SPP

Streamlined LCA: PP single-use containers vs. Wax-CBC single-use containers

Highlights of Analysis

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2019 Streamlined Life Cycle Assessment (LCA) of SPP Plastic Packaging: PP Containers vs Wax CBC Containers SUMMARY

ES.1 Background and Objective

SeaCA Plastic Packaging, LLC (SPP) has developed a recyclable single-use polypropylene (PP) container with the goal of replacing their wax-corrugated container (wax-CBC). Even though both containers target the single-use container market, the PP container reduces packaging waste to landfill as well as freight emissions as it weighs less than the wax-CBC container.

Currently, the wax-CBC container is the most common container used in this sector.

Main objectives of this study:

- Compare the environmental impacts and sustainable packaging attributes of both containers:
  - SPP's PP container
  - Wax-CBC container
- Inform and educate customers and stakeholders about the PP container.
- Assess the two containers in terms of sustainable packaging criteria

This study was performed following the principles described in the ISO 14040/14044 standards. No comparative assertions are to be made publicly. The priority was to inform their sustainability team regarding how each container product system performed from an environmental and sustainable packaging perspective.

ES.2 Products Studied

SPP's PP container produced in Arizona and Commencement Bay Corrugated (CBC)'s wax-CBC container.
Each container is manufactured in the US, and, the primary ingredients – polypropylene and corrugated board – are sourced within the US as well.
The SPP PP container was assumed to contain 25% recycled PP and 75% virgin PP. SPP is working with its partners to develop a closed-loop recycling system to allow for used PP containers to be recycled. Even through wax-CBC containers contain high percentages of recycled CBC (as high as 65%), the addition of wax prevents them from being accepted into municipal recycling facilities, therefore, they are landfilled. A small portion of these wax-CBC boxes will be incinerated, or, re-purposed into clean-burning fire logs (CleanFlame, for example.)

Containers for 5 different types of produce were analyzed:

- Asparagus,
- Broccoli,
- Celery,
- Corn and
- Leafy greens

Table 1. Container Systems Studied

Produce	PP Box Weight (lbs.)	CBC-Wax Box Weight (lbs.)
Asparagus	0.5	0.93
Broccoli	1.17	2.13
Celery	1.19	2.03
Corn	1.61	2.75
Leafy Greens	1.17	2.13

Each of these companies has integrated numerous recycling loops within their container manufacturing processes, therefore, losses due to manufacturing waste were considered insignificant to the overall results. To account for freight, the reference flow of 1 truckload of empty containers for each of the produce types was studied. As the produce weight was the same for each container, it was not necessary to include freight data including the produce weight as the goal was to examine how the containers influenced the overall freight impact.

ES.3 The Study Design and Methods Employed

The functional unit for the study is **"a truckload of empty produce containers shipped to the distribution center."** To account for differences in produce to container material efficiencies, the 5 packaging systems were studied, and, the average impacts were reported.

The following product systems are included in this comparative analysis:

1) a truckload of empty PP produce containers shipped to the distribution center (DC).
2) a truckload of empty wax-CBC produce containers shipped to the distribution center (DC).

For the functional unit to provide a true basis for comparison, it was necessary to study the 5 most common types of produce shipped in these containers.
The reference flow for the comparative analysis is one truckload of empty produce containers shipped from the manufacturer to the DC.
The system boundary includes all raw material extraction and preparation, container manufacturing, shipping and end of life as shown in Figure 1.

Exclusions from the system boundary

- Capital equipment, infrastructure and facilities
- Loss rates associated within the container manufacturing for both the PP and Wax-CBC containers
- Co-products from either container manufacturing process
- No freight for incoming materials was considered

The container product system was separated into three life cycle phases:

1) **Raw materials and container manufacturing**

   For both product systems, all inputs and their upstream flows were included.

   SPP PP:

   - Virgin PP – petroleum extraction, processing, PP pellet manufacturing
   - Recycled PP – Material recycling facility (MRF) flows including transportation to the MRF.
   - PP container manufacturing – grid electricity consumption and thermoforming manufacturing process

   Wax-CBC:

   - Data from the 2017 update of the 2014 NCASI Life Cycle Assessment of U.S. Average Corrugated Product was used to model both the virgin pulp and recycled pulp.
   - Naphtha wax – petroleum extraction, naphtha refining and wax production

2) **Distribution**
   - Freight transport to the DC was modelled using the same estimated distance from container manufacturing to the DC for both container systems
     - The distance from the container manufacturing to the DC was 1,000 miles
   - The number of containers per truckload was provided by SPP.

3) **End of Life (EoL)**
   - PP Container EoL waste stream allocation – 75% to landfill and 25% to recycling
   - Wax-CBC EoL waste stream allocation – 80% to landfill and 20% to incineration, assume 0% recycling

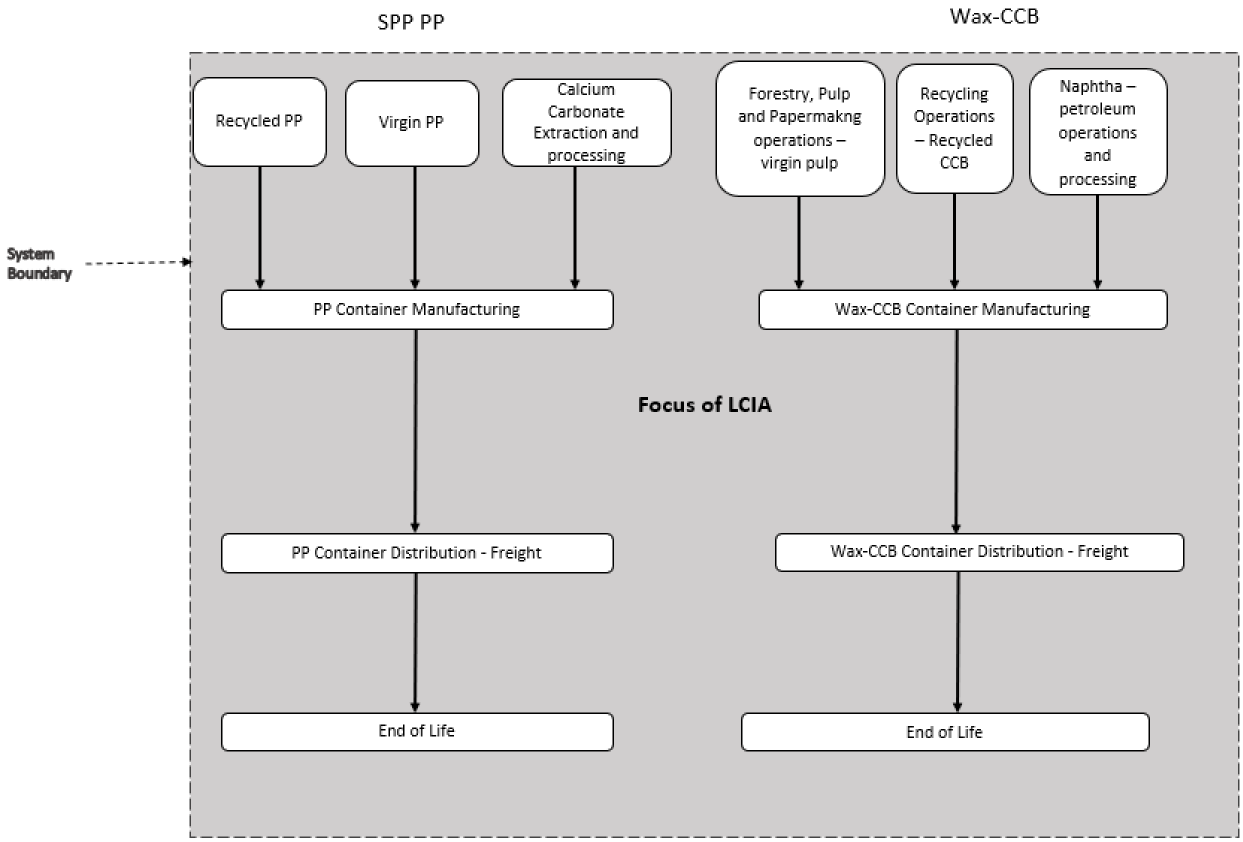

Figure 1 Container Systems Studied

The data for the study was obtained from the following sources:

Primary data was collected from SPP and secondary data from high quality literature, such as peer-reviewed LCAs for corrugated board and polypropylene recycling.
All upstream data for the corrugated input was sourced from the 2017 update of the 2014 NCASI Life Cycle Assessment of U.S. Average Corrugated Product. All recycled and virgin polypropylene upstream and pellet production data was obtained from the Association of Plastic Retailers (APR) December 2018 LIFE CYCLE IMPACTS FOR POSTCONSUMER RECYCLED RESINS: PET, HDPE, AND PP prepared by Franklin Associates. This data is considered of very high quality due to its technological and geographical representativeness. Secondary data was used for thermoforming, grid electricity, calcium carbonate, naphtha, freight and end of life was modeled using ecoinvent v3.5 datasets for the most recent technology available. This database is validated in a review process, known for its high quality, and is well-regarded in the LCA community.
For generic processes, the best regional representative was selected. However, for several processes, only global (GLO) or rest-of-world (ROW) averages exist in the ecoinvent database. Electricity mixes with the appropriate geographical scope were used.
All datasets were selected with the correct time representativeness. Background datasets (such as electricity mixes) are time representative.
No allocation of coproducts was considered.

Figure 2. provides the material and process listing for the baseline PP container – corn.
All other PP containers were modeled with the same ratio of inputs:

- 10% CaCO3
- 90% PP – 25% of this PP feedstock is from PCR sources and 75% is virgin PP

Table 2. provides the mass basis used for each container scenario modeled. The number of containers/truckload varies by produce type.
SPP PP Container materials listing – only the value will vary by produce type, identical materials are used in exactly the same ratios as stated above.

Table 2. PP Container Inventory

Produce	PP Carton Weight (kg)	# of Containers/Truck	Total Truckload PP Container Weight (kg)	NaCO3 mass (kg)	vPET mass (kg)	rPET mass (kg)	Freight - Mfg->DC-Retailer (tonne*km) - Truckload Corn PP Containers
Corn	0.59	20,160	11,887.75	1,188.77	8,024.23	2,674.74	19,131.48
Broccoli	0.54	20,160	10,790.42	1,079.04	7,283.53	2,427.84	17,365.49
Celery	0.53	20,160	10,607.53	1,060.75	7,160.08	2,386.69	17,071.16
Leafy Greens	0.75	16,240	12,154.46	1,215.45	8,204.26	2,734.75	19,560.71
Asparagus	0.23	67,500	15,308.74	1,530.87	10,333.40	3,444.47	24,637.03

Raw Materials and Container Manufacturing

Output

Material	Value	Unit
Virgin PP	8,024.23	kg
Recycled PP	2,674.74	kg
extrusion of plastic sheets and thermoforming, inline	11,887.75	kg
calcium carbonate, precipitated	1,188.78	kg

Output

Material	Value	Unit
PP Container - Corn	11,887.75	kg

Distribution

Material	Value	Unit
transport, freight, light commercial vehic	19,131.48	metric ton*km
PP Container - Corn	11,887.75	kg

EoL

Material	Value	Unit
PP Container - Celery - to Recycling	2,971.94	kg
waste plastic, mixture	8,915.81	kg
waste plastic, mixture	8,915.81	kg

Figure 2. Baseline PP Model – Corn Container

Figure 3. provides the material and process listing for the baseline wax-CBC container – corn. All other wax-CBC containers were modeled with the same ratio of inputs:

- 45% Wax
- 55% CBC – CBC data was built upon NCASI industry average split between recycled and virgin CBC.

Table 3. provides the mass basis used for each container scenario modeled. The number of containers/truckload varies by produce type.
Wax-CBC Container materials listing – only the value will vary by produce type, identical materials are used in exactly the same ratios as stated above.

Table 3. Wax-CBC Inventory

Produce	Wax-CBC Carton Weight (kg)	# of Containers/Truck	Total Truckload Wax-CBC Container Weight (kg)	Naphtha mass (kg)	Recycled and virgin CBC mass (kg) NCASI	Freight - Mfg->DC-Retailer (tonne*km) - Truckload Corn wax-CBC Containers
Corn	1.25	20,160	25,147.16	11,316.22	13,830.94	40,470.43
Broccoli	0.97	20,160	19,477.62	8,764.93	10,712.69	31,346.19
Celery	0.92	20,160	18,563.18	8,353.43	10,209.75	29,874.54
Leafy Greens	0.97	16,240	15,690.30	7,060.64	8,629.67	25,251.10
Asparagus	0.42	67,500	28,474.26	12,813.42	15,660.84	45,824.88

Raw Materials and Container Manufacturing

Input

Material	Value	Unit
paraffin	13,830.94	kg
CCB	11,316.22	kg

Output

Material	Value	Unit
Wax CCB Corn Container	25,147.16	kg

Distribution

Material	Value	Unit
Wax CCB Corn Container	25,147.16	kg
transport, freight, light commercial vehicle	40,470.43	metric ton*km

EoL

Material	Value	Unit
Wax CCB Corn Container	**25,147.16**	**kg**
waste paperboard	5,029.43	kg
waste paperboard	20,117.73	kg

Figure 3. Baseline Wax-CBC Container - Corn

The life cycle modeling was done using the Umberto LCA+™ software package and the data sources mentioned above. Environmental impacts were characterized using the following impact categories

- TRACI - Climate Change (Global Warming Potential, GWP)
- TRACI - Eutrophication
- CML 2001 – Acidification
- Cumulative Energy Demand (CED)
- Water Usage

Impact/Inventory	Description	Unit	LCIA/LCI Methodology
Total energy demand	Total energy from point of extraction; results include both renewable and non-renewable energy sources	MJ	Cumulative energy inventory
Water consumption	Freshwater withdrawals which are evaporated, incorporated into products and waste, transferred to different watersheds, or disposed into the sea after usage	M3	Cumulative water consumption inventory
Global warming potential (GWP)	Represents the heat trapping capacity of greenhouse gases. Important emissions include fossil CO_2, CH_4, N_2O, fluorinated gases.	kg CO_2 equivalents (eq)	TRACI 2.0
Acidification potential	Quantifies the acidifying effect of substances on their environment. Important emissions: SO_2, NO_x, NH_3, HCl, HF, H_2S	kg SO_2 eq	CML 2001
Eutrophication potential	Assesses impacts from excessive load of macro-nutrients to the environment. Important emissions: NH_3, NO_x, COD and BOD, N and P compounds	kg N eq	TRACI 2.0

Sensitivity analyses was not performed.

Material Efficiency
A 'product-to-packaging ratio' calculation was conducted to provide data on material efficiency.
The **Product-to-Package Ratio:**
The Product-to-Package Ratio takes the declared product weight divided by the total package weight to develop a ratio showing material efficiency.
Product-to-Package ratio = (declared product weight/ primary package weight)
A higher product number (the first number) indicates more efficient use of materials as less packaging by weight is being used to protect the product.
The Product-to-Package ratio (by percentage) is calculated by dividing the declared product weight, by the (total weight of declared product + primary packaging weight), resulting in a percentage of what proportion sold to the consumer is attributed to the product (by weight) and the percentage attributed to the package (by weight).
Product-to-Package ratio (by percentage) for a product = declared product weight/ (declared product weight + primary package weight)
Again, this is a measure of the efficiency of overall material usage. As before, a high first number for the product, and lower second number for the package is preferred as it shows the most efficient use of packaging resources necessary to contain and protect the product.
Product-to-Package ratio (by percentage) for a product = declared product weight/ (declared product weight + primary package weight)
This is a measure of the efficiency of overall material usage.
A high first number for the product, and lower second number for the package is preferred as it shows the most efficient use of packaging resources necessary to contain and protect the product.
*(source: **A Holistic View of the Role of Flexible Packaging in a Sustainable World,** Todd Bukowski and Michael Richmond, PhD PTIS, LLC, Prepared for the Flexible Packaging Association, 2018 Flexible Packaging Association)*

ES.4 Results

This section summarizes the results obtained from this study.

ES.4.1 Results: LCIA Profile

LCIA is defined in ISO 14044 section 3.4 as the "phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product."
Table 4 illustrates the comparative results for the average PP container and Wax-CBC Container as well as material efficiency.

Table 4 PP Container and Wax-CBC Container Impact Results

Sustainability Criteria	**Unit**	**PP Container Average**	**Wax-CBC Average**	**% Difference - PP Improvement**
Environmental Impact	GWP (kg CO2-eq)	68,042.11	103,330.96	-34.15%
Environmental Impact	Acidification (kg SO2-eq)	276.13	466.84	-40.85%
Environmental Impact	Eutrophication (kg N)	20.95	40.25	-47.95%
Environmental Impact	CED (MJ-eq)	1,302,322.74	1,829,696.12	-28.82%
Environmental Impact	Water Usage (m3)	247.29	400.74	-38.29%
Material Efficiency	Product-to-Packaging Ratio	33	19	73.68%
Recyclable		Y	N	

ES.4.2 Results: Sustainable Packaging Criteria

Design Strategy	SPP PP Container	CBC Wax Box
Minimize Materials	★	
Included and Increase Recycled Content %	★	★
Design for Transport – minimize hops	★	
Use Renewable and/or Recyclable Materials	★	★
Source Responsibly	★	★
Design for Recovery	★	
Design for Waste Reduction	★	
Provide Use and Disposal Information to Consumer	★	

ES.5 Discussion

This study represents a streamlined LCA comparison of two produce container product systems. Even though it is not as rigorous study as a study including sensitivity analysis, some preliminary conclusions can be drawn.

Due to the wax additive preventing the wax-CBC container from being recycled, the wax-CBC container sends much more material to landfill. CBC in landfill will breakdown quickly, but there is uncertainty to how the wax additive impacts the decomposition process.

As the PP container is, on average, about 42% lighter than the wax-CBC container, there will be material and freight efficiencies realized.

Due to this light-weighting and efficient use of material, the estimated environmental impacts were much improved by transitioning to the SPP PP container.