

Literature Review on the Impacts to the Composting Value Chain When Introducing Compostable Foodservice Packaging

Scope and Objectives

In 2016, the Foodservice Packaging Institute’s Paper Recovery Alliance/Plastics Recovery Group commissioned a study to review the existing literature regarding the impacts of compostable foodservice packaging (FSP) at different points in the composting value chain. The objectives of this literature review were twofold:

1. To support cross-stakeholder collaboration with other in-progress initiatives including those of the U.S. Composting Council’s Compostable Product Task Force and GreenBlue’s Sustainable Packaging Coalition.
2. To inform PRA/PRG’s 2017 strategies, investments, and activities promoting increased recovery of post-consumer compostable foodservice packaging.

The literature review focused on the below questions.

How does compostable foodservice packaging impact:

1. Composting program participation rates?
2. Food scraps diversion rates?
3. Contamination of composting feedstocks and finished compost?
4. The composting process compared with traditional carbon sources?

For the purpose of this review, we reviewed literature on both “foodservice packaging” and “foodservice ware,” with the understanding that these terms are often used interchangeably to describe single-use items intended for serving, conveying, and consuming food (e.g., cups, plates, utensils, and takeaway containers). Compostable foodservice packaging can refer to both paper- and plastic-based materials. In the detailed findings, we use compostable FSP to mean both compostable paper and plastic, and separately call out references to compostable plastic foodservice packaging where relevant.

Executive Summary

This is an emerging field of study. The impacts of compostable foodservice packaging on composting program participation, customer behavior, and diversion rates is a relatively new area of study and as such the availability of relevant sources varies widely by topic area.



However, there is a growing body of evidence that shows the use of compostable foodservice packaging can lead to an increase of food scrap diversion and a reduction in contamination. Available data suggest that compostable FSP use, in conjunction with a suite of programs that include outreach, education, new infrastructure, and models of the desired behavior, can increase food scrap diversion rates and reduce observed contamination rates.

Coordinated efforts around customer education are key. In order to realize the full benefits of compostable packaging in increasing food scraps diversion and minimizing contamination, coordinated efforts around customer education are essential between manufacturers, operators, consumers, municipalities, haulers, and composters.

The key identified gap in available research is the extent to which compostable foodservice packaging compares to natural carbon sources typically used during composting (e.g., yard trimmings, straw, wood shavings, paper) in their ability to balance compost C:N ratios, moisture content, porosity, composting rate, ammonia volatilization, and final compost properties.

Detailed Findings

Impacts on Composting Program Participation Rates

Most studies available today track diversion rates rather than program participation. While not the intended focus of our review, we believe diversion rates are reflective of both the quantity and quality of participation (i.e., engagement reflected by avoiding landfill, minimizing stream contamination, etc.). **The existing data indicate that use of compostable foodservice packaging, in conjunction with a suite of waste management best practices such as customer education and clear signage, does increase overall diversion rates.** For the purposes of this review, we used diversion rate as a stand-in for program participation when it was the sole metric available. Among the success stories reviewed, key findings include:

1. Published case studies by compostable plastics manufacturers show an increase in diversion rates at stadiums, large event centers, and cafeterias after those facilities switched to compostable FSP.

These activities often took place in conjunction with additional attendee outreach and education efforts, as well as improvements in collection infrastructure.

- NatureWorks, which produces compostable bio-based foodservice ware, cites a diversion rate increase at Minneapolis Target Field from 61 to 79 percent from 2013 to 2015 after replacing concessions packaging with compostable alternatives (NatureWorks, n.d.).
- Penn State's Beaver Stadium similarly increased the diversion rate in its suites from 95 to 100 percent over a single season after switching to compostable cups, utensils, plates, and straws (NatureWorks, n.d.).

- Seattle’s Safeco Field switched to all compostable/recyclable materials in 2009, choosing to eliminate the option for attendees at baseball games to place items in the trash as a means of minimizing contamination of streams. At the same time, the stadium worked closely with vendors to manage packaging. Diversion increased from 38 to 70 percent in the year following the change (Natural Resources Defense Council, 2012).
2. **Both participation rates and diversion rates of some municipal composting programs that accept compostable FSP are increasing.** Note that the data reviewed are from opt-in programs (where participants may be more motivated than the average person to divert waste) and mature, high-performing programs.
- King County, Washington has published studies on its curbside composting program—which accepts yard waste, food scraps, and compostable FSP—since 2007. These studies have shown increasing participation in its food scraps diversion program (including food-soiled paper) over the course of its waste monitoring program. The percentage of organics subscribers that include food scraps and/or compostable FSP in their set-outs has increased from 7 to 27 percent from 2007 to 2014, and the estimated capture rate of food scraps among those who divert their food scraps has increased from 32 to 67 percent (Cascadia Consulting Group, 2012-2015, not yet published).

Impacts on Food Scraps Diversion Rates

There is a growing body of evidence that shows the use of compostable foodservice packaging can lead to an increase of food scrap diversion. Specific findings from the literature are provided below.

1. **Data collected over several years of operation by AgRecycle, a composter, strongly suggest that a switch to compostable FSP in cafeterias can increase food scrap capture rates.**
- Over three years of observation, AgRecycle found that cafeterias that introduced food scrap collection in their front-of-house operations in conjunction with compostable foodservice ware increased diversion of food scraps by 78 percent compared to a 9 percent increase in cafeterias that used non-compostable FSP. (Castagnero, 2016).
2. **A case study written in partnership between Cedar Grove (a commercial composter in the Seattle Area), Taco Time (a quick service restaurant chain in the Pacific Northwest), and several members of the compostable product manufacturing industry showed a dramatic increase in diversion rates after introducing compostable serviceware.**
- Prior to introducing compostable serviceware and converting to a single bin disposal system in front-of-house in 2012, Taco Time was diverting roughly 30 percent of their total waste volume from landfill. That number has more than doubled, and today 70 to 75 percent of

their waste is diverted from landfill through composting and recycling and other system enhancements such as converting used cooking oil to biodiesel (NatureWorks, 2016).

- Signage was cited as key in engaging and educating customers, and the conversion to fully compostable food serveware was also noted as a key to program success. Additionally, collection areas were temporarily staffed throughout the stores to acquire feedback and insights before full-scale program implementation across 57 restaurants (NatureWorks, 2016).

3. A comparison of single-family organics characterization data in Washington State suggests that compostable FSP acceptance in curbside organics collection programs may be correlated with increased food scrap diversion.

- The City of Tacoma accepts yard waste and food scraps, but not compostable FSP (including food-soiled paper), in its organics collection program. In contrast, King County and the City of Seattle accept yard waste, food scraps, and all forms of compostable FSP. Table 2, below, compares differences in annual pounds of food diverted per capita and the food capture rate in each jurisdiction. These data show that King County and the City of Seattle, which both accept compostable FSP in addition to yard and food scraps, capture more food scraps than Tacoma, which does not accept compostable FSP (Cascadia Consulting Group, 2012-2015, not yet published; Cascadia Consulting Group, 2015, not yet published; Cascadia Consulting Group, 2012; Cascadia Consulting Group, 2014).

Table 1 Annual Food Diversion and Capture Rates in Washington State Organics Programs

Location	Accepted Material			Food Diverted per Person per Year ¹ (lbs)	Food Capture Rate (%)
	Yard	Food	CFSP*		
Tacoma	X	X		11.6	11%
King County ²	X	X	X	21.9	22%
Seattle	X	X	X	61.3	52%

* Compostable foodservice packaging

¹ Composting program subscriber counts were not available for all data sets examined; per person per year diversion rates are instead based on the U.S. Census Bureau’s total population data for a given jurisdiction.

² Including only King County cities with weekly, embedded organics service in order to provide data that are comparable with Seattle’s program.

4. The Urban School Food Alliance’s project to replace polystyrene trays with compostable trays in six of the nation’s largest school districts may offer a future opportunity to collect data on the impact of compostable FSP on food scrap diversion.

- New York City began piloting collection of yard waste, food scraps, and compostable paper in its public schools in 2012. By 2015, over 40 percent of schools were in the organics collection program (NYC Sanitation, 2015). In September 2015, all DOE schools began using compostable plates instead of a polystyrene tray. The City has not yet published information on program diversion since the switch.

Impacts on Contamination of Composting Feedstocks and Finished Compost

There are limited available data about the direct impact of compostable FSP acceptance as a standalone intervention on contamination rates in organics collection programs. However, available data do indicate that compostable FSP use, in conjunction with a suite of programs that include outreach, education, new infrastructure, and models of the desired behavior, can reduce observed contamination rates. Specific findings from the literature review are provided below.

1. Several sports stadiums that switched to compostable foodservice packaging initially experienced challenges with customer confusion and contamination. Instead of relying solely on customer sorting to achieve desired diversion results, staff at these facilities emphasized the need for a full suite of education and engagement in all parts of the value chain, from vendors to stadium guests to post-event sorting staff, when implementing a switch to compostable FSP.

- The San Francisco Giants found that the introduction of compostable cups produced “some conflict and confusion” for its attendees. Attendees were contaminating the recycling stream and failing to compost cups. The Giants then simplified its waste diversion message by communicating to attendees that all drinkware is recyclable and other food packaging is mostly compostable. Despite simplification of their messaging and ongoing education of attendees, the stadium reports that it still sees fans who struggle to understand which items are recyclable or compostable (Natural Resources Defense Council, 2012).
- The Cleveland Indians’ assistant director of ballpark operations noted that a lack of public education in their area is a real challenge, saying that “if I put out composting, it would be contaminated in a minute.” Instead, the stadium finds that the most effective way to divert front-of-house organics is to do separate ballpark picks by custodial staff, first for compostables, then recyclables, and finally for waste. In 2010, the Seattle Seahawks similarly encouraged fans to leave compostable FSP and unconsumed food in the seating area so staff could collect and sort items to minimize compost contamination, rather than leaving separation of waste in the hands of its attendees (Natural Resources Defense Council, 2012).

- Other teams that report sorting attendee waste post-collection or after games to achieve both high diversion and low contamination include the Philadelphia Eagles, San Francisco Giants, Seattle Mariners, and Montreal Canadiens. While time-consuming, these stadiums report that post-collection sorting is one way (and in the case of the Canadiens, “the only way”) to achieve diversion targets. It also reduces costs associated with contamination, and, for the Cleveland Indians, helps the stadium get a better price for higher-quality, source-separated commodities (Natural Resources Defense Council, 2012).
2. One study demonstrated that **staffing recycling and composting bins with “bin guards” to help individuals at the point of disposal significantly decreased observed contamination rates at a stadium.**
 - Researchers at Arizona State University tested the impact of staffing composting and recycling bins on contamination rates. Researchers relied on two approaches at the stadium to help attendees identify in which bin materials should be placed: signage on recycling and composting bins describing accepted materials and volunteer “bin guards” who would help ballpark visitors at the point of disposal. Contamination decreased from 33.5 percent in the signs-only condition to 11.3 percent when both signs and bin guards were present. When the bin guards were not present at a third game one week later, contamination increased to 22.5 percent, but improvements over the first game of the season suggested that repeat attendees may have learned where to put materials over the course of multiple games (Hottle, Bilec, Brown, & Landis, 2015).
 3. **Some data indicate a relationship between increased use of compostable products in food scraps diversion programs and reduced contamination.**
 - AgRecycle found that contamination was higher (3.5%) in the cafeteria where non-compostable disposables were used compared to cafeterias that used compostable foodservice ware (2%) (Castagnero, 2016).
 - The Italian Composting and Biogas Association reported in 2013 that food scraps collected in non-compostable bags contained, on average, 9 percent non-compostable contamination, while in contrast, food scraps collected in compostable bags had a contamination rate as low as 1.4 percent (Italian Composting and Biogas Association, 2015).
 4. **Paper foodservice products coated with conventional plastic linings have been shown to contaminate finished compost with micro-plastic fragments. By comparison, compostable foodservice products are designed to fully degrade in commercial composting operations, thereby reducing this source of contamination.**

- A study conducted by Woods End Laboratories and Eco-Cycle demonstrated that micro-plastic fragments are shed from conventional plastic-coated paper products during composting because these plastic coatings are not designed to break down in a composting environment. Since composters generally use sieves between 9-12mm to screen out contaminants, conventional plastic particles under this size remain in finished compost (Woods End Laboratories and Eco-Cycle, 2016).

5. Outreach, education, and training are essential tools in minimizing contamination by non-compostable items.

- In addition to the introduction of compostable foodservice ware, AgRecycle cites outreach and education, training and retraining, and signage as core components for minimizing contamination by non-compostable items. Other best management practices include establishing protocols to ensure compostable products are BPI-certified and testing the compostability of accepted products at the composting facility (Goldstein, 2016).

Impacts on Composting Process Compared to Traditional Carbon Sources

As noted above, we did not find any studies designed to measure the extent to which compostable FSP compares to natural carbon sources typically used during composting (e.g., yard trimmings, straw, wood shavings, paper) in their ability to balance compost C:N ratios, moisture content, porosity, composting rate, ammonia volatilization, and final compost properties. This is a clear opportunity for further study. What limited data we did find are outlined below.

1. In general, the published literature suggests that compostable FSP materials have high carbon content, averaging nearly 60 percent. These figures are largely based on theoretical carbon content rather than measured carbon content.

- One literature review on anaerobic digestion feedstocks found that bioplastics can range from 30 to 80 percent in carbon content, and that compostable plastic foodservice ware averages about 59 percent by weight (Cascadia Consulting Group, 2014).
- However, real values of carbon content of compostable FSP may be closer to 20 percent. CalRecycle (formerly the California Integrated Waste Management Board) looked at both the theoretical carbon content (based on chemical structure of the material) and actual carbon, as measured through bomb calorimetry, for several compostable FSP materials.³ The results are shown in Table 3 below (California Integrated Waste Management Board, 2007).

³ Bomb calorimetry is a measurement method in which a material is combusted in a constant-volume vessel that can withstand high pressure and force. The composition and volume of carbon dioxide gas produced in combustion is measured, after which the amount of carbon in the original sample can be derived through a series of equations.

Table 2 Theoretical and Measured Carbon Content of FSP Materials

Material	Theoretical Carbon (%)	Measured Carbon (%)
Corn-based BioBag liner	Not given	21.9
PLA cup	30	17.0
Sugar cane (bagasse) plate	42	15.1

- 2. Compostable FSP potentially has a role as a compost bulking and liquid absorption agent similar to that of traditionally compostable paper products.** Professor Ramani Narayan, a leading researcher on compostable plastics at Michigan State University, noted in email communication that PLA foodservice ware would “behave the same way like paper” to provide both bulking and carbon that promotes the composting process (Narayan, 2016).

Conclusions and Next Steps

We are encouraged by the growing body of evidence that shows the use of compostable foodservice packaging can increase food scrap diversion and reduce contamination. As an industry, we recognize that, in order to fully realize these benefits, it is essential to support coordinated efforts around customer education between manufacturers, operators, consumers, municipalities, haulers, and composters. As such, we will continue to partner with organizations in the public and private sector in pursuit of our shared goals.

The key gap in available research identified in our review was the extent to which compostable foodservice packaging compares to traditional carbon sources typically used during composting. The PRA/PRG will begin to coordinate a study on this topic in early 2017.

Finally, as stated at the beginning of this summary, this is an emerging field of study. As an industry, we are aware of a growing number of success stories beyond those which have been academically reviewed. We support and encourage both more academically minded studies and operational field studies to be completed regarding these success stories to better identify best practices.

Appendix: Literature Review Source List

In addition to the journal articles, reports, and other studies listed below, we also reviewed a number of articles from publications such as *BioCycle* and leading blogs that cover composting, organics processing, and materials management; wherever possible, we sought out and cited the specific source data. Such sources are reflected in this literature review source list.

California Integrated Waste Management Board. (2007). *Evaluation of the Performance of Rigid Plastic Packaging Containers, Bags, and Food Service Packaging in Full-Scale Commercial Composting*.

Cascadia Consulting Group. (2012). *Seattle Public Utilities' Organics Stream Composition Study*.

Cascadia Consulting Group. (2012-2015, not yet published). *Organics Characterization Report. Prepared for King County, WA*.

Cascadia Consulting Group. (2014). *Metro Anaerobic Digestion Assessment*.

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Cascadia Consulting Group. (2015, not yet published). *City of Tacoma Waste Composition Study*.

Castagnero, C. (2016). Quantifying Food Recovered with Certified Compostable Food Service Ware. *BioCycle West*, (pp. 18-19).

Goldstein, N. (2016, August). Compostable Products And Postconsumer Food Scraps. *BioCycle*.

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Narayan, D. R. (2016, August). Professor, Chemical & Biochemical Engineering. (N. Tim Goodman, Interviewer)

Natural Resources Defense Council. (2012). *Game Changer: How the Sports Industry is Saving the Environment*.

NatureWorks. (2016). *Taco Time Embraces Seattle Waste Ordinance by Redefining Quick Service Restaurant Industry*.

NatureWorks. (n.d.). *Renewing Ingeo: End-of-Life Options Case Studies*. Retrieved from <http://www.natureworkslc.com/The-Ingeo-Journey/End-of-Life-Options/Case-Studies>

NYC Sanitation. (2015). *2015 NYC Organics Collection Report*.

Woods End Laboratories and Eco-Cycle. (2016). *Micro-plastics in Compost*.