boundaries and what is included and what is excluded.

Table 1: Boundary Conditions

Included	Excluded
Raw material extraction	Capital equipment
Component manufacturing	Secondary and tertiary packaging
Average market transportation for materials, processing, and collection at EOL	Tray sealing film
Supply chain specific transport for final product distribution	Absorbent pad
End-of-Life	Label, label adhesive, and printing ink
	Meat product

Impact Assessment

The COMPASS® method is used to calculate the environmental impacts for all packaging systems in this study. This method consists of eight indicators to provide a full picture view of the impact across different categories and considerations. The indicator descriptions are shown in the Appendix. These indicators represent a collection of impacts deemed appropriate for package environmental impact and represent the impacts that packaging companies are focused on optimizing.

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[1] Yu L, Zhu Q, Yu J. Development and application of expanded polypropylene foam. J Wuhan Univ Technol – Mater Sci Ed. 2013; 373-379.

[2] Xanthos M, Dey SK, Zhang Q, et al. Parameters affecting extrusion foaming of PET by gas injection. J Cell Plast. 2000; 36: 102-111.

Allocation

EcoImpact-COMPASS uses the cut-off allocation methodology to ensure that double counting of recycling benefits doesn't occur. This allocation methodology provides the benefit of using the recycled material to the second package as well as considers the impacts of recycling this material to be used as post-consumer recycled (PCR) content. The first package that is recycled has zero impact at end-of-life for recycling this material because this process is attributed to the use of the recycled material in the next package as PCR.

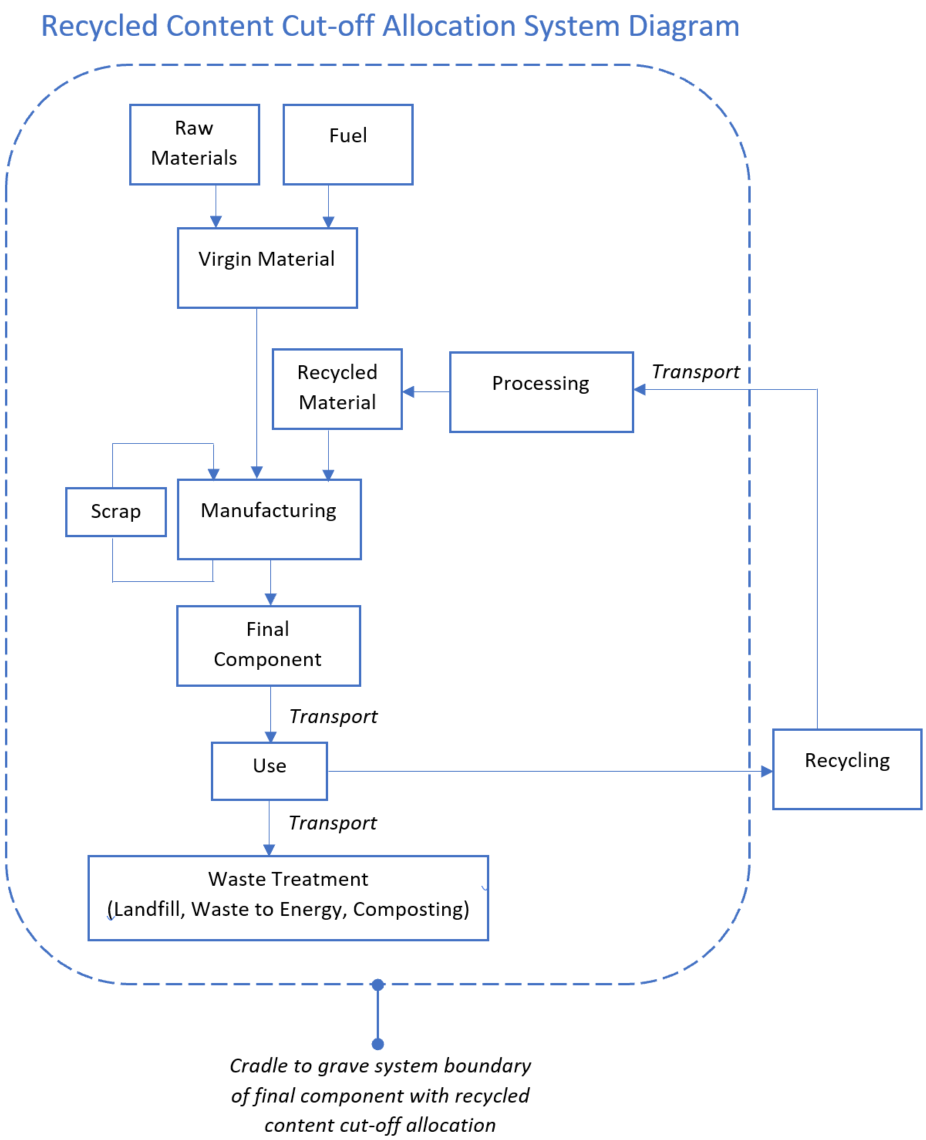

Figure 1: Meat Tray Packaging System Flow Diagram

This LCA utilizes ecoinvent data for the life cycle inventory which uses both economic and mass allocation in the background processes. This LCA uses the general 1% cut-off by mass rule, so any component of the trays that was less than 1% of the mass isn't included.

Interpretation

These results will be used as a comparison between a variety of plastic meat trays and a wood molded fiber meat tray. It will serve as an example to customers how the impacts of the various meat trays differ and help inform their purchasing decision. This report also details what impacts come from the material and manufacturing process of the meat tray.

Data Quality and Documentation

Within this LCA, various materials, processes, end-of-life impacts, and transportation modes have been modeled and used within the various packaging systems. The mapping of these materials and processes to the data source is provided along with a data quality breakdown in the Appendix and accompanying documentation. Trayak has detailed the process used, any changes made to the background data, data sources, and data quality.

Assumptions and Limitations

To conduct this LCA, some assumptions needed to be made to fill in some data gaps. The results generated through EcoImpact-COMPASS are limited to the data provided, modeled, and assumptions made where data was absent such as proxying a material or process. Trayak is not responsible for user-entered values into EcoImpact-COMPASS. The EcoImpact-COMPASS user is responsible for providing supporting documentation for user entered data.

EcoImpact-COMPASS Assumptions

EcoImpact-COMPASS assumes cut-off allocation for all the materials and processes. The 1% cut-off by mass rule is applied to determine insignificant components of the packaging systems. Virgin materials are assumed to be global market averages and manufacturing processes are regionalized by electricity grids and water flows.

Pactiv Evergreen Specific Assumptions

This LCA was modeled to only consider the meat trays and does not include secondary or tertiary packaging. Secondary and tertiary packaging were excluded because it is assumed that based on the general dimensions of the meat trays they would be packaged in a similar way. While there may be some differences in secondary and tertiary packaging among the meat tray types, it is assumed that the majority of the differences in environmental impacts would come from the trays themselves.

Value Choices

The choices of the impact indicators and the life cycle inventory data were made by Trayak and represent the current understanding of calculating environmental impact of packaging. Additional data quality assessment is provided in the Appendix and accompanying documentation.

Third Party Critical Review

This report and this LCA comparison are conducted to be conformant to ISO 14071, so that comparative assertions can be made to the public. This report is to be reviewed by an external third-party panel consisting of the following members:

- Tom Gloria, Managing Director at Industrial Ecology Consultants; LCA Panel Chair
- Joongmin Shin, Associate Professor at California Polytechnic State University; Packaging Subject Matter Expert
- Matt Dingee, Co-Founder- President- COO at OnPoint2020; Packaging Subject Matter Expert

Life Cycle Inventory

The Life Cycle Inventory (LCI) refers to the background processes that are used to calculate the environmental impact of the various materials, processes, end-of-life processes, and transportation within an LCA. The LCA was conducted for meat trays made of foam PET, foam PET with 30% PCR, PET with 30% PCR, foam PP, foam PS, foam PS with 30% PCR, and wood molded fiber.

Data Collection

The data was modeled using data collected by Pactiv Evergreen and was reviewed by Trayak. The masses of the majority of the meat trays were taken from Pactiv Evergreen spec sheets and the molded fiber tray mass was determined through 15 samples from a precision lab scale. The masses, material choices, conversion process selections, and transportation distances were from Pactiv Evergreen data. Trayak verified that these choices were accurate representations of the materials and processes used to make these meat trays.

Data Source

The life cycle inventory data was used to construct the packaging system models within the LCA. The life cycle inventory data was broken down into four main phases: raw material, manufacturing, transportation, and end-of-life.

Material

The ecoinvent 3.8 database was used for all the materials within the LCA and represents a global market, so they are not regionalized. For the recycled materials within the LCA, the electricity grids and water flows have been regionalized, so they are specific to a manufacturing region. The data sources for the various materials used within this LCA are detailed in the Appendix.

Manufacturing

The conversion processes for the various components use ecoinvent 3.8 data that has been regionalized to the US by changing the electricity grids and water flows. The data sources for the various manufacturing processes used within this LCA are detailed in the Appendix.

Transportation

Transportation impacts are calculated on a mass per distance basis and vary depending on the vehicle types. The background data for the vehicle type characterization factors comes from ecoinvent 3.8. These impacts are not regionalized. Average market transportation is used for materials, processing, and collection at EOL. Supply chain specific transportation is used for

final product distribution. For each tray, the distance traveled by road between manufacturing and the consumer is estimated to be 1,609.34 km (1,000 miles) due to varying distances for multiple clients. A truck greater than 32 metric tons was chosen as it is a typical vehicle used in shipping these types of products.

End-of-Life

Each end-of-life region within EcoImpact-COMPASS has auto-populated percentages based on the likelihood that each packaging type and material combination will be recycled, landfilled, or incinerated, or composted. These percentages are pulled from various published reports and agencies detailing waste management in a particular region. The end-of-life impacts come from ecoinvent 3.8 and change from material to material and are regionalized. The US end-of-life split between percentage recycled, landfill, and incinerated for the various components is pulled from Table 25 of the Environmental Protection Agency's Advancing Sustainable Materials Management: 2018 Tables and Figures report published in December 2020. From this table, EOL percentages were taken from "Plastics Packaging: Other Plastics Packaging" for PS, "Plastics Packaging: Other Plastics Packaging" for PET, "Plastics Packaging: Other Plastics Packaging" for PP, and "Paper & Paperboard Packaging: Subtotal Other Paper & Paperboard Packaging" as a proxy for wood molded fiber.

Table 2: End-of-life Percentages by Meat Tray Type

Name	Quantity (Each)	EOL Recycling Potential (%)	EOL Waste-to-Energy Potential (%)	EOL Landfill (%)
Foam PS	1.0	6.0	18.0	76.0
Foam PS 30% PCR	1.0	6.0	18.0	76.0
PET 30% PCR	1.0	10.0	17.0	73.0
Foam PET 30% PCR	1.0	10.0	17.0	73.0
Foam PET	1.0	10.0	17.0	73.0
Foam PP	1.0	3.0	19.0	78.0
Wood Molded Fiber	1.0	21.0	15.0	64.0

EcoImpact-COMPASS Modeling

Foam PS

BOM Classifications

BOM Name	Quantity (Each)	Mfg. Region	Sales-Use Region
Foam PS	1	US	US

Name	Material	PCR %	PIR %	Manufacturing Process	Mass Per Occurrence	#	Transport
Foam PS Meat Tray	Polystyrene (PS)	0	0	Foaming/Expanding Inline Extrusion (plastic sheet and thermoforming)	8.8 g	1	1,609.34 km

Foam PS 30% PCR

BOM Classifications

BOM Name	Quantity (Each)	Mfg. Region	Sales-Use Region
Foam PS 30% PCR	1	US	US

Name	Material	PCR %	PIR %	Manufacturing Process	Mass Per Occurrence	#	Transport
Foam PS Meat Tray	Mechanically Recycled Polystyrene	30	0	Foaming/Expanding Inline Extrusion (plastic sheet and thermoforming)	8.8 g	1	1,609.34 km

PET 30% PCR

BOM Classifications

BOM Name	Quantity (Each)	Mfg. Region	Sales-Use Region
PET 30% PCR	1	US	US

Name	Material	PCR %	PIR %	Manufacturing Process	Mass Per Occurrence	#	Transport
PET Meat Tray	Polyethylene Terephthalate (PET)	30	0	Inline Extrusion (plastic sheet and thermoforming)	32.5 g	1	1,609.34 km

Foam PET 30% PCR

BOM Classifications

BOM Name	Quantity (Each)	Mfg. Region	Sales-Use Region				
Foam PET 30% PCR	1	US	US				
Name	**Material**	**PCR %**	**PIR %**	**Manufacturing Process**	**Mass Per Occurrence**	**#**	**Transport**
PET Meat Tray	Polyethylene Terephthalate (PET)	30	0	Foaming/Expanding Inline Extrusion (plastic sheet and thermoforming)	17.3 g	1	1,609.34 km

Foam PET

BOM Classifications

BOM Name	Quantity (Each)	Mfg. Region	Sales-Use Region				
Foam PET	1	US	US				
Name	**Material**	**PCR %**	**PIR %**	**Manufacturing Process**	**Mass Per Occurrence**	**#**	**Transport**
PET Meat Tray	Polyethylene Terephthalate (PET)	0	0	Foaming/Expanding Inline Extrusion (plastic sheet and thermoforming)	17.3 g	1	1,609.34 km

Foam PP

BOM Classifications

BOM Name	Quantity (Each)	Mfg. Region	Sales-Use Region				
Foam PP	1	US	US				
Name	**Material**	**PCR %**	**PIR %**	**Manufacturing Process**	**Mass Per Occurrence**	**#**	**Transport**
Foam PP Meat Tray	Polypropylene (PP)	0	0	Foaming/Expanding Inline Extrusion (plastic sheet and thermoforming)	20 g	1	1,609.34 km

Wood Molded Fiber

BOM Classifications

BOM Name	Quantity (Each)	Mfg. Region	Sales-Use Region				
Wood Molded Fiber	1	US	US				
Name	**Material**	**PCR %**	**PIR %**	**Manufacturing Process**	**Mass Per Occurrence**	**#**	**Transport**
Fiber Meat Tray	Molded Pulp Material Only	0	0	Molded Pulp Process	50 g	1	1,609.34 km

Figure 2: Bill of Materials (BOM) Characteristics

Life Cycle Impact Assessment

The COMPASS method is a compilation of indicators that were selected for their relevance to packaging as well as those that are well accepted by the LCA community. This method consists of eight indicators to provide a full picture view of the impact across different categories and considerations. There is further documentation of the selection of the impact categories and justification of their use for this LCA in the Appendix. The environmental impact results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins, or risks.

Overview of Functional Unit Comparison

Table 3: Functional Unit Comparison

Package Name	# of Primary Packages	# of Secondary Packages	# of Tertiary Packages
Foam PS	1	0	0
Foam PS 30% PCR	1	0	0
PET 30% PCR	1	0	0
Foam PET 30% PCR	1	0	0
Foam PET	1	0	0
Foam PP	1	0	0
Wood Molded Fiber	1	0	0

Life Cycle Assessment Results

Figure 2 shows a spider web chart of the LCA comparison with the eight COMPASS indicators. Each meat tray type is denoted in a different colored area in the spider web chart. For each indicator, the points closer to the center of the graph represent the better or lower environmental impact. For example, looking at water use, the lowest impact comes from the foam PS with 30% PCR and the highest impact comes from the wood molded fiber.

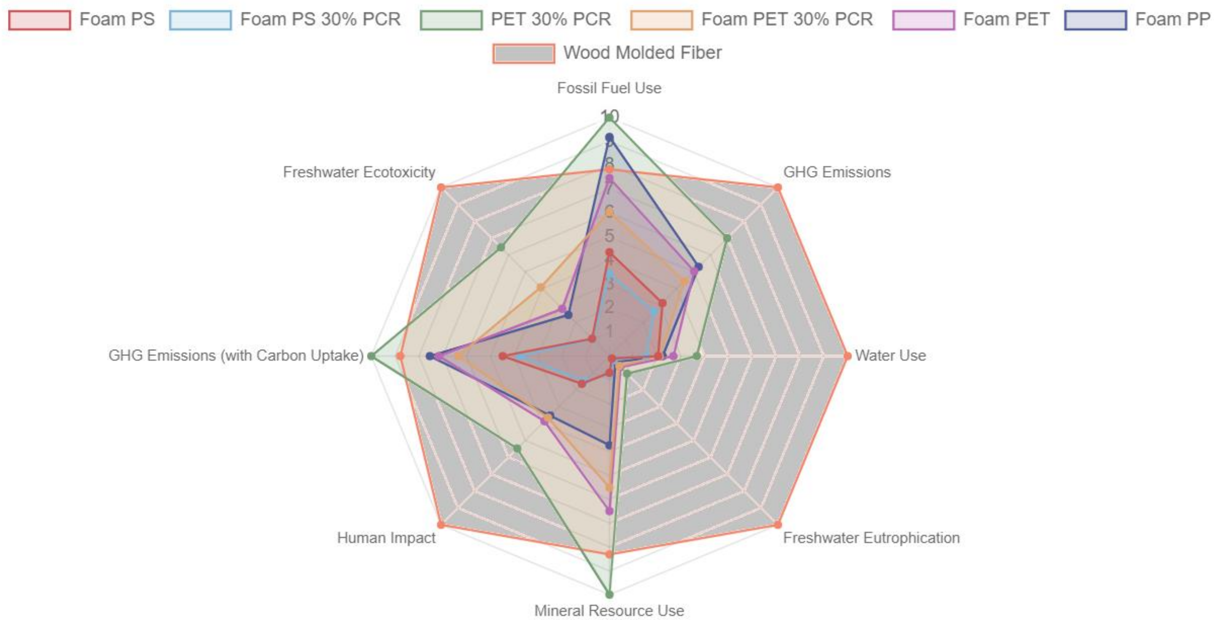

Figure 3: LCA Comparison of the 7 Meat Trays

When comparing all the meat trays, the foam PS tray with 30% PCR has the lowest environmental impact in nearly all the indicators, except for freshwater eutrophication and mineral resource use, in which the foam PS (without PCR) tray is slightly lower. The next best option is the foam PS tray. The most environmentally-impactful meat tray across nearly all indicators was the wood molded fiber tray. Reasons for this include higher water use for the pulping of the wood and the heavier weight of the tray increasing impacts from transportation, material, and manufacturing. However, the PET tray with 30% PCR has a higher impact in fossil fuel use, GHG emissions with carbon uptake, and mineral resource use.

The absolute values of the comparison are shown below in Table 4 with the higher impacts highlighted in red and the lower impacts highlighted in green. The impacts are shown for the functional unit of 1 item count.

Table 4: LCA Results for the 7 Meat Trays

Indicators	**BOMs**						
Name	**Foam PS**	**Foam PS 30% PCR**	**PET 30% PCR**	**Foam PET 30% PCR**	**Foam PET**	**Foam PP**	**Wood Molded Fiber**
Fossil Fuel Use (MJ deprived)	1.03	0.8156	2.36	1.43	1.76	2.17	1.85
GHG Emissions (kg CO_2 eq)	0.0532	0.0447	0.1182	0.0751	0.0851	0.0895	0.1691
Water Use (liters)	21.9	16.37	39.25	22.52	28.73	23.91	107.02
Freshwater Eutrophication (kg PO_4 eq)	1.64E-07	2.80E-07	1.19E-06	6.63E-07	7.38E-07	3.99E-07	1.14E-05
Mineral Resource Use (kg deprived)	1.17E-04	1.26E-04	0.0017	9.00E-04	0.0011	6.27E-04	0.0014
Human Impact (DALY)	2.73E-08	2.46E-08	9.10E-08	6.07E-08	6.41E-08	5.85E-08	1.66E-07
GHG Emissions (with Carbon Uptake) (kg CO_2 eq)	0.0534	0.0449	0.1191	0.0757	0.0853	0.0898	0.1046
Freshwater Ecotoxicity (CTUe)	6.23	6.02	38.93	24.62	16.93	14.75	60.38

Lowest Impact for Each LCA Indicator — Highest Impact for Each LCA Indicator

Life Cycle Phase Breakdown

The LCA results are broken into the four phases of the life cycle: material, manufacturing, transportation, and end-of-life. The definition of each phase is detailed in the Appendix. The tables for the LCA results broken down by phase are also located in the Appendix.

Fossil Fuel Use

The meat tray made of foam PS with 30% PCR has the lowest fossil fuel use, followed by the tray made of foam PS. The highest fossil fuel use comes from the tray made of PET with 30% PCR. The biggest impact for fossil fuel comes from the material and manufacturing phases.

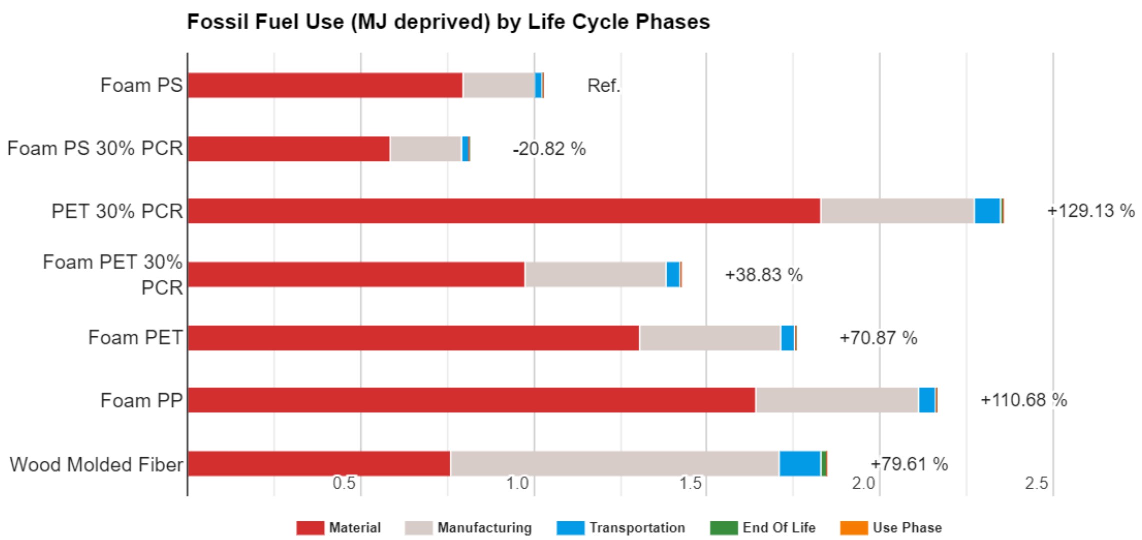

Figure 4: Fossil Fuel Use for the Meat Trays

Greenhouse Gas Emissions

The lowest GHG emissions come from the meat tray made of foam PS with 30% PCR while the highest come from the tray made of wood molded fiber. With GHG emissions, end of life impacts are more significant than in fossil fuel use. The wood molded fiber tray has the highest end-of-life impact. The foam PS tray with 30% PCR has a lower impact because of the significantly lighter weight compared to the majority of the other trays and the addition of recycled material.

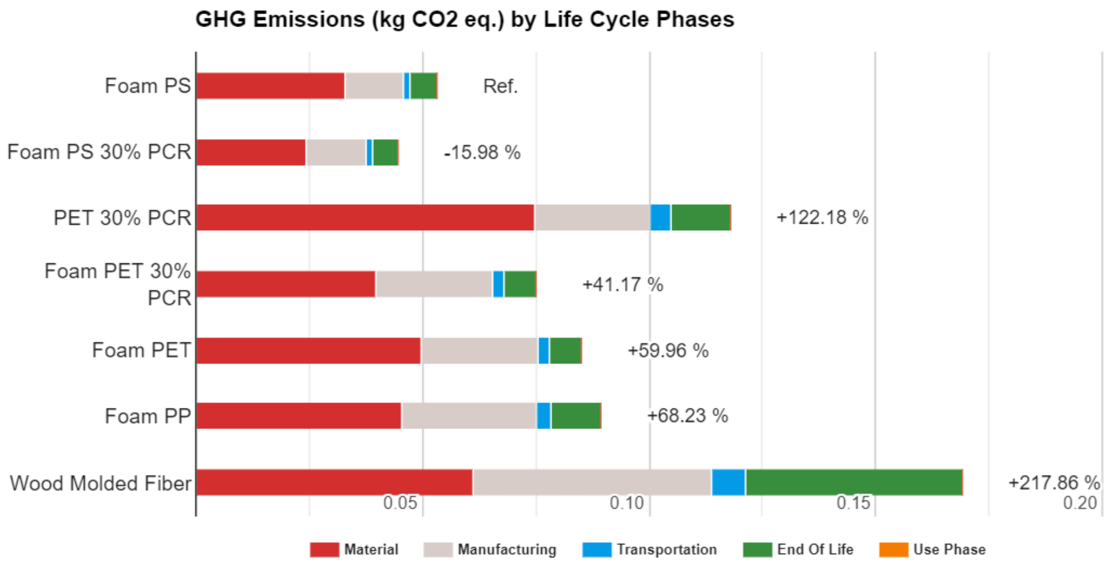

Figure 5: Greenhouse Gas Emissions for the Meat Trays

Water Use

When looking at water use, all the trays have a much lower impact than the wood molded fiber tray. The biggest driver here is the material phase of the life cycle, followed by the manufacturing phase. This is due to water use during the pulping of the wood.

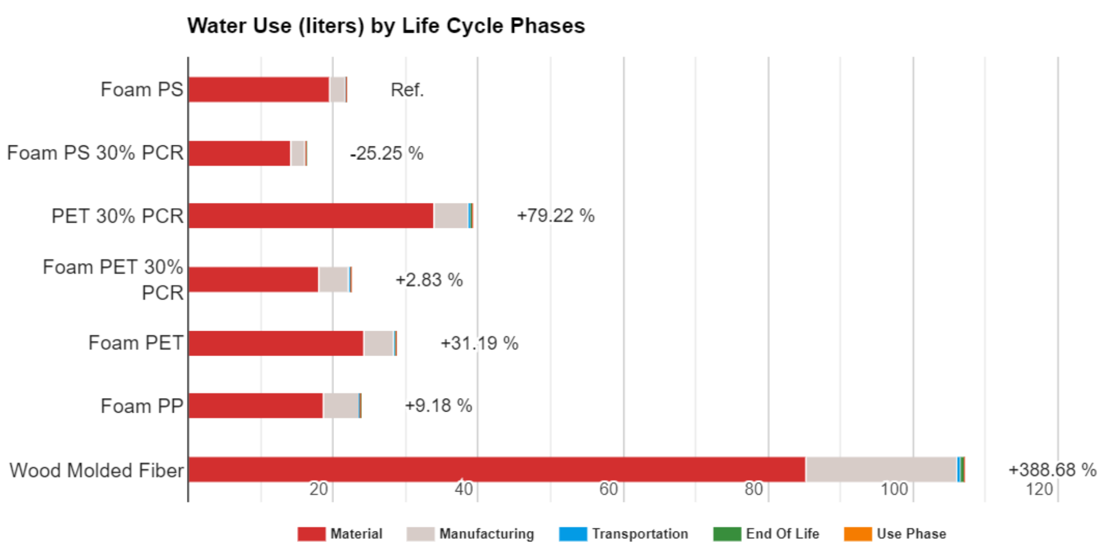

Figure 6: Water Use for the Meat Trays

Additional Sustainability Attributes

For the remaining five impacts, the wood molded fiber tray had the highest impact in three categories (freshwater ecotoxicity, human impact, and freshwater eutrophication). However, for GHG emissions with carbon uptake and mineral resource use, the PET tray with 30% PCR had a higher impact. Definitions for each of these five attributes may be found in the Appendix.

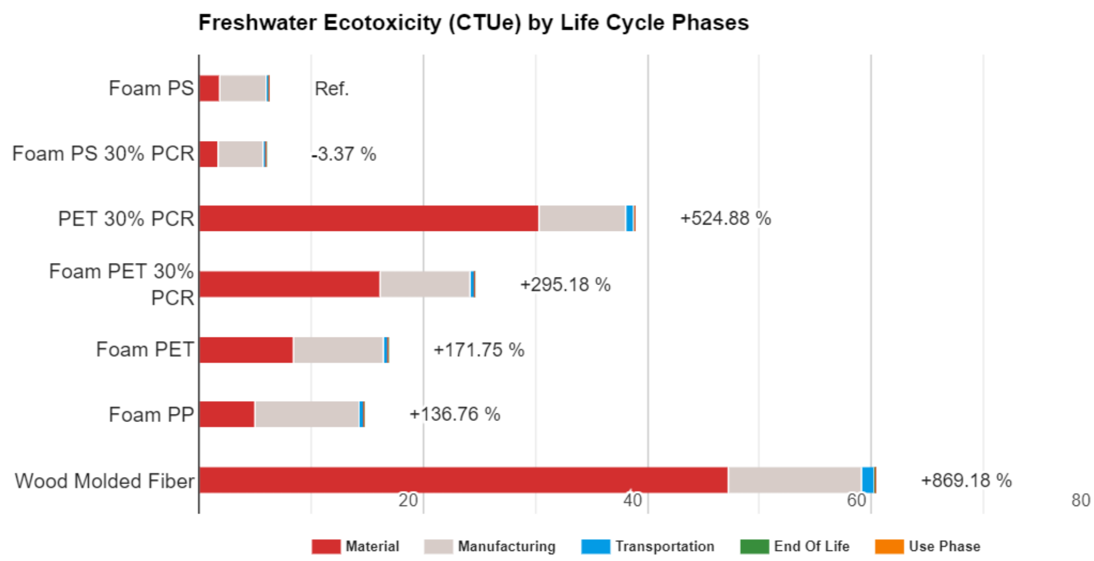

Figure 7: Freshwater Ecotoxicity for the Meat Trays

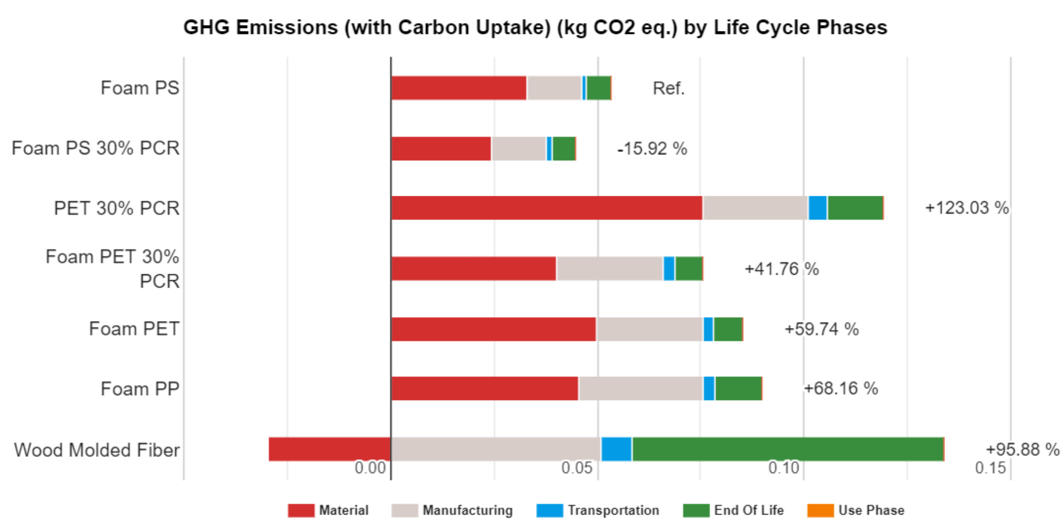

Figure 8: Greenhouse Gas Emissions (with Carbon Uptake) for the Meat Trays

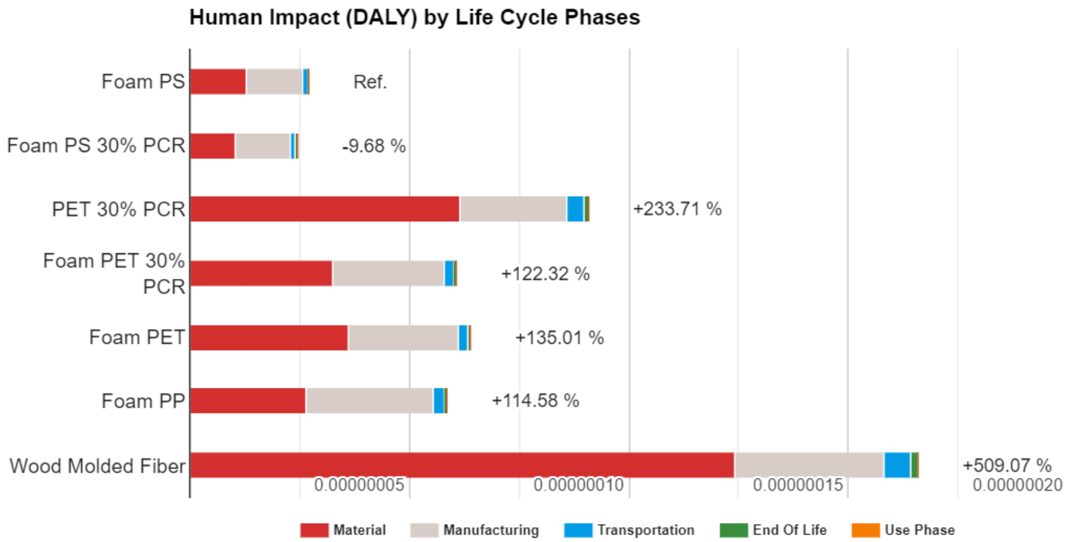

Figure 9: Human Impact for the Meat Trays

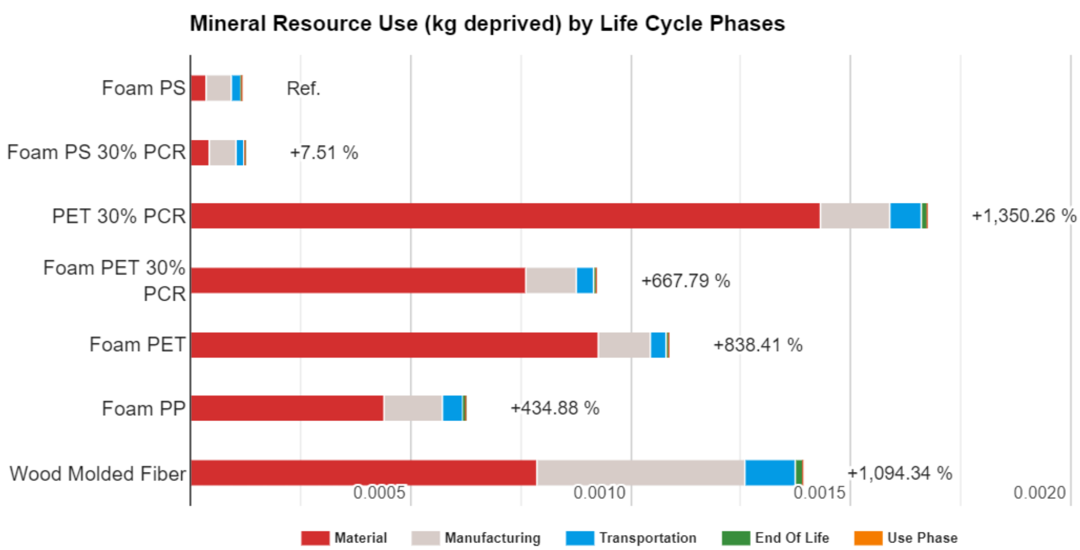

Figure 10: Mineral Resource Use for the Meat Trays

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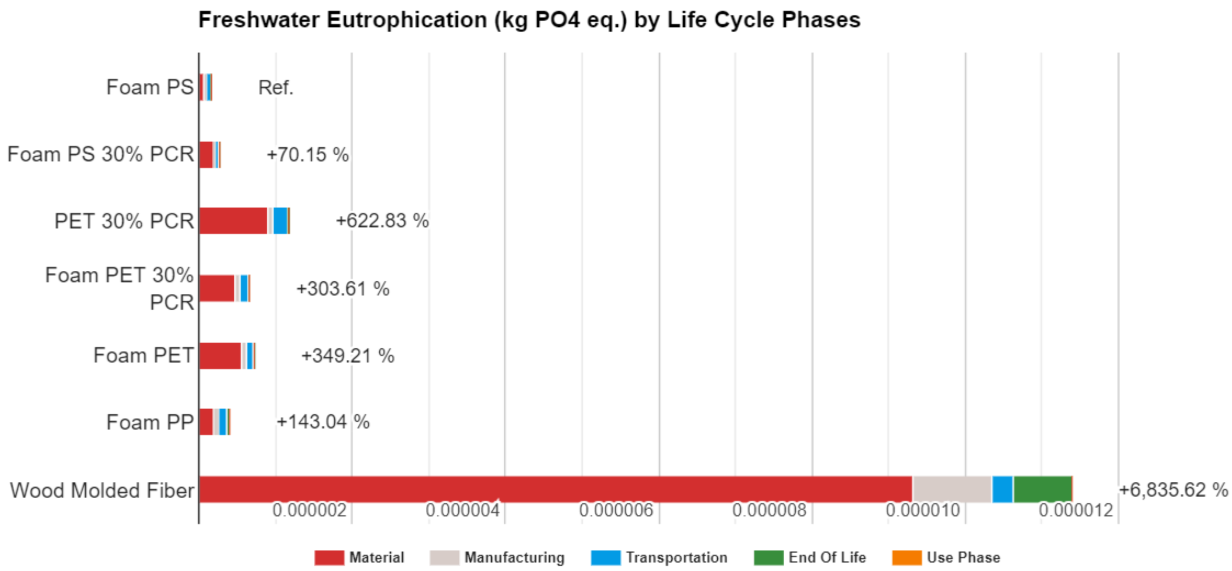

Figure 11: Freshwater Eutrophication for the Meat Trays

Interpretation

This report details the results of the LCA conducted between a variety of meat trays made of PET, PS, PP, and wood molded fiber. The tray with the best environmental footprint appeared to be the foam PS with 30% PCR and the most environmentally-impactful tray was made of wood molded fiber and PET with 30% PCR.

Fulfilling the Goal of the LCA

This report details results of the comparison between various meat trays. The chosen indicators provide a holistic view of the packaging impact and inform Pactiv Evergreen of the environmental impact and general trends between processes, recycled material content, and material in the context of their meat trays.

This study is complete and includes all significant aspects of the life cycle of these packaging systems, therefore can provide them with internal guidance and quantitative data to current and prospective customers. The models detailed in this report and the boundary conditions applied are consistent with the goal of providing Pactiv Evergreen with a comparison of meat trays.

Study Limitations

The results from this study must be looked at in the context of the limitations of this study. This report was limited to data provided and assumptions made where data was absent. The end-of-

life scenarios for the trays uses the latest data for the United States about overall collection percentages for various material and packaging types.

Another limitation to this LCA is that it includes only primary packaging. As shipping container size and pallet loading can change depending on the tray characteristics, impacts could possibly change based on secondary and tertiary packaging.

Shelf life and damage rate were also not considered as this can depend on storage conditions, handling, tray covering, and other factors beyond simply tray design.

Sensitivity Analysis

Since end-of-life scenarios for the trays uses the latest data for the United States about overall collection percentages for various material and packaging types, adjustment to the percentages for the wood molded fiber tray was performed to determine if this affected the overall environmental impact. When increasing the recycling or waste to energy percentages, the impacts in most categories did not change or decreased by less than 2%. The categories GHG emissions and GHG emissions with carbon uptake are affected by increasing the recycling rate, however. When increasing the recycling percentage, the landfill percentage was decreased by the corresponding amount. If the recycling percentage is increased by 5%, 10%, 15%, and 20%, the GHG emissions and the GHG emissions with carbon uptake decreased by 2 and 5%, 4 and 10%, 7 and 14%, and 9 and 19%, respectively. However, this eventually reaches a recycling rate of 41%, which is unlikely.

If waste to energy percentage is increased by the same amounts, the same percent decrease is observed for the GHG emissions category. However, for every 5% increase of waste to energy (with the corresponding 5% decrease to landfill), there is only a 1% decrease in impact for GHG emissions with carbon uptake.

Figure 12 shows a comparison of the wood molded fiber tray with a wood molded fiber tray with adjusted recycling and waste to energy rates. The figure on the left illustrates an increase of recycling by 5% and an increase in waste to energy of 5%. On the right, the increases are 20%.

Figure 12: LCA of a Wood Molded Fiber Tray Compared to Trays with Adjusted End-of-Life Percentages

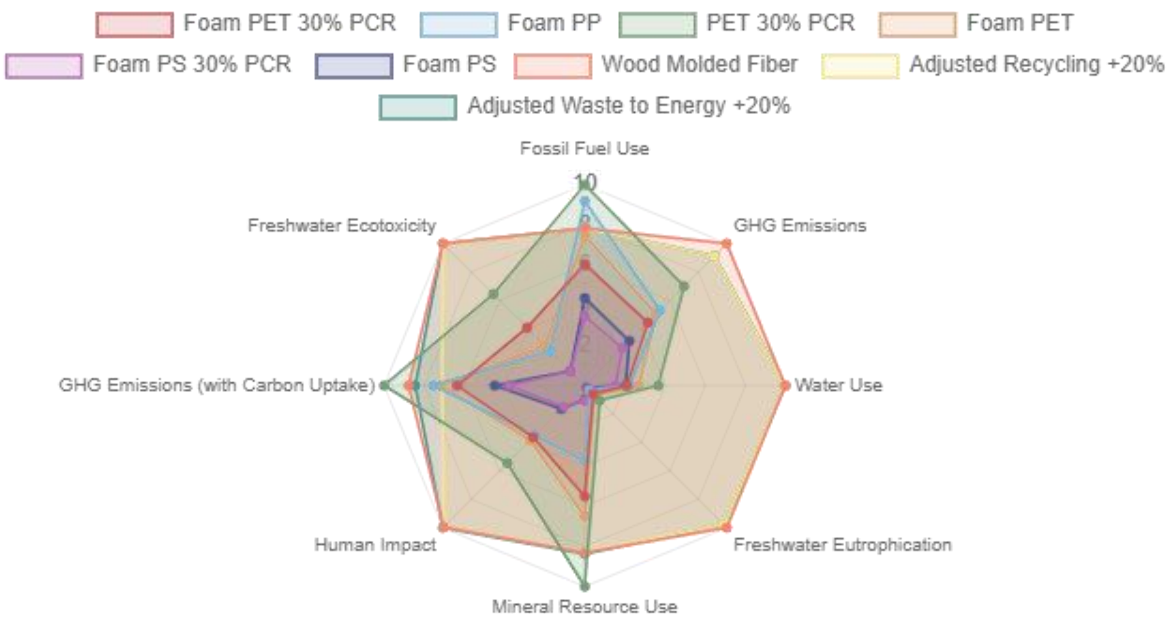

Figure 13: LCA for All Trays Compared to Wood Molded Fiber Trays with Adjusted End-of-Life Percentages

The wood molded fiber tray was also the heaviest of all by 17.5 g to 41.2 g, depending on the comparison tray. Since it is possible that there may be lower weight trays, a sensitivity analysis was also performed to determine the role the higher weight has on the environmental impact outcomes. When the weight of the wood molded fiber tray was adjusted from 50 g to 33 g, approximately the weight of the next heaviest tray (the PET tray with 30% PCR), its impacts for freshwater eutrophication, human impact, and water use were still the highest and the impact for freshwater ecotoxicity was slightly higher (by 2%) than the PET tray with 30% PCR. However, when considering the adjusted weight for the wood molded fiber tray, the PET tray with 30% PCR was higher in fossil fuel use, GHG emissions, GHG emissions with carbon uptake, and mineral resources use. Except for the GHG emissions being higher for the PET tray with 30% PCR, this was the same for when the 50 g wood molded fiber tray was considered.

For the impact category of fossil fuel use, at 33 g the wood molded fiber tray has a lower impact than all trays except for the foam PS tray and the foam PS tray with 30% PCR. At the higher weight, the wood molded fiber tray has a higher impact than all the trays except for the foam PP tray and the PET tray with 30% PCR (Figure 14).

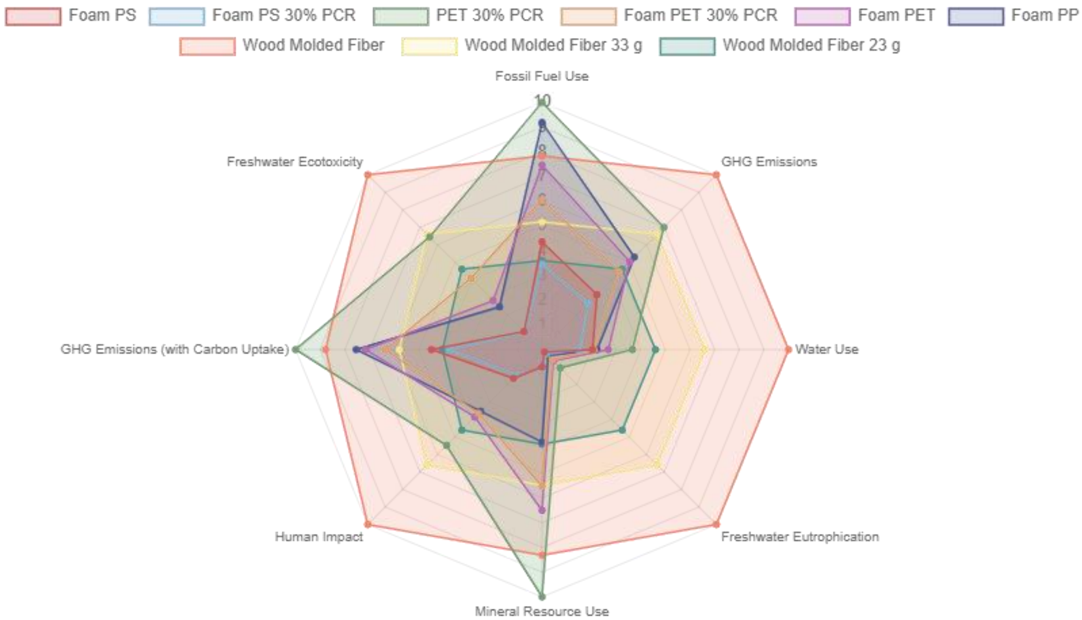

Figure 14: LCA for All Trays Compared to Wood Molded Fiber Tray with Adjusted Weight

For 3P dimensions, there are wood molded fiber trays on the market that are lighter than this. The lightest tray that Trayak was able to locate weighed 23 g and had the dimensions of 8.6" x 6.5" x 1.25" (which are 3P tray dimensions). When this sensitivity analysis was repeated for a wood mold fiber tray weighing 23 g, this tray did have a lower overall impact. While the foam PS and Foam PS 30% PCR trays still had a lower impact overall, the 23 g wood molded fiber tray had a lower impact than the plastic trays for the categories of fossil fuel use and GHG emissions with carbon uptake (except for Foam PS 30% PCR, which still had a lower impact). For the categories of water use and freshwater eutrophication, the 23 g wood molded fiber tray still had a higher impact than all the plastic trays.

When comparing the 50 g, 33 g, and 23 g wood molded fiber trays, there is a 34 to 36% reduction in each impact category for the 23 g tray and a 54% reduction for the 23 g tray (Figure 15). As expected, the weight of the tray and the impact percentage exhibits a linear relationship.

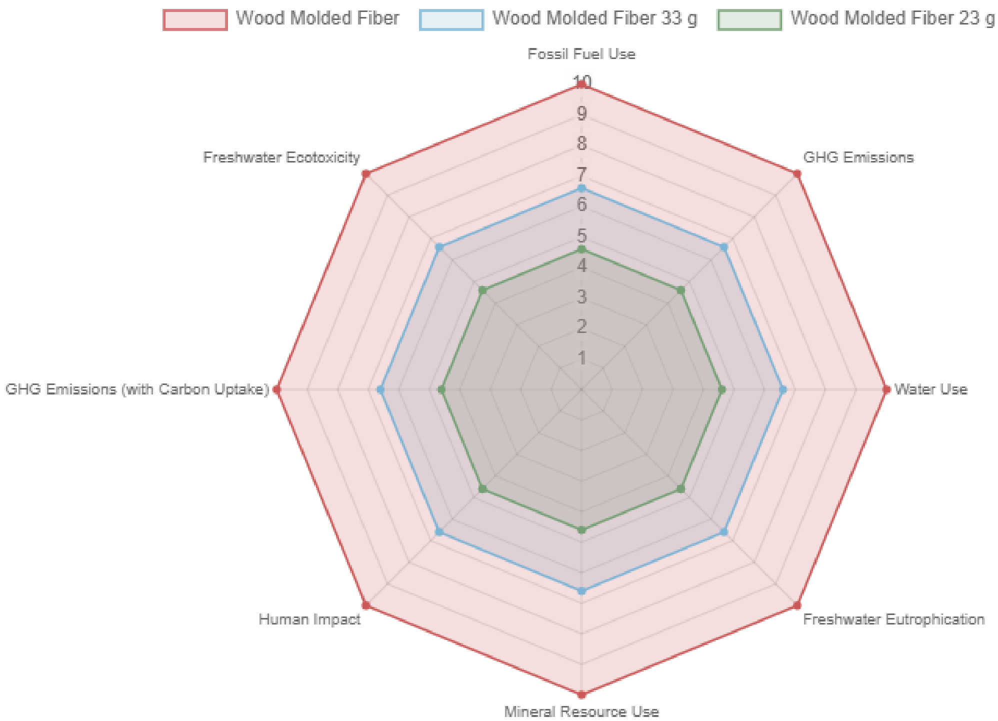

Figure 15: LCA for a Wood Molded Fiber Tray Compared to a Wood Molded Fiber Trays with Adjusted Weight

Recommendations

This LCA was modeled to compare a variety of meat trays made of foam PS, foam PS with 30% PCR, PET with 30% PCR, foam PET with 30% PCR, foam PET, foam PP and wood molded fiber. To model a more complete comparison, secondary and tertiary packaging should also be included.

Conclusions

Overall, Pactiv Evergreen conducted this LCA to compare meat trays made of varying material and PCR content. The tray with the best environmental footprint was the foam PS with 30% PCR followed by the foam PS. The foamed trays were generally lower impact than the non-foamed trays, and the PS was lower impact than the PP and PET among the foamed trays.

Appendix

COMPASS Methodology and Indicator Descriptions

Documentation

The COMPASS methodology and indicators are informed by a cross-functional team of brands, packaging suppliers, LCA professionals, and educators. The methodology was agreed upon when COMPASS was created by GreenBlue as a project of the Sustainable Packaging Coalition. Trayak now has ownership of the COMPASS tool, but the indicators and decisions made in regards to packaging are still present today. These indicators provide a holistic view of the environmental impacts of a packaging system and help support the goal of providing Pactiv Evergreen with quantitative data for their meat trays.

The indicators within the COMPASS methodology consist of consumption and emission metrics. When possible, the indicators are used as is with the latest characterization factors available. Some of the indicators are scarcity based including fossil fuel use, water use, and mineral resource use. Human impacts are severity based and are also a collection of impacts for particulate matter, toxic non-cancer causing, and carcinogenic compounds. All of the indicators serve as a reference point for Pactiv Evergreen to have a big picture view of the environmental impacts of their packaging systems. Below are more descriptions about each of the indicators and their sources.

Consumption

- **Fossil Fuel Consumption (MJ-eq deprived):** Total quantity of fossil fuel consumed throughout the life cycle reported in megajoules (MJ) equivalents deprived. This calculation uses the IMPACT World+ method and assumes fossil resources mainly used for energy purposes. Fossil fuels include coal, petroleum, and natural gas. Inputs for nuclear fuel such as uranium are accounted for in the MINERAL CONSUMPTION metric.
- **Water Use (Liters eq):** The relative available water remaining per area in a watershed after the demand of humans, aquatic ecosystems, and manufacturing process has been met. This metric accounts for water scarcity and the result represents the relative value in comparison with the average liters consumed in the world. Essentially, the total water used to make the package is multiplied by the region's scarcity factor which will either increase or decrease the water usage value based on the scarcity or excess availability of water in a specific region, respectively. We use the AWARE method for this.
- **Mineral Consumption (kg deprived):** This indicator uses the material competition scarcity index from de Bruille (2014) as a midpoint indicator. The factor represents the fraction of material needed by future users that are not able to find a reliable substitute for the mineral. It is expressed in units of kilograms of deprived resource per kilogram of resource dissipated. It considers mineral scarcity and viable substitutes.

Emissions

- **GHG Emissions (kg CO_2 eq) (Default):** The total quantity of greenhouse gases (GHG) emitted throughout the lifecycle reported in kilograms of CO_2 equivalents. This calculation follows the latest IPCC 2013 method and considers climate feedback loops.
- **GHG Emissions – with Carbon Uptake (kg CO_2 eq):** The total quantity of greenhouse gases (GHG) emitted throughout the lifecycle reported in kilograms of CO_2 equivalents. This calculation follows the latest IPCC 2013 with Carbon Uptake method. This indicator also accounts for carbon sequestration and biogenic carbon emissions.
- **Human Impacts (Total) (DALY):** The quantity of environmental emissions resulting in particulate, cancer & toxic non-cancer impacts to humans released throughout the lifecycle. The metric reports these three measurements in Disability Adjusted Life Years (DALY). Calculated using Impact World+ and considers severity factors of any adverse effects.
- **Freshwater EcoToxicity (CTUe):** The quantity of environmental emissions resulting in aquatic toxic impacts released throughout the lifecycle reported in Comparative Toxic Unit ecosystem (CTUe). CTUe corresponds to a fraction of disappeared species over a cubic meter of freshwater (or marine water) during one year. This is a measure of ecotoxicity impact of chemical releases to air, water, and land using aquatic toxicity factors and is calculated using characterization factors from USEtox 2.0.
- **Eutrophication (kg PO_4-eq):** Eutrophication is the abnormal increase in chemical nutrients that results in excessive plant/algal growth and decay resulting in an anoxic condition in freshwater systems. (The major consequence is algal blooms.) Typically, these are emissions of phosphorus compounds released during the production of materials. It is reported in phosphate (PO_4) equivalents and is calculated with Impact World+ characterization factors.

Definitions

●**Material phase:** measures the environmental footprint of extracting and processing materials

●**Manufacturing phase:** calculates the impact of the manufacturing or conversion processes that companies use to create the package

●**Transportation phase:** the impact is calculated based on the mode of transportation (road, rail, air, sea) as well as the distances traveled

●**End-of-Life phase:** incorporates the most likely fate of the product/package and its components based on typical curbside municipal waste management. Typical percentage rates for region-based recycling, incineration, and landfill are used to calculate the impacts.

● **Primary package:** typically, a package that surrounds the product directly. It can also be called retail or consumer packaging. Examples are bottles, flexible bags, or glass jars.

●**Secondary package:** shipper or case that holds the primary packages. This is most commonly a corrugated box.

●**Tertiary package:** transport unit that holds the secondary packages. In most cases, this is a pallet.

Acronyms

- BOM = Bill of Materials
- EOL = End-of-Life
- GHG = Greenhouse Gas Emissions
- LCA = Life Cycle Assessment
- LCI = Life Cycle Inventory
- PCR = Post-Consumer Recycled Content
- PET = Polyethylene Terephthalate
- PP = Polypropylene
- PS = Polystyrene

Assumptions

Table 5: Data Source and Uncertainty

Name in EcoImpactCOMPASS	Source	Ecoinvent Process if applicable	Pedigree Matrix	Uncertainty	Data Quality Rating
Polystyrene (PS)	ecoinvent 3.8	Polystyrene, general purpose {GLO}| market for | Cut-off, U	[2,1,1,1,1]	1.54	Excellent Quality
Polyethylene Terephthalate (PET)	ecoinvent 3.8	Polyethylene terephthalate, granulate, amorphous {GLO}| market for | Cut-off, U	[2,1,1,1,1]	1.54	Excellent Quality

Name in EcoImpactCOMPASS	Source	Ecoinvent Process if applicable	Pedigree Matrix	Uncertainty	Data Quality Rating
Polypropylene (PP)	ecoinvent 3.8	Polypropylene, granulate {GLO}| market for | Cut-off, U	[2,1,1,1,1]	1.54	Excellent Quality
Foaming/Expanding	ecoinvent 3.8	Polymer foaming {US}| processing | Cut-off, U	[2,4,2,4,1]	1.57113865	Good Quality
Inline Extrusion (plastic sheet and thermoforming)	ecoinvent 3.8	Extrusion of plastic sheets and thermoforming, inline {US}| processing | Cut-off, U	[1,3,2,4,2]	1.22352682	Good Quality
Polystyrene (PS) - Landfill	ecoinvent 3.8	Waste polystyrene {US}| treatment of, sanitary landfill | Cut-off, U	[2,3,2,3,1]	1.55477171	Good Quality
Polystyrene (PS) - Waste to Energy	ecoinvent 3.8	Waste polystyrene {US}| treatment of, municipal incineration | Cut-off, U	[3,3,2,3,1]	1.62402260	Good Quality

Name in EcoImpactCOMPASS	Source	Ecoinvent Process if applicable	Pedigree Matrix	Uncertainty	Data Quality Rating
Polyethylene Terephthalate (PET) - Landfill	ecoinvent 3.8	Waste polyethylene terephtalate {US}| treatment of waste polyethylene terephthalate, sanitary landfill | Cut-off, U	[2,3,2,3,1]	1.55477171	Good Quality
Polyethylene Terephthalate (PET) - Waste to Energy	ecoinvent 3.8	Waste polyethylene terephtalate {US}| treatment of waste polyethylene terephthalate, municipal incineration | Cut-off, U	[3,3,2,3,1]	1.6240226	Good Quality
Polypropylene (PP) - Landfill	ecoinvent 3.8	Waste polypropylene {US}| treatment of, sanitary landfill | Cut-off, U	[2,3,2,3,1]	1.55477171	Good Quality
Polypropylene (PP) - Waste to Energy	ecoinvent 3.8	Waste polypropylene {US}| treatment of, municipal incineration | Cut-off, U	[3,3,2,3,1]	1.6240226	Good Quality

Name in EcoImpactCOMPASS	Source	Ecoinvent Process if applicable	Pedigree Matrix	Uncertainty	Data Quality Rating
Road-Truck > 32 ton-US	ecoinvent 3.8	Transport, freight, lorry >32 metric ton, EURO4 {RoW}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off, U	[2,3,1,3,1]	1.55323171	Very Good Quality

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Additional Data

Table 6: Fossil Fuel Use for the Meat Trays

Fossil Fuel Use (MJ deprived)							
Total quantity of fossil fuel consumed throughout the life cycle reported in megajoules (MJ) equivalents deprived. This indicator uses the Impact World+ method and assumes fossil resources mainly used for energy purposes. Fossil fuels include coal, petroleum, and natural gas. Inputs for nuclear fuel such as uranium are accounted for in the MINERAL CONSUMPTION indicator.							
Indicators	**Phases**						
	Total	**Material**	**Manufacturing**	**Transportation**	**End-Of-Life**	**Use Phase**	**% Difference**
Foam PS	1.03	0.7971	0.2062	0.0216	0.002	0.0	ref.
Foam PS 30% PCR	0.8156	0.5857	0.2062	0.0216	0.002	0.0	-20.58
PET 30% PCR	2.36	1.83	0.4397	0.0798	0.0073	0.0	129.54
Foam PET 30% PCR	1.43	0.9744	0.4054	0.0425	0.0039	0.0	38.87
Foam PET	1.76	1.31	0.4054	0.0425	0.0039	0.0	71.29
Foam PP	2.17	1.64	0.4687	0.0491	0.0047	0.0	110.86
Wood Molded Fiber	1.85	0.7622	0.9464	0.1227	0.0143	0.0	79.71

Table 7: Greenhouse Gas Emissions for the Meat Trays

GHG Emissions (kg CO2 eq.)							
The total quantity of greenhouse gases (GHG) emitted throughout the life cycle reported in kilograms of CO2 equivalents. This calculation follows the IPCC Sixth Assessment Report (AR6) 2021 100a w/o CO2 Uptake method and considers climate feedback loops.							
Indicators	**Phases**						
	Total	**Material**	**Manufacturing**	**Transportation**	**End-Of-Life**	**Use Phase**	**% Difference**
Foam PS	0.0532	0.0329	0.013	0.0013	0.0059	0.0	ref.
Foam PS 30% PCR	0.0447	0.0245	0.013	0.0013	0.0059	0.0	-15.86
PET 30% PCR	0.1182	0.0748	0.0253	0.0048	0.0133	0.0	122.4
Foam PET 30% PCR	0.0751	0.0398	0.0256	0.0026	0.0071	0.0	41.29
Foam PET	0.0851	0.0498	0.0256	0.0026	0.0071	0.0	60.01
Foam PP	0.0895	0.0456	0.0296	0.003	0.0113	0.0	68.35
Wood Molded Fiber	0.1691	0.0611	0.0528	0.0074	0.0478	0.0	218.06

Table 8: Water Use for the Meat Trays

Water Use (liters)							
The relative available water remaining per area in a watershed after the demand of humans, aquatic ecosystems, and manufacturing process has been met. This indicator uses the AWARE method and accounts for water scarcity. The result represents the relative value in comparison with the average liters consumed in the world. Essentially, the total water consumed to make the package is multiplied by the region's scarcity factor which will either increase or decrease the water usage value based on the scarcity or excess availability of water in a specific region.							
Indicators	**Phases**						
	Total	**Material**	**Manufacturing**	**Transportation**	**End-of-Life**	**Use Phase**	**% Difference**
Foam PS	21.9	19.62	2.1	0.0785	0.0969	0.0	ref.
Foam PS 30% PCR	16.37	14.1	2.1	0.0785	0.0969	0.0	-25.22
PET 30% PCR	39.25	33.91	4.71	0.2899	0.3411	0.0	79.24
Foam PET 30% PCR	22.52	18.05	4.13	0.1543	0.1816	0.0	2.83
Foam PET	28.73	24.26	4.13	0.1543	0.1816	0.0	31.21
Foam PP	23.91	18.73	4.78	0.1784	0.2266	0.0	9.21
Wood Molded Fiber	107.02	85.19	20.82	0.446	0.5619	0.0	388.71

Table 9: Freshwater Eutrophication for the Meat Trays

Freshwater Eutrophication (kg PO4 eq.)							
Eutrophication is the abnormal increase in chemical nutrients that results in excessive plant/algal growth and decay resulting in an anoxic condition in freshwater systems, the major consequence being algal blooms. Typically, these are emissions of phosphorus compounds released during the production of materials. It is reported in phosphate (PO4) equivalents and is calculated with Impact World+ characterization factors.							
Indicators	**Phases**						
	Total	**Material**	**Manufacturing**	**Transportation**	**End-of-Life**	**Use Phase**	**% Difference**
Foam PS	1.64E-7	6.8E-8	3.24E-8	4.93E-8	1.46E-8	0.0	ref.
Foam PS 30% PCR	2.8E-7	1.83E-7	3.24E-8	4.93E-8	1.46E-8	0.0	70.15
PET 30% PCR	1.19E-6	9.07E-7	6.16E-8	1.82E-7	3.76E-8	0.0	622.83
Foam PET 30% PCR	6.63E-7	4.83E-7	6.38E-8	9.69E-8	2.0E-8	0.0	303.61
Foam PET	7.38E-7	5.58E-7	6.38E-8	9.69E-8	2.0E-8	0.0	349.2
Foam PP	3.99E-7	1.85E-7	7.37E-8	1.12E-7	2.88E-8	0.0	143.04
Wood Molded Fiber	1.14E-5	9.31E-6	1.03E-6	2.8E-7	7.8E-7	0.0	6835.52

Table 10: Mineral Resource Use for the Meat Trays

Mineral Resource Use (kg deprived)							
This indicator uses the material competition scarcity index from de Bruille (2014) as a midpoint indicator and is pulled from Impact World+. The factor represents the fraction of material needed by future users that are not able to find a reliable substitute for the mineral. It is expressed in units of kilograms of deprived resource per kilogram of resource dissipated. It considers mineral scarcity and viable substitutes.							
Indicators	**Phases**						
	Total	**Material**	**Manufacturing**	**Transportation**	**End-of-Life**	**Use Phase**	**% Difference**
Foam PS	1.17E-4	3.46E-5	5.87E-5	1.97E-5	4.3E-6	0.0	ref.
Foam PS 30% PCR	1.26E-4	4.34E-5	5.87E-5	1.97E-5	4.3E-6	0.0	7.51
PET 30% PCR	0.0017	0.0014	1.57E-4	7.26E-5	1.41E-5	0.0	1329.66
Foam PET 30% PCR	9.0E-4	7.62E-4	1.15E-4	3.86E-5	7.51E-6	0.0	688.3
Foam PET	0.0011	9.0E-4	1.15E-4	3.86E-5	7.51E-6	0.0	829.13
Foam PP	6.27E-4	4.39E-4	1.33E-4	4.47E-5	9.72E-6	0.0	434.87
Wood Molded Fiber	0.0014	7.88E-4	4.72E-4	1.12E-4	2.11E-5	0.0	1088.6

Table 11: Human Impact for the Meat Trays

Human Impact (DALY)							
The quantity of short-term environmental emissions resulting in particulate, cancer & toxic non-cancer impacts to humans released throughout the lifecycle. The metric reports these three measurements in Disability Adjusted Life Years (DALY). Calculated using Impact World+ and considers severity factors of any adverse effects.							
Indicators	**Phases**						
	Total	**Material**	**Manufacturing**	**Transportation**	**End-of-Life**	**Use Phase**	**% Difference**
Foam PS	2.73E-8	1.29E-8	1.28E-8	1.1E-9	5.22E-10	0.0	ref.
Foam PS 30% PCR	2.46E-8	1.02E-8	1.28E-8	1.1E-9	5.22E-10	0.0	-9.68
PET 30% PCR	9.1E-8	6.14E-8	2.44E-8	3.9E-9	1.34E-9	0.0	233.71
Foam PET 30% PCR	6.07E-8	3.27E-8	2.51E-8	2.1E-9	7.15E-10	0.0	122.32
Foam PET	6.41E-8	3.62E-8	2.51E-8	2.1E-9	7.15E-10	0.0	135.01
Foam PP	5.85E-8	2.63E-8	2.91E-8	2.4E-9	7.51E-10	0.0	114.58
Wood Molded Fiber	1.66E-7	1.24E-7	3.41E-8	6.0E-9	2.02E-9	0.0	509.07

Table 12: Greenhouse Gas Emissions (with Carbon Uptake) for the Meat Trays

GHG Emissions (with Carbon Uptake) (kg CO2 eq.)							
The total quantity of greenhouse gases (GHG) emitted throughout the life cycle reported in kilograms of CO2 equivalents. This calculation follows the IPCC Sixth Assessment Report (AR6) 2021 100a w/ CO2 Uptake method. This indicator also accounts for carbon sequestration and biogenic carbon emissions.							
Indicators	**Phases**						
	Total	**Material**	**Manufacturing**	**Transportation**	**End-of-Life**	**Use Phase**	**% Difference**
Foam PS	0.0534	0.033	0.0132	0.0013	0.0059	0.0	ref.
Foam PS 30% PCR	0.0449	0.0246	0.0132	0.0013	0.0059	0.0	-15.84
PET 30% PCR	0.1191	0.0755	0.0254	0.0048	0.0133	0.0	123.03
Foam PET 30% PCR	0.0757	0.0402	0.0259	0.0026	0.0071	0.0	41.82
Foam PET	0.0853	0.0498	0.0259	0.0026	0.0071	0.0	59.8
Foam PP	0.0898	0.0456	0.0299	0.003	0.0113	0.0	68.23
Wood Molded Fiber	0.1046	-0.0295	0.0509	0.0074	0.0757	0.0	95.88

Table 13: Freshwater Ecotoxicity for the Meat Trays

Freshwater Ecotoxicity (CTUe)							
The quantity of environmental emissions resulting in aquatic toxic impacts released throughout the life cycle reported in Comparative Toxic Unit ecosystem (CTUe). CTUe corresponds to a fraction of disappeared species over a cubic meter of freshwater (or marine water) during one year. This is a measure of the ecotoxicity impact of chemical releases to air, water, and land using aquatic toxicity factors and is calculated using the Impact World+ midpoint indicator with exclusion of long-term emissions.							
Indicators	**Phases**						
	Total	**Material**	**Manufacturing**	**Transportation**	**End-of-Life**	**Use Phase**	**% Difference**
Foam PS	6.23	1.93	4.08	0.2028	0.0218	0.0	ref.
Foam PS 30% PCR	6.02	1.71	4.08	0.2028	0.0218	0.0	-3.46
PET 30% PCR	38.93	30.34	7.75	0.7488	0.0931	0.0	524.41
Foam PET 30% PCR	24.62	16.15	8.03	0.3986	0.0496	0.0	294.99
Foam PET	16.93	8.46	8.03	0.3986	0.0496	0.0	171.58
Foam PP	14.75	4.96	9.28	0.4608	0.0447	0.0	136.56
Wood Molded Fiber	60.38	47.26	11.79	1.15	0.1786	0.0	868.52

Industrial Ecology Consultants

February 7, 2023

Elizabeth Avery
Trayak
5700 Gateway Blvd | Mason, OH 45040

Verification Report: Pactiv Meat Tray

The Life Cycle Assessment (LCA) Practitioner, **Trayak Inc.** commissioned a panel of experts to perform an external independent verification of the **Supplemental Report for ISO Conformant Life Cycle Assessment** on behalf of the commissioning organization, **Pactiv Evergreen**.

The goal of this review is to demonstrate the generation of a comparative life cycle assessment that meets the requirements of the following standards:

International Organization for Standardization. (2006). *Environmental management -- Life cycle assessment – Principles and framework* (ISO 14040:2006 Amd 1:2020).

International Organization for Standardization. (2006). *Environmental management -- Life cycle assessment -- Requirements and guidelines* (ISO 14044:2006 Amd1:2017/Amd 2:2020).

International Organization for Standardization. (2014). *Environmental management -- Life cycle assessment -- Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006*. (ISO/TS 14071:2014).

The independent third-party verification was conducted by the following panel of experts per ISO 14044:2006 Section 6.2: Critical review:

Thomas Gloria (Chair)
Managing Director
Industrial Ecology Consultants

Matt Dingee
Co-Founder – President – COO
OnPoint 2020 – Packaging Insights and Consulting Services

Joongmin Shin,
Associate Professor
California Polytechnic State University

REVIEW SCOPE

The intent of this review was to provide an independent third-party external verification of various meat tray materials, including varying post-consumer recycled (PCR) content. The meat trays included: foam polystyrene (PS), foam PS with 30% PCR, polyethylene terephthalate (PET) with 30% PCR, foam PET with 30% PCR, foam PET, foam polypropylene (PP) and wood molded fiber. The assessment was executed using the EcoImpact Compass model generating Package Comparison reports supplemented by a manually generated report to bring the study into full conformance with the aforementioned ISO standards. This review did not include an assessment of the Life Cycle Inventory (LCI) model; however, it did include a detailed analysis of the individual datasets used to complete the study.

REVIEW PROCESS

The review process involved the verification of all requirements for the meat tray options in the context of a comparative assessment report. There were three rounds of comments by the reviewers submitted to the LCA practitioner. Responses by the LCA practitioner to each issue raised were resolved and acknowledged by the review panel to have been satisfactorily addressed.

VERIFICATION STATEMENT

Based on the independent verification objectives, the **Supplemental Report for ISO Conformant Life Cycle Assessment** for **Pactiv Evergreen** prepared by **Trayak Inc. January 26, 2023,** was determined to be ***in conformance*** with the applicable ISO standards. The plausibility, quality, and accuracy of the LCA-based data and supporting information are confirmed.

As the Chair of the External Independent Third-Party Review Panel, I confirm that the members of the panel have sufficient scientific knowledge and experience of packaging systems and the applicable ISO standards to carry out this verification.

Sincerely,

Thomas P. Gloria, Ph.D.
Managing Director
Industrial Ecology Consultants