POLLUTION PREVENTION IN FOOD & BEVERAGE PACKAGING TECHNICAL ASSISTANCE

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EXECUTIVE SUMMARY

This report outlines a comprehensive approach to evaluating and reducing the potential pollution associated with packaging materials within Vermont food and beverage manufacturing facilities. This initiative was a voluntary, non-regulatory project funded by a Pollution Prevention (P2) grant from the United States Environmental Protection Agency (U.S. EPA) and the project was implemented by the Vermont Department of Environmental Conservation (VTDEC), Civil & Environmental Consultants, Inc (CEC), and Packaging Technology and Research, LLC (PTR). The primary goals of the project were to evaluate and reduce per- and polyfluoroalkyl substances (PFAS) and microplastics from entering the food waste system and to help prevent further exposure to consumers and the environment via the food waste related pathways (e.g. anaerobic digestion, composting, and mechanical depackaging). CEC's primary focus was to support Vermont food and beverage manufacturers in addressing potential PFAS contamination and the generation of microplastics in their food packaging and processing.

To achieve these goals, ingredient and consumer-facing packaging, along with manufacturing processes, were evaluated for their potential to contain PFAS and microplastics that could impact human and environmental health from food consumption, the management of waste packaging, and the recycling of food waste.

The project also focused on helping manufacturers assess and document their packaging materials to identify viable alternatives that align with Vermont's new law prohibiting intentionally added PFAS in food and beverage packaging. Furthermore, the report outlines key steps for conducting a comprehensive inventory of food and packaging materials and offers recommendations for packaging alternatives.

Through this initiative, manufacturers who participated in the study received support in identifying and addressing potential sources of PFAS and microplastic contamination in their supply chains, product packaging, and manufacturing equipment. By following the steps outlined in the report, facilities can improve the safety and sustainability of their products and meet compliance requirements with state regulations.

It's important to note that research on the connection between packaging, PFAS, microplastics, and their potential presence in food waste is still limited, and this is an emerging area of study. The industry is actively working to understand and address these concerns, alongside other challenges they face. Our conclusions should be viewed as provisional, based on current knowledge, with future developments likely to inform alternative approaches to this study. Facilities will need to consider a range of trade-offs and clarify their ultimate objectives in managing these issues. If the end goal is to reduce environmental impact, the focus should first be minimizing the amount of packaging that environmental systems must process, followed by reducing food waste, embracing the principles of reduce, reuse, and recycle.

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PREFACE

The authors of this report recognize the challenges presented to the food and beverage industry relating to the presence of environmental contaminants in food packaging and the potential for that packaging to make its way into the environment through well intentioned activities such as composting. Environmental stewardship is just one of the many priorities that businesses must balance and complex tradeoffs must be considered when evaluating options relating to product lifecycle such as when to use recycled content and whether or not to consider compostable products.

While we have tried to keep the above complexities in mind, this report has been prepared to focus on the narrow area of pollution prevention as it relates to PFAS and microplastics from food packaging entering the environment. The report provides detailed assessments based upon our experience with a relatively small number of manufacturers who volunteered to work with us to advance knowledge and understanding on this topic.

Given the high level of detail included in the report, we felt it appropriate to offer some observations of "low hanging fruit" for individuals in the packaging industry who are interested in this topic:

1. PFAS - For those interested in minimizing the pollution potential from PFAS in food packaging, we suggest choosing virgin paper products, rather than products containing any recycled content, for materials that may come in contact with food or are likely to be disposed with food scraps or other "compostables." Where grease or moisture repellant properties are needed, be sure to target these products when gathering attestations from packaging manufacturers. While the use of recycled paper in general is an environmental benefit, there are other ways recycled paper can be used.
2. Microplastics – When it comes to keeping microplastics out of the organics waste stream, avoid choosing coated paper/cardboard for any packaging that is likely to be intentionally or inadvertently disposed of with food scraps or other "compostables."
3. General Pollution Prevention – One of the best ways to reduce the potential for pollution from food packaging is to minimize the overall amount of packaging used.

As a final note, we would like to thank all the manufacturers who participated in this project whether through a facility visit or participation in surveys and round table events.

1.0 GENERAL INFORMATION – PFAS

1.1 What are PFAS?

PFAS are a group of fluorinated organic compounds containing at least one fully fluorinated carbon atom (Maine State Legislature 2021). PFAS have been used in a variety of industries and products due to their resistance to heat, oil, stains, grease, and water. These consumer products include waterproof clothing, firefighting foam, non-stick cookware, stain-resistant furniture and carpets, food and beverage packaging, compostable products, and many others (NH DHHS 2024). Exposure to some types of PFAS have been linked to serious health effects. Exposure to PFAS can occur by consuming PFAS-contaminated water or food, using products made with PFAS, or breathing air containing PFAS. Exposure to PFAS through dermal absorption is limited (ATSDR 2024). Since PFAS are persistent, do not readily degrade in the environment, and bioaccumulate, people are repeatedly exposed to them and the blood levels of some PFAS can build up over time (NIH 2024).

1.2 What are the health effects of PFAS?

There is evidence suggesting that increased exposure to specific PFAS is associated with certain health effects and research is ongoing to understand PFAS toxicity. The risk of health effects associated with PFAS depend on exposure factors (e.g., dose, frequency, route, and duration), individual factors (e.g., sensitivity and disease burden), and other determinants of health (e.g., access to safe water and quality health care) (ATSDR 2024). Some examples of certain health effects include:

- Increases in cholesterol levels (PFOA, PFOS, PFNA, PFDA)
- Lower antibody response to some vaccines (PFOA, PFOS, PFHxS, PFDA)
- Changes in liver enzymes (PFOA, PFOS, PFHxS)
- Pregnancy-induced hypertension and preeclampsia (PFOA, PFOS)
- Small decreases in birth weight (PFOA, PFOS)
- Kidney and testicular cancer (PFOA)

1.3 Are PFAS regulated federally and/or at the state level in food and beverage packaging?

At the federal level, the Food and Drug Administration (FDA) has taken proactive measures to regulate PFAS in food and beverage packaging. Although the FDA has authorized certain PFAS for use in specific food contact applications, it regularly evaluates new scientific information to ensure their continued safety. As of November 2016, long-chain PFAS are no longer used in food contact applications sold in the United States (FDA 2025). In February 2024, the FDA declared that manufacturers stop selling PFAS-based grease-proofing substances containing for food contact use in the U.S. market. In January 2025, the FDA published a Notice in the Federal Register stating that the 35 food contact notifications related to PFAS-containing substances used as grease-proofers in paper and paperboard food packaging are no longer effective based on the discontinuation of these uses (FDA 2025).

Several states, including Vermont, have implemented strict regulations to limit the use of PFAS in consumer products, particularly food packaging. Vermont law 18 V.S.A. § 1671-1695 prohibits manufacturers, suppliers, and distributors from the manufacture, sale, offer for sale, distribution for sale, or distribution for use of food packaging, residential carpets and rugs, aftermarket stain and water-resistant treatments, and ski wax and related tuning products with PFAS intentionally added to them. The prohibition is effective beginning July 1, 2023. This prohibition does not apply to the sale or resale of used products (VT Department of Health 2023).

Similar actions are being taken in other states, which have also introduced laws to phase out PFAS in food packaging and other consumer goods in the coming years. These are summarized below:

- New York (December 31, 2022) – bans the distribution and sale of food packaging containing intentionally added PFAS
- California (January 1, 2023) – prohibits any person from distributing, selling, or offering any food packaging that contains PFAS (either intentionally added or at or above 100 parts per million)
- Washington (February 1, 2023) – provides a tiered ban on the manufacture, sale, and distribution in Washington of any "food packaging to which PFAS chemical shave been intentionally added in any amount" once safer alternatives have been identified. Washington State Department of Ecology is required to identify safer alternatives to PFAS in food packaging
- Connecticut (December 31, 2023) – bans food packaging to which PFAS have been intentionally introduced during manufacturing or distribution
- Colorado (January 1, 2024) – phases out the sale or distribution of certain products and product categories that contain intentionally added PFAS between 2024 and 2027
- Maryland (January 1, 2024) – bans manufacturers or distributors from manufacturing, selling, or distributing "a food package or food packaging component designed and intended for direct food contact to which PFAS chemicals were intentionally added"
- Minnesota (January 1, 2024) – bans the manufacture, sale, or distribution of food packaging containing intentionally added PFAS
- Rhode Island (January 1, 2024) – bans food packaging to which PFAS have been intentionally introduced during manufacturing or distribution

- Hawaii (December 31, 2024) – makes it unlawful to manufacture, sell, or distribute "any food packaging specified in subsection (b) [wraps and liners, plates, food boats, and pizza boxes] to which PFAS have been intentionally introduced in any amount
- Maine – provides that the Maine Department of Environmental Protection may, by rule, "prohibit a manufacturer, supplier, or distributor from offering for sale or for promotional purposed in the State a food package to which PFAS have been intentionally introduced in any amount greater than an incidental presence" (Perkins Coie, 2023)

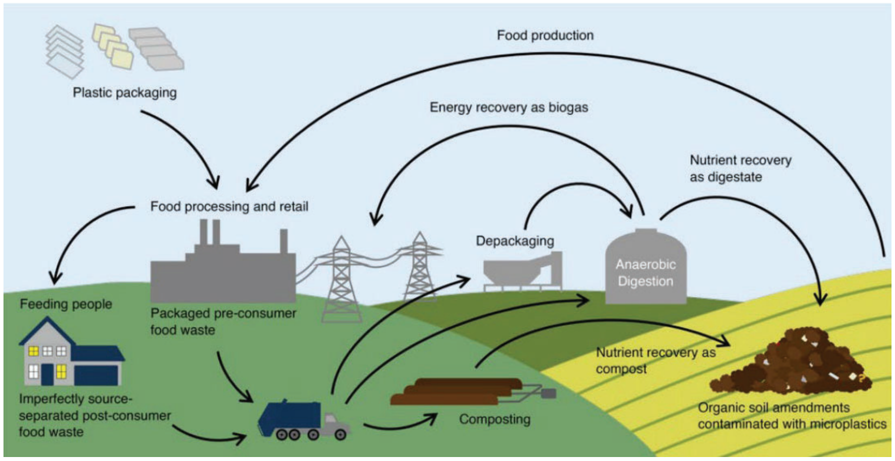
1.4 Why are PFAS used in food packaging?

PFAS are used in food packaging for their non-stick and grease, oil, and water-resistant properties. For this reason, they are most commonly used in the paperboard industry. These materials have become ubiquitous in food packaging because they are durable, lightweight, versatile, and cost-effective.

1.5 Why are PFAS in food packaging a concern and how does PFAS in food packaging enter the environment?

PFAS are a concern in food packaging because they are highly persistent, mobile, and toxic chemicals. Their use in food packaging is a concern since PFAS within packaging can migrate into food as well as into the environment. The migration of PFAS from packaging is a function of the food type, packaging material, and conditions of use. Environmental contamination from food packaging has been associated with drinking water and soil. PFAS can leach from food packaging and into the food itself. When discarded, either the food or the packaging containing PFAS may be recycled into compost or anaerobic digestate. These processes can lead to PFAS entering the environment through organic waste streams. It can also enter the environment through improper disposal of food or packaging as litter and may contaminate soil, groundwater, or surface water. Packaging that is disposed of into a modern landfill has a lower potential to impact environmental media. Food packaging most likely to end up in organics waste streams includes consumer-facing wrappers, compostable bags/liners, and containers made from paper treated with PFAS or polymers that are produced using PFAS.

PFAS may be present in food packaging as a degradation product, legacy contamination from paper recycling, an impurity, or a contaminant and may be intentionally or non-intentionally added. PFAS can also occur as a contaminant through cross-contamination, for example, water used in manufacturing food packaging can contain PFAS from environmental contamination (FDA 2024).



(Porterfield et al., 2023)

1.6 What types of packaging materials are most likely to contain PFAS?

The types of packaging materials that are most likely to contain PFAS include, but are not limited to:

- Fiber drums (DTSC 2021)
- Condensation polymers (polyethylene terephthalate (PET), nylon)
- Oil/grease resistant of paperboard cartons and paper (FDA 2024)
- Added barrier when plastic containers are formed (high barrier polyethylene (PE)) (DTSC 2021)
- Release agents when containers are formed (NYDEC 2024)
- Reusable containers

2.0 GENERAL INFORMATION – MICROPLASTICS

2.1 What are microplastics?

Microplastics are small plastic particles intentionally manufactured and added to products for specific purposes or unintentionally formed by the degradation of plastic materials. Microplastics come in a variety of different products used in food and beverage, agricultural, cosmetic, marine, commercial and fishing, and clothing industries. Microplastics can enter soil or a body of water from runoff from land or the degradation of larger plastic items which are typically called meso- or macro- plastics. Various environmental factors such as sunlight, water, temperature, and physical stress influence the degradation of plastic materials to generate microplastics (Frias et al., 2019). Microplastics are typically considered less than five millimeters in size in at least one dimension (FDA 2024).

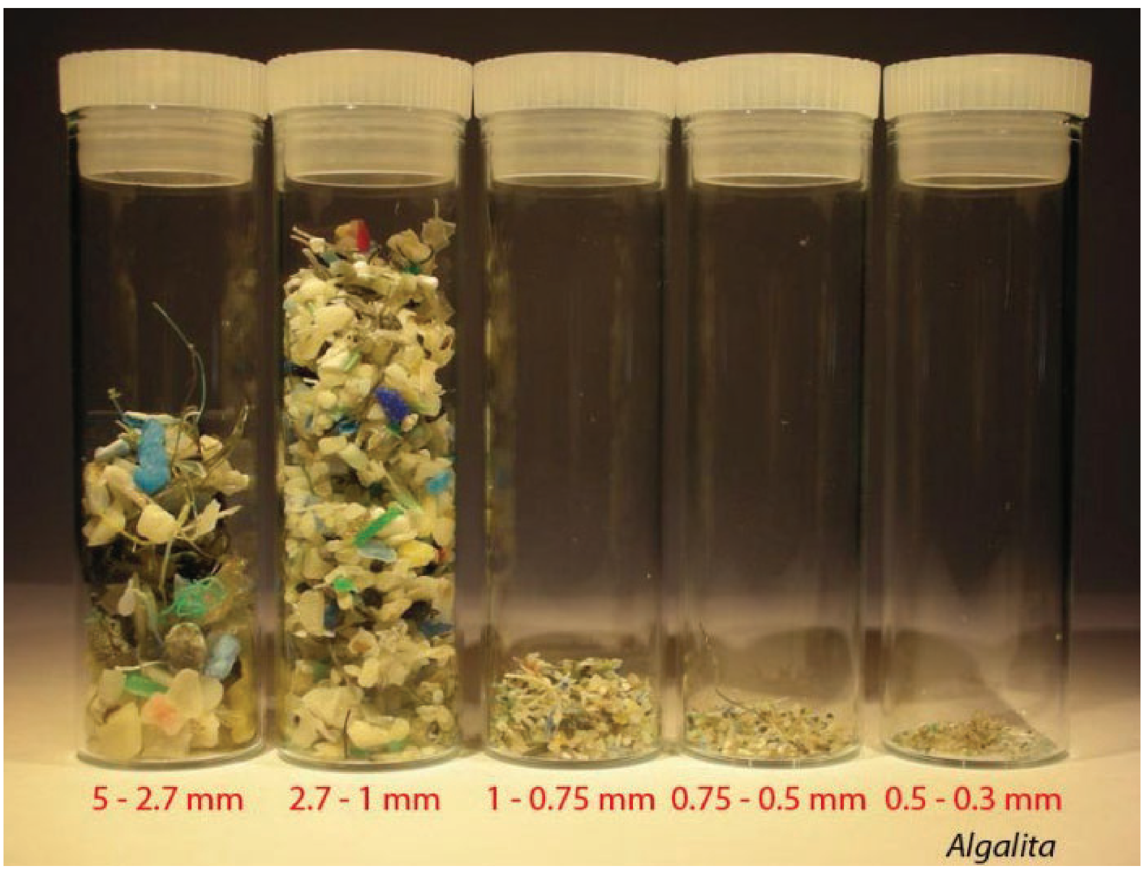


Image from University of Michigan – School of Natural Resources & Environment (SNRE 2024)

2.2 What are the health effects of microplastics?

Microplastic pollution is an emerging concern for its potential impacts on soil, freshwater, marine systems, snow, wastewater, air, plants, animal organisms, and drinking water sources.

Microplastics and nanoplastics, which are smaller than microplastics, have been found in human samples, including urine, stool, blood, and organs, but there is not enough known about their potential health effects and additional research is needed to fill data gaps. There are also no standardized methods for how to detect, quantify, or characterize microplastics and nanoplastics. Many scientific studies have used methods of variable, questionable, and/or limited accuracy and specificity (FDA 2024).

2.3 Are microplastics regulated federally and/or at the state level?

The United States Congress passed the Microbead-Free Waters Act in 2015 which prohibits the manufacturing, packaging, and distribution of water disposable cosmetics containing microbeads (Pallone 2015). Aside from the Microbead-Free Waters Act, there are no regulatory requirements for microplastics. The FDA and EPA have encouraged research on microplastics; however, neither have proposed regulations specifically targeting microplastics in drinking water, packaging, food additives, or food contact substances.

Many states have regulated microplastics by banning the use of synthetic microbeads in cosmetics. In Vermont, legislation under 10 V.S.A. § 6691 – 6700 has banned single use plastic carry-out bags, expanded polystyrene food service ware, single-use plastic straws, and single-use plastic stirrers.

2.4 Why are microplastics a concern in food packaging?

Microplastics in food and beverage packaging are a concern because additives used during the plastic processing stage may be released as the plastic degrades, potentially harming human and animal health. From VTDEC's perspective, the micro- and nanoplastics from food packaging can carry these additives and affect the physiochemical properties of healthy soil, potentially altering water retention, compaction, conductivity, and organism diversity.

2.5 Why are plastics used in food and beverage packaging?

Plastics are used in food and beverage packaging and containers for their durability and sealability, to protect products from damage, prevent deterioration, and extend shelf life. Various plastics may be used for their different characteristics including clarity, moisture barrier, oxygen barrier, acid resistance, grease/oil resistance, stiffness, impact resistance, heat resistance, cold resistance, and sunlight resistance. Examples of plastics used in food and beverage packaging are low-density polyethylene (LDPE), high-density polyethylene (HDPE), PET, and polypropylene (PP). The table below provides a comparison of LDPE, HDPE, PET, and PP based on several key characteristics.

Characteristic	Material			
	LDPE	HDPE	PET	PP
Clarity	●●½	●●½	●●●●	●●
Moisture Barrier	●●●½	●●●	●●½	●●●½
Oxygen Barrier	●	●	●●●	●
Acid Resistance	●●½	●●½	●●½	●●½
Grease/Oil Resistance	●●●	●●●	●●●	●●●
Stiffness	●	●●	●●●½	●●½
Impact Resistance	●●●●	●●●½	●●●½	●½
Heat Resistance	●●	●●●	●½	●●●
Cold Resistance	●●●●	●●●●	●●●	●½
Sunlight Resistance	●●	●●	●●●	●●

Image from Litesmith Plastic Container Guide

2.4 How do microplastics from food packaging enter the environment?

Microplastics can enter the environment from improper waste management practices. Littering is the primary pathway for plastic-containing packaging to contaminate soil, groundwater and surface water. Additionally, plastic packaging disposed of with food waste can pass through composting or anaerobic digestion processes and end up in the final products. It can be challenging for both consumers and food and beverage manufacturers to determine whether packaging is suitable for composting or digestion. For example, packaging may appear to be paperboard but contain hard-to-detect plastic barrier layers or coatings. Furthermore, there is a lack of certification programs in the compostable product/packaging industry to guarantee that specific packaging will fully breakdown in a commercial composting process. This often leads to incomplete degradation of "compostable" packaging and the presence of microplastics in the final compost. Additionally, some packaging may be "green-washed" to appear compostable when it is actually traditional plastic, which can contaminate finished compost with microplastics if not removed beforehand. Due to these contamination concerns, many Vermont composting facilities have implemented policies prohibiting compostable packaging.

2.5 What types of packaging materials are most likely to generate microplastics?

Plastic food packaging materials and containers are commonly made up of thermoplastic resins which include PLA, PET, HDPE, LDPE, linear LDPE (LLDPE), PP, polyvinyl chloride (PVC), polystyrene (PS), polycarbonate (PC), and PE. The types of plastic generally used as food packaging that are considered as microplastics are specifically PET, HDPE, LDPE, PP, PVS, and PS (Siddiqui et al., 2023).

3.0 COMPANY IDENTIFICATION AND OUTREACH EFFORTS

VTDEC, CEC, and PTR identified various Vermont food and beverage manufacturers that were potential candidates for this pollution prevention study. This was a voluntary, non-regulatory project funded through a Pollution Prevention grant from the United States Environmental Protection Agency (U.S. EPA). The goals of the project were to determine if and how PFAS and microplastics were entering the food waste system and to help prevent further exposure to consumers and the environment. CEC's specific project focus was assisting VT food and beverage manufacturers with assessing potential PFAS and microplastics generation from their food packaging and processes. The benefits of the Vermont food and beverage company participation included:

- Identification of PFAS in the supply chain and potential microplastic contamination resulting from the company's products;
- Guidance on how to provide more environmentally safe and non-toxic packaging alternatives;
- Guidance on and compliance with the new Vermont law prohibiting PFAS in food packaging;
- Technical assistance at no cost; and
- Opportunities to share lessons learned from reduction of PFAS in, or microplastics resulting from, food and beverage packaging.

From December 2023 to March 2024, CEC conducted outreach efforts to 38 companies of which 6 companies were interested in the study. These companies were involved in the dairy, snack food, maple syrup, and agribusiness industries. CEC held various meetings to discuss the overall study, Vermont PFAS regulatory requirements, and the assistance program in general. Due to the holiday season company priorities, and confidentiality concerns, these six companies declined to continue further in the study.

In April 2023, CEC continued additional outreach efforts and reached out to 162 food and beverage manufacturers in Vermont. Out of the 162 companies, 10 were interested in the study and could contribute at various levels of effort. These companies were provided with a survey to gauge their level of interest, level of availability, knowledge of PFAS and microplastics, general packaging details, and their personal goals on the potential outcome of the project. For confidentiality reasons, the list of interested parties will remain anonymous throughout the duration of this memo. These surveys are referenced in Appendix A.

Eight facilities completed the survey and seven companies were interested in receiving direct technical assistance which included a facility site visit, customized pollution prevention evaluation, and meetings with other participating businesses. Budget constraints limited the site visits to three businesses. All survey participants hoped that by the end of the project, they would be able to identify packaging types that are PFAS-free or unlikely to contain PFAS, as well as available alternative packaging options. Most survey participants manage unsellable food products by composting unpackaged raw ingredients or finished food items. The most commonly used packaging materials in their businesses are paper (including cardboard and uncoated paperboard), as well as multi-material packaging. The packaging materials are used mainly for product stability and the materials' recyclability. The compiled responses to these surveys are referenced in Appendix B.

4.0 LEVEL OF RISK ASSESSMENT

4.1 PFAS Assessment

Ingredient and consumer-facing packaging, along with manufacturing processes, were evaluated for their potential risk of containing PFAS. The key factors considered in assessing this risk include:

- The need for package protection and grease and oil resistance
- Use of recycled content with non-secure supply chains and potential PFAS contamination
- Application of release agents during packaging production
- Presence of PFAS in condensation polymers
- Oil and water resistance testing (modified Cobb test)
- Visibility of coating on packaging
- Direct food contact
- Potential for cross-contamination from other PFAS-containing packaging

The factors influencing the level of PFAS risk in product manufacturing include:

- The use of release agents between products and molds, or during processes that involve moving or releasing products
- Products or ingredients with high grease, oil, or water content

These factors collectively helped assess the likelihood of PFAS presence in both packaging and manufacturing processes, guiding efforts to reduce risks and identify safer alternatives.

4.2 Microplastics Assessment

Ingredient and consumer-facing packaging and manufacturing were evaluated for their potential risk of releasing microplastics. The key factors considered in assessing this risk include:

- The need for package protection and grease and oil resistance
- Presence and type of plastic used
    - Brittleness at storage temperature
    - Impact strength
    - Chemical resistance
- Oil and water resistance testing (modified Cobb test)
- Visibility of coating on packaging
- Scuffing or abrasion of products during distribution or filling
- Direct food contact

The factors influencing the level of microplastics risk in product manufacturing include:

- The plastics manufacturing process, such as:
  - Brittleness at storage temperature
  - Impact strength
  - Chemical resistance
- The use of plastic in direct food contact

These factors collectively helped assess the likelihood of microplastics generation in both packaging and manufacturing processes, guiding efforts to minimize risks and identify safer alternatives.

5.0 RISK MITIGATION AND RECOMMENDATIONS

5.1 PFAS Risk Mitigation in Ingredient Packaging

Food and beverage manufacturing facilities can take proactive steps to ensure PFAS is absent from ingredient packaging by following a few key steps. First, establishing a partnership between ingredient suppliers, packaging companies, and the brand is essential. This collaboration will allow for transparency in ingredient packaging, facilitate access to detailed packaging material information, enable health and toxicity assessments, and provide access to disclaimers or attestations confirming that PFAS have not been intentionally added to any packaging material.

Second, food and beverage manufacturing facilities should build internal expertise on PFAS within the organization and among their ingredient and packaging suppliers. By developing a deeper understanding of the various PFAS compounds in their packaging and ingredients, manufacturers can prioritize eliminating the more toxic compounds from their packaging processes. Ongoing toxicological and health assessments of various PFAS compounds may lead to new regulations. As public concern over PFAS in packaging grows, having this internal knowledge will help manufacturers effectively address inquiries and communicate and maintain trust with consumers.

Food and beverage manufacturing facilities can ensure that ingredient packaging materials are free of PFAS by requesting and obtaining "No PFAS" attestations from ingredient suppliers. Some examples of the language in these attestations include a.) We warrant and certify that the package does not intentionally use PFAS, formally defined "as a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom," in manufacturing the product(s), including, for instance, as processing aids; b.) Additionally, we do not specify the use of PFAS in the raw materials that we obtain from our suppliers; or c.) Intentionally added PFAS are not present. Each attestation should be documented with the packaging manufacturer, manufacturing location, FDA facility number, distributor and the date the information was collected.

Along with obtaining attestations from ingredient suppliers, food and beverage manufacturers must ensure all ingredient packaging is FDA-compliant. Packaging materials should meet FDA conditions of use for the specific food types they are intended to contain. Status such as "Food Contact Notification", "FDA approved" or "Generally Recognized as Safe (GRAS)" must specify which foods can be in direct contact with the packaging and under what conditions of use.

Manufacturers and packaging companies should address potential sources of PFAS in direct food contact materials, which can include metal, plastic, paperboard, corrugated cardboard, and biodegradable papers and plastics. Metal foils with ink coatings require FDA approval. Both coatings and recycled content in paperboard, plastic, corrugated materials, and cardboard should be verified to be PFAS-free. Alternatives to fluorinated PE should be considered for plastic packaging requiring enhanced oxygen or moisture barriers. PFAS is also commonly used as a release agent in injection molding or blow-molding packaging. Manufacturers and packaging companies should also ensure that releasing agents in these processes are PFAS-free. Additionally, biodegradable papers and plastics, such as PLA, cellulose, and starch materials, may have PFAS-containing coatings that should be avoided.

Beyond packaging materials, manufacturing processes can also introduce potential PFAS sources that may come in direct food contact. For example, conveyor systems used to transport products through various stages of production could release PFAS if made from materials that are prone to abrasion or chipping. Similarly, plastic screws used in processing equipment may also pose a risk of PFAS contamination.

Cross-contamination between outer (secondary and tertiary) packaging and direct food-contact ingredient packaging is another potential source of PFAS contamination. Outer packaging that contains PFAS can transfer these substances to food-contact packaging during handling. This risk increases when secondary packaging is handled before food packaging in the production environment. Cross-contamination can also occur if labels, coatings, and cartons used in packaging contain PFAS.

Lastly, both single-use packaging and reusable packaging should be evaluated prior to use. Single-use packaging should be used for bulk ingredient totes, bags, liners, barrels, and bins wherever possible. If reusable packaging is used, it must be checked to ensure it is free from prior PFAS contamination and any abrasions. Abrasions can increase surface area, creating more sites for PFAS migration.

Effectively mitigating PFAS risks in ingredient packaging requires a comprehensive approach that includes material selection, manufacturing processes, and supply chain collaboration. Food and beverage manufacturers can reduce the likelihood of PFAS contamination by following these recommendations. Proactive measures will promote regulatory compliance, protect consumer health, and maintain brand integrity.

5.2 Microplastics Risk Mitigation in Ingredient Packaging

Similar to PFAS risk mitigation, food and beverage manufacturing facilities can take proactive steps to ensure microplastics are absent from ingredient packaging. Establishing a partnership between ingredient suppliers, packaging companies, and the brand is essential and allows for transparency in ingredient packaging, facilitates access to detailed packaging material information, and enables health and toxicity assessments.

Internal microplastic expertise should be built within the organization and among their ingredient and packaging suppliers. By developing a deeper understanding of microplastics, food and beverage manufacturing companies will become more familiar with the products that can degrade into microplastics and their potential health risks. As health assessments emerge, potential regulations may be developed and enforced.

Food and beverage manufacturing facilities can ensure that ingredient packaging is FDA compliant, especially for those in direct food contact with plastic materials. Labels such as “Food Contact Notification”, “FDA approved” or “GRAS” must specify which foods can be in direct contact with the packaging and under what conditions.

Manufacturers and packaging companies should identify and address potential sources of microplastics in materials that come into direct contact with food, which can include metal, plastic, and biodegradable papers and plastics. Metal packaging with plastic coatings should be assessed to ensure it does not generate microplastics. Plastic materials, as well as coatings and recycled content, can degrade over time and release microplastics. Single-use packaging such as totes, bags, liners, barrels, and bins should be used for bulk ingredients when possible. If reusable packaging is necessary, it should be evaluated to ensure it’s free from abrasions free since damaged surfaces can increase the likelihood of microplastic generation.

In addition to packaging materials, manufacturing processes can also introduce microplastics that may come in direct food contact. For example, conveyor belts used to transport products through various stages of production could release microplastics if made from plastic materials that are prone to abrasion or chipping. Similarly, plastic screws used in processing equipment may also pose a risk of microplastic contamination. Products can be filled into packaging or processing equipment with plastic-lined tubes made from a variety of different plastics, which may contribute to microplastic contamination. For example, although PVC has a high chemical resistance it is likely to generate microplastics through abrasion. Similarly, PE tubing can be very brittle and have a high likelihood of microplastic contamination. Plastic tubing should be checked for abrasion periodically to reduce the potential for microplastics contamination. Lastly, manufacturers and packaging suppliers typically use plastic containers as interim storage for the product. Containers that are used to fill and hold abrasive ingredients or products are more likely to abrade and generate microplastics. It is recommended to use more rigid containers, such as PC or PE containers.

Effectively mitigating microplastics risks in ingredient packaging requires a comprehensive approach that includes material selection, manufacturing processes, and supply chain collaboration. By following these recommendations, food and beverage manufacturers can reduce the likelihood of microplastics contamination. Proactive measures will not only promote regulatory compliance, but also protect consumer health and maintain brand integrity.

6.0 FACILITY ASSESSMENT

After reviewing the survey responses and assessing each facility's commonly used packaging materials, three facilities were selected for further assessment. During the assessment, CEC, VTDEC, and PTR staff visited and reviewed each company's food and beverage manufacturing process as well as food packaging disposal practices. Large complex manufacturers with numerous processes and product lines were reviewed and in some cases only a subset of processes were evaluated for this project. The subset of processes was prioritized based on the volume of product sold and the potential for that packaging to contain PFAS and/or microplastics. The manufacturer's food packaging material information and PFAS-free documentation received from suppliers was also reviewed or discussed when available. CEC, VTDEC, and PTR staff performed these assessments on July 25 and July 26, 2024. Additional details related to each facility are provided below.

6.1 Case Study A – Chocolate Manufacturer

6.1.1 Facility Overview

Case Study A was conducted at a chocolate manufacturing company. The building is 33,000 square feet and includes general office space, a manufacturing floor, a kitchen area, a sterilization room, a packaging room, and an inventory room. The manufacturer in Case Study A (also identified as Manufacturer A) makes over 150 varieties of premium chocolate truffles. They have been actively participating in environmentally responsible decisions and assessments regarding packaging alternatives, such as eliminating bubble wrap from the process and exploring corn starch-based Styrofoam alternatives.

6.1.2 Generalized Production and Packaging Process

The three most commonly used raw materials used for making chocolate truffles are chocolate, heavy cream, and corn syrup. Raw chocolate bars are received on pallets inside a plastic blue liner bag within a cardboard box. Heavy cream is received in a gallon recyclable plastic jug and corn syrup is received on a pallet in 1,000 L intermediate bulk containers (IBC). The chocolate truffle manufacturing process typically begins with heating heavy cream and corn syrup in a copper kettle which is then transferred into a vacuum mixer with the chocolate bars. These ingredients are blended and emulsified together into a ganache which is then transferred into polycarbonate molds in the truffle making machine. The polycarbonate molds do not contain releasing agents. While this is not a source of PFAS, microplastics could be generated if scraping is required for product removal. Once cooled, the truffles are placed into a metal bin and transferred to a conveyor, where they receive an additional layer of chocolate, decorations, and are then packaged for distribution. Truffles are packaged in a variety of ways including:

- Layered in pure Kraft recyclable stock boxes, each layer separated by a piece of layered cardboard. Coated deli paper is used to prevent further movement of the truffles. Boxes are shrink-wrapped in secondary packaging.
- Placed in plastic trays in pure Kraft recyclable stock boxes. Each tray is separated by a layer of bubble wrap and a piece of layered cardboard. Boxes are shrink-wrapped in secondary packaging.
- Individually wrapped in foil

To prevent possible contamination, the manufacturer does not typically use cleaning agents. When necessary, coconut oil, Sterilite cleaner, Dawn Dish soap, and environmentally friendly and non-toxic alternatives may be used.

Off-specification products or products that are considered unacceptable for distribution are typically reused throughout the process during capture and meltdown. Manufacturer A produces low volumes of waste and proactively identifies alternatives for re-purposing the chocolates. The remaining wasted chocolates are given to local farmers to provide for their cows, increasing their energy supply and milk production.

In preparation for shipment, boxes may be placed in larger cardboard boxes surrounded by post consumer Styrofoam. The typical packaging used at Manufacturer A's facility is provided in Table 1 below. The corresponding photos of each packaging material are provided in Appendix C.

Table 1. Manufacturer A's Typical Packaging and Risk Assessment

Packaging Stage	Packaging	Package Material	Product in Packaging	Direct Food Contact	Photo ID	Packaging Risk Assessment		Litter Potential	Potential to Enter Organics Stream	Alternative Lower Risk Packaging
						PFAS Presence	Microplastics Presence			
Obsolete Packaging	Plastic Woven Sack	Nylon	Chocolate	Yes	NA	Low-Medium	Low-Medium	Low	Low	N/A – already obsoleted from the process
Raw Material	Box lined with plastic bag	Paperboard & PE	Chocolate	Yes	1, 2	Low-High	Low-Medium	Low	Low	Non-recycled content paperboard
	Gallon Plastic Jug	HDPE or PP	Heavy Cream; flavorings	Yes	5	Medium	Low-Medium	Low	Low	Work with suppliers and manufacturers to identify no PFAS use
	1,000 L IBC	PET Blow Molded	Corn Syrup	Yes	7	Low	Low	Low	Low	None recommended
	Corrugated Box with Plastic Liner	Likely multilayer PET, nylon, PP/PE	Sea Salt; Hazelnuts; Food coloring	Yes	3, 4	Low	Medium-High	Low	Low	Rigid containers; Barrel with wider opening and liner
Intermediate Packaging	Plastic Molding Tray	PC	Chocolate Truffles	Yes	27	Low	Low	Low	Low	None recommended
	Plastic Storage Container	PET, PE, or PP	Chocolate truffles	Yes	6	Low	Low	Low	Low	None recommended
Consumer-Facing Packaging	Coated Deli Paper	Thin wax coated paper	Chocolate truffles	Yes	8, 9	Low	Low	High	High	None recommended
	Plastic Tray	PS		Yes	10, 11, 18	Low	Medium	Low	Low	A softer and recyclable material such as PET or metalized PE.
	Bubble Wrap	PE/PP		Yes	10, 12, 18	Low	Low-Medium	Low	Low	Integrate added cushioning into box design
	Kraft Box	Recycled paperboard		Yes	8, 13, 14, 15, 18	Medium-High	Low	Low	High	Virgin paperboard; plastic free coated materials; reusable plastic/metal containers
	Layered Paperboard	Recycled paperboard		Yes	18, 19	Medium-High	Low	Medium	High	Virgin paperboard; plastic free coated materials; reusable plastic/metal containers
	Gift Box	Solid bleached sulfate paperboard		Yes	20, 21	Low	Low	Medium	Medium	None recommended
	Gift Box Liner	Recycled newspaper and solid bleached sulfate coating		Yes	22, 23	Low	Low	High	High	None recommended
	Individually Wrapped in Foil	Metalized film		Yes	24	Low	Low	High	Medium	None recommended
	Plastic wrap around box	LLDPE		No	26	Low	Low	Low	Low	None recommended
	Cow box packaging	Recycled paperboard / PS		No	16, 17	Low-Medium	Low-High	Low	Low	Recycled or recyclable paperboard; sealed air in recyclable PE; or PE foam or use double/triple wall corrugated

6.1.3 Level of Risk Assessment

Using the rationale and criteria discussed in the Level of Risk Assessment section, Manufacturer A's typical packaging (Table 1) were further evaluated to identify PFAS and microplastics risk, litter potential, potential to enter the organics stream, and whether alternative lower risk-based packaging options existed. Additional information related to the reasoning and rationale behind the risk assessment is provided below.

6.1.3.1 Plastic Woven Nylon Sack

Manufacturer A previously used a manufacturer that supplied raw chocolate in plastic woven nylon sacks. This packaging has been obsoleted from the packaging process. The PFAS risk was identified as a low-medium since oil and grease resistance, as well as releasing agents, are not required for this solid product. However, woven nylon poses a higher PFAS risk due to its nature as a condensation polymer. Condensation polymers are polymers that undergo polymerization which involves a condensation reaction (water or methanol is produced as a byproduct). Examples of condensation polymers with PFAS include nylon, polyvinyl fluoride, polyvinylidene fluoride, polytetrafluoroethylene, perfluoroalkoxy, and polyfluoroethylene propylene. These polymers are typically used in processes that require high chemical resistance / non-stick surfaces (gaskets, seals, etc). The microplastics risk was identified as a low-medium due to the high-fat nature of chocolates, which can facilitate the migration of microplastics from nylon packaging. This risk increases when the product is exposed to high temperatures or prolonged exposure.

Risk Assessment	Rationale
PFAS Presence Low Risk	Oil and grease resistance not required Releasing agents not required
PFAS Presence Medium Risk	Woven nylon is a condensation polymer
Microplastics Presence Low Risk	High-fat nature of chocolates can cause migration of microplastics from nylon packaging into the food product
Microplastics Presence Medium Risk	Increased temperature or prolonged exposure can cause an increase in migration of microplastics from nylon packaging into the food product

6.1.3.2 Paperboard Box Lined with Plastic Bag

As a replacement for the plastic woven nylon sack, Manufacturer A currently uses a paperboard box lined with a plastic bag, most likely made from PE, to store raw chocolate bars. The PFAS risk was identified as low-high since PE is not a condensation polymer and does not require a PFAS coating. Oil and grease resistance, as well as releasing agents, are not required for this solid product; however, it is important to verify that corrugated cases are free from PFAS, as cross-contamination can occur. The microplastics risk was identified as a low-medium due to the high-fat content of chocolate, which allows microplastics from PE packaging to migrate more easily into the product. This risk increases when the product is exposed to high temperatures or prolonged exposure. Alternative risk-based packaging includes using non-recycled content paperboard. The use of recycled content paperboard increases the risk of PFAS hence, the wide range of risk.

Risk Assessment	Rationale
PFAS Presence Low Risk	PE is not a condensation polymer PE does not require a PFAS coating Oil and grease resistance are not required Releasing agents are not required
PFAS Presence High Risk	Cross-contamination of corrugated cases containing PFAS
Microplastics Presence Low Risk	High-fat nature of chocolates can cause migration of microplastics from PE packaging into the food product
Microplastics Presence Medium Risk	Increased temperature or prolonged exposure can cause an increase in migration of microplastics from PE packaging into the food product

6.1.3.3 Gallon Plastic Jug

Manufacturer A receives heavy cream and flavoring in one gallon plastic jugs, most likely made of HDPE or PP. Since HDPE plastic jugs are produced using manufacturing methods with potential PFAS releasing agents, and potentially the use of PFAS to improve the barrier property, the PFAS risk was identified as medium. The microplastics risk was identified as low-medium, given the liquid form of the product, where minimal abrasion can occur. However, flavorings – particularly alcohol-based ones - can interact with the plastic, potentially increasing the risk of microplastic-related compound migration. It is recommended to work with suppliers and manufacturers to identify no PFAS use.

Risk Assessment	Rationale
PFAS Presence Medium Risk	Potential manufacturing process Barrier resistance
Microplastics Presence Low Risk	Minimal abrasion to release microplastics
Microplastics Presence Medium Risk	Interaction of alcohol-based flavorings with plastic can cause microplastic-related compound migration

6.1.3.4 Plastic Storage Container

Manufacturer A uses plastic storage containers, most likely made of PET, PE, or PP, for intermediate packaging of products. Assuming there is low temperature storage and releasing agents are not required, the PFAS risk was identified as low. Due to minimal abrasion and limited contact time, the microplastics risk was also identified as low. No alternative risk-based packaging was recommended.

Risk Assessment	Rationale
PFAS Presence Low Risk	Low temperature storage Releasing agents are not required
Microplastics Presence Low Risk	Minimal abrasion and limited contact time

6.1.3.5 1,000 Liter IBC PET Blow Molded

Manufacturer A uses 1,000 liter IBC PET blow molded containers for corn syrup. Assuming these IBC containers are single use, the PFAS risk was identified as low as minimal fat resistance is required. The microplastics risk was identified as low due to minimal abrasion. No alternative risk-based packaging was recommended as long as these containers are single use.

Risk Assessment	Rationale
PFAS Presence Low Risk	Single use Minimal fat resistance required
Microplastics Presence Low Risk	Minimal abrasion

6.1.3.6 Corrugated Box with Plastic Bag

Manufacturer A receives sea salt, hazelnuts, and food coloring in corrugated boxes with plastic bags. The plastic packaging used for sea salt most likely is made of a multilayer of PET, nylon, and/or PP/PE. The PFAS risk was identified as low as minimal fat resistance is required. The microplastics risk was identified as medium-high due to the abrasive filling operation involved in high-speed vertical form-fill-seal packaging. Alternative lower risk packaging options include using rigid containers and/or barrels with a wider opening and liner to allow for slower filling and result in less abrasion.

Risk Assessment	Rationale
PFAS Presence Low Risk	Minimal fat resistance required
Microplastics Presence Medium-High Risk	Abrasive filling operation may generate microplastics

6.1.3.7 Plastic Molding Tray

Manufacturer A uses a plastic molding tray, most likely polycarbonate, to mold chocolate truffles. The PFAS risk was identified as low because polycarbonate is a rigid plastic with high chemical resistance and no releasing agents are required. The microplastics risk was identified as low since polycarbonate is not a brittle plastic. No alternative risk-based packaging was recommended, provided the molding trays remain undamaged. Any microlevel chipping of plastic could increase the risk of microplastics. If faster release is a concern, silicone may be considered an alternative.

Risk Assessment	Rationale
PFAS Presence Low Risk	Polycarbonate is a rigid plastic High chemical resistance No releasing agents are required
Microplastics Presence Low Risk	Polycarbonate is a rigid plastic

6.1.3.8 Coated Deli Paper

Manufacturer A uses coated deli paper, which is a thin wax-coated paper, to eliminate movement in the packaging container. Excessive movement can cause product damage creating an imperfect appearance. The PFAS and microplastics risks were identified as low since the wax coating is a poor moisture barrier indicating that PFAS and plastics are most likely absent. No alternative risk-based packaging was identified; however, parchment paper could be used as an alternative.

Risk Assessment	Rationale
PFAS Presence Low Risk	Poor moisture barrier indicating absence of PFAS
Microplastics Presence Low Risk	Poor moisture barrier indicating absence of plastics

6.1.3.9 Plastic Tray

Manufacturer A uses a plastic tray, most likely made of PS, as part of the final packaging for the products. The PFAS risk was identified as low since no releasing agent is required. The microplastics risk was identified as medium due to the brittleness of PS which can cause micro and macro cracks. PS is an excellent odor and flavor barrier, therefore any alternative material used needs to include these properties. PS is not recycled in North America. An alternative risk-based packaging option would include using a softer and recyclable material such as PET or metalized PE. The metalized structure would provide a better barrier than PET. Additional costs can be reduced and plastic minimized if compartment size is optimized to truffle shape. Another option for lowering costs is to mold the tray in house.

Risk Assessment	Rationale
PFAS Presence Low Risk	No releasing agents are required
Microplastics Presence Medium Risk	Brittleness of PS can generate microplastics

6.1.3.10 Bubble Wrap

Manufacturer A uses bubble wrap, most likely made of PE or PP, as an insulator and to prevent product damage through transport. The PFAS risk was identified as low since no releasing agent is needed with PE. The microplastics risk was identified as low-medium due to the softness of bubble wrap; punctured bubbles could cause the plastic to tear, potentially generating microplastics. An alternative risk-based packaging option would be to integrate added cushioning into the box design using an additional layer of corrugate or with corrugate panels. However, alternatives containing recycled content paperboard would increase the risk of PFAS cross-contamination.

Risk Assessment	Rationale
PFAS Presence Low Risk	No releasing agents are required
Microplastics Presence Low-Medium Risk	Punctured bubbles can generate microplastics

6.1.3.11 Kraft Box

Manufacturer A uses a Kraft box, most likely made of recycled paperboard, as part of its final packaging for the products. The Kraft boxes are typically lined with a layer of bubble wrap on the bottom, followed by the polystyrene plastic tray, and layered paperboard. The PFAS risk was identified as medium-high due to the packaging material containing some grease resistance and recycled content, making the PFAS content variable. As previously mentioned, paperboard suppliers should be required to provide PFAS test results and sign an attestation confirming no PFAS (intentional and nonintentional) are present in the packaging material. The microplastics risk was identified as low due to the minimal use of plastic coating. Recycled paperboard should be limited to when the source of recycled fibers is known and for certain FDA conditions of use. Alternative lower-risk-based packaging options include using virgin paperboard for direct product contact, plastic-free coating materials, and reusable plastic or metal containers.

Risk Assessment	Rationale
PFAS Presence Medium-High Risk	Grease resistance Recycled content
Microplastics Presence Low Risk	Minimal use of plastic coating

6.1.3.12 Cow Box Packaging

Manufacturer A uses "cow box" packaging, most likely made of recycled paperboard, as the secondary packaging in preparation for transport of off-spec product. The cow box packaging typically includes a Kraft box surrounded by polystyrene. The PFAS risk was identified as low-medium due to the recycled content, which made the PFAS content variable. The microplastic risk was identified as low-high. The risk is low risk due to the minimal use of corrugated plastic coating on the recycled paperboard, but the risk increases significantly with polystyrene, as it can flake and contaminate the environment. Recycled paperboard should be limited to when the source of recycled fibers is known and for certain FDA conditions of use. Alternative lower risk-based packaging options include using recycled or recyclable paperboard, sealed air in a recyclable PE container or PE foam, or double/triple-wall corrugated for added product protection. Additionally, resizing the case to minimize headspace is recommended.

Risk Assessment	Rationale
PFAS Presence Low-Medium Risk	Recycled content
Microplastics Presence Low Risk	Minimal use of corrugated plastic coating
Microplastics Presence High Risk	Polystyrene can flake and generate microplastics

6.1.3.13 Layered Paperboard

Manufacturer A uses layered paperboard, most likely made of recycled paperboard, as part of its final packaging to separate product layers. The PFAS risk was identified as medium-high due to the recycled content making the PFAS content variable and there is some grease resistance. The microplastics risk was identified as low since there is minimal plastic coating. Recycled paperboard should be limited to when the source of recycled fibers is known and for certain FDA conditions of use. Alternative lower risk packaging options include using virgin paperboard for direct product contact, plastic-free coating materials, and re-usable plastic or metal containers.

Risk Assessment	Rationale
PFAS Presence Medium-High Risk	Recycled content Grease resistance
Microplastics Presence Low Risk	Minimal use of plastic coating

6.1.3.14 Gift Box

Manufacturer A uses a gift box, most likely made of solid bleached sulfate paperboard, as part of its final packaging for smaller products. The PFAS risk was identified as low since the packaging had minimal grease resistance and no recycled content. The microplastics risk was identified as low since minimal plastic coating exists. No alternative risk-based packaging was recommended.

Risk Assessment	Rationale
PFAS Presence Low Risk	No recycled content Minimal grease resistance
Microplastics Presence Low Risk	Minimal use of plastic coating

6.1.3.15 Gift Box Liner

Manufacturer A uses a gift box liner, most likely made of recycled newspaper and solid bleached sulfate coating material, as part of its final packaging to separate product layers. The PFAS risk was identified as low since a plastic coating is potentially made of a PP/PE blend. The microplastics risk was identified as low since the gift box liner is soft resulting in minimal abrasion. No alternative risk-based packaging was recommended.

Risk Assessment	Rationale
PFAS Presence Low Risk	Plastic coating potentially made of a PP/PE blend
Microplastics Presence Low Risk	Minimal abrasion

6.1.3.16 Individually Wrapped Foil

Manufacturer A uses foil, most likely made out of metalized film, to individually wrap products in their final packaging. The PFAS and microplastics risks was identified as low due to the minimal plastic coating. No alternative risk-based packaging was identified; however, switching to PE can reduce metallization use and lower costs, while offering the benefit of recyclability.

Risk Assessment	Rationale
PFAS Presence Low Risk	Minimal plastic coating
Microplastics Presence Low Risk	Minimal plastic coating

6.1.4 Case Study A Pollution Prevention Packaging Summary

As Manufacturer A continues to evaluate environmentally conscious alternatives, additional modifications can be made to help mitigate PFAS and microplastics from entering the environment. A summary of the recommendations are provided below:

- Review recommended alternative lower risk-based packaging options and consider implementing changes in processes.
- Prioritize replacing packaging with high PFAS or high microplastics risk that have a high litter potential or high potential to enter the organics stream.

- Letters should be obtained directly from the manufacturers and production plants of the packaging used for ingredients, as a blanket statement may not provide sufficient assurance.
- It should be confirmed that release agents are not used on the inner plastic bags, and that these bags are not made from recycled content.
- Transfer sheets can be made with alternative release agents such as the following elastomers with their corresponding Chemical Abstracts Service Registry Numbers (CASRN): 2-hydroxy-2-methylpropiophenone (7473-98-5), Siloxanes and Silicones, di-Me, hydrogen-terminated, reaction products with acrylic acid and 2-ethyl-2- [(2-propenyloxy)methyl]-1,3-propanediol (155419-56-0), Cyclohexane-1,2,4-triyltris(ethylene) (2855-27-8), Siloxanes and Silicones, di-Me, Me vinyl, hydroxy-terminated, reaction products with 2-((3-(trimethoxysilyl)propoxy)methyl)oxirane (102782-94-5), and Siloxanes and Silicones, di-Me, Me vinyl, hydroxy-terminated, reaction products with 3-(2-(trimethoxysilyl)ethyl)bicyclo(4.1.0)heptane (917773-10-5) (OECD 2022).
- For molds, if release agents are needed, replace polycarbonate molds with silicone and ensure trays are inspected for abrasion for both polycarbonate and silicone molds.
- For corrugated cases with inner PE bags, verify that no PFAS is present in the recycled content of the corrugated cases.
- For PE bags, ensure they are single-use whenever possible, confirm totes are single-use, and ensure bags are not abraded on the inside.

6.2 Case Study B – Chocolate Manufacturer

6.2.1 Facility Overview

Case Study B was conducted at a chocolate manufacturing company. The building is approximately an 80,000-square foot warehouse building which includes general office space, manufacturing floor, kitchen area, sterilization room, packaging room, inventory room, and shipping room. The manufacturer in Case Study B (also identified as Manufacturer B) has a variety of gourmet chocolates made from local dairy, honey, and maple syrup sources and high quality, non-GMO, organic, and fair-trade certified ingredients. Manufacturer B has been actively participating in environmentally responsible decisions and assessments throughout their duration of operation.

6.2.2 Generalized Production and Packaging Process

The largest volume of raw materials Manufacturer B uses is chocolate. Other commonly used ingredients include nuts, peppermint, fruit, confectionaries, honey, syrup, and rice syrup. Raw chocolate is received as chocolate chips in large plastic metalized bags, typically 25 pounds. Honey and syrup are typically received in 5-gallon plastic pales and rice syrup is received in 50-pound barrels. Raw ingredients are stored in the warehouse and arrive in various packaging, including plastic jugs, glass jars, plastic pales, metalized bags, and secondary packaging such as bubble wrap and corrugated boxes. Typically, the process includes melting raw chocolate and other ingredients. The mixture is placed on a tempering machine to cool slowly and steadily. After cooling, it is poured into plastic molds which do not contain releasing agents. While this is not a source of PFAS, microplastics could be generated if scraping is required for product removal. Once hardened, molded chocolates are placed on a conveyor for additional decorations and packaging. Molded chocolates are packaged in a variety of ways including:

- Loosely or individually wrapped in foil and placed in plastic lined bags or pouches, polypropylene/cellophane bags, or recycled natural Kraft paper bags lined with a polylactic acid (PLA) compostable,
- Individually placed in mini paper cups surrounded by presentation paper in a paperboard box,
- Individually placed inside a plastic tray with outer paperboard packaging, or
- Wrapped in foil inside production recycled paper.

Off-specification or unacceptable products are rare; however, in the unlikely event they occur, they are sold in retail stores to minimize waste.

In preparation for shipment, products may be placed in secondary packaging which consists of larger cardboard boxes. The typical packaging used at Manufacturer B’s facility is provided in Table 2 below. The corresponding photos of each packaging material are provided in Appendix D.

Table 2. Manufacturer B's Typical Packaging and Risk Assessment

Packaging Stage	Packaging	Package Material	Product in Packaging	Direct Food Contact	Photo ID	Packaging Risk Assessment		Litter Potential	Potential to Enter Organics Stream	Alternative Lower Risk Packaging
						PFAS Presence	Microplastics Presence			
Raw Material	Jars	Glass	Cherries	Yes	10	Low	Low	Low	Low	None recommended
	Plastic Bags/Jugs	HDPE	Flavorings, canola oil	Yes	4, 5, 9, 13	Medium	Low-Medium	Low	Low	Work with suppliers and manufacturers to identify no PFAS use
	Paper Bag	Coated paper	Citric Acid	Yes	13	Low	Low-Medium	High	High	Higher abrasion resistant inner layer
	Plastic Pail	Coated metal	Toffee and Almond Mix	Yes	6	Low	Low-Medium	Low	Low	Work with suppliers and manufacturers to identify no PFAS use
	Plastic bag	PE	Light Brown Sugar	Yes	7	Low	Low-Medium	Low	Low	Higher abrasion resistant inner layer
Intermediate Packaging	Plastic molding tray	Unknown / PC	Chocolate	Yes	29	Low	Low	Low	Low	None recommended
	Plastic transportation tray	PC		Yes	27	Low	Low	Low	Low	None recommended
Consumer-Facing Packaging	Plastic lined bag/pouch	PET/LLDPE	Chocolate	Yes	42, 43	Low	Medium	High	Low	More rigid food contact layer
	Bubble Wrap	PE/PP		No	25	Low	Low-Medium	High	Low	Integrate added cushioning into box design
	Polypropylene bag	PP		Yes – if unwrapped product No – if foil wrapped	44, 45	Low-Medium	Low-Medium	High	Low	Work with suppliers and manufacturers to identify no PFAS use
	Production recycled paper	Bleached recycled paper		No	38, 49, 50, 51	Medium	Low	High	High	Non-recycled content
	Paperboard box	Solid bleached sulfate box with acetate layer inside		Yes	17, 18	Low	High	High	High	Plastic free coated paperboard
	Plastic tray	PET		Yes	41	Low	Low	Low	Low	None recommended
	Mini paper cups	Coated paper		Yes	20, 21	Low	High	High	High	More resistant plastic or metalized liner; plastic-free coating
	Presentation paper	Uncoated paper		Yes	22, 23, 48	Low	Low	High	High	None recommended
	Foil	Foil with logo ink		Yes	8, 51 52	Low	Low	High	Low	Raised embossing to replace coating
	Paper bag	Recycled natural kraft paper and lined with a PLA compostable		Yes	46, 47	Low	Medium	High	High	Single-layer resistant polymer

6.2.3 Level of Risk Assessment

Using the rationale and criteria discussed in the Level of Risk Assessment section, Manufacturer B's typical packaging (Table 3) were further evaluated to identify PFAS and microplastics risk, litter potential, potential to enter the organics stream, and recommended alternative lower risk-based packaging options. Additional information related to the reasoning and rationale supporting the risk assessments are provided below.

6.2.3.1 Glass Jar

Manufacturer B receives cherries and other raw materials in glass jars. Both the PFAS and microplastics risk were identified as low. No alternative risk-based packaging was recommended.

Risk Assessment	Rationale
PFAS Presence Low Risk	No releasing agent required
Microplastics Presence Low Risk	Minimal plastic coating

6.2.3.2 Foil

Manufacturer B uses metalized foil as part of the final packaging for individually wrapped chocolate bars. These rolls are placed in corrugated boxes prior to use. Both the PFAS and microplastics risk were identified as low. No alternative lower risk-based packaging options were recommended; however, if ink is applied to the foil it is recommended to use foil packaging without ink application. A raised embossing is recommended to replace this coating.

Risk Assessment	Rationale
PFAS Presence Low Risk	Minimal plastic coating
Microplastics Presence Low Risk	Minimal plastic coating

6.2.3.3 Plastic Bag/Jug

Manufacturer B receives flavorings and canola oil in plastic jugs, most likely made of HDPE. Since HDPE plastic jugs are produced using manufacturing methods with potential PFAS releasing agents, and potentially the use of PFAS to improve the barrier property, the PFAS risk was identified as medium. The microplastics risk was identified as low-medium, given the liquid form of the product, where minimal abrasion can occur. However, flavorings – particularly alcohol-based ones - can interact with the plastic, potentially increasing the risk of microplastic-related compound migration. It is recommended to work with suppliers and manufacturers to identify no PFAS use.

Risk Assessment	Rationale
PFAS Presence Medium Risk	Potential manufacturing process Barrier resistance
Microplastics Presence Low Risk	Minimal abrasion to release microplastics
Microplastics Presence Medium Risk	Interaction of alcohol-based flavorings with plastic can cause microplastic-related compound migration

6.2.3.4 Coated Paper Bag

Manufacturer B uses coated paper bags to store citric acid. The PFAS risk was identified as low since minimal fat resistance is required. The microplastics risk was identified as low medium due to the possibility that the paper is coated, which could serve as a microplastic entry point if the material becomes abraded. Alternative lower risk-based packaging options include using a higher abrasion resistance inner layer.

Risk Assessment	Rationale
PFAS Presence Low Risk	Minimal fat resistance required
Microplastics Presence Low-Medium Risk	Coated paper Abrasive filling operation may generate microplastics

6.2.3.5 Metal Coated Plastic Pail

Manufacturer B receives ingredients such as toffee and almonds in plastic pails, that are most likely coated metal. The PFAS risk was identified as low while the microplastics risk was identified as low-medium. Metal-coated plastic pails are generally considered low risk except for the coating. The potential risk depends on the acidity of the product, as it may affect the coating's integrity. While these pails are likely reusable for the same product, they should be inspected for abrasions, which could increase the risk of microplastics. It is recommended to work with suppliers and manufacturers to identify no PFAS use.

Risk Assessment	Rationale
PFAS Presence Low Risk	Minimal fat resistance required
Microplastics Presence Low-Medium Risk	Abrasive filling operation may generate microplastics Interaction of acidic product with plastic can cause microplastic migration

6.2.3.6 Plastic Bag

Manufacturer B receives light brown sugar in plastic bags, most likely made out PE. The PFAS risk assessment was identified as low while the microplastics risk assessment was identified as low-medium. Due to the abrasive filling operation involving a high-speed vertical form-fill-seal packaging, the potential for microplastic contamination is increased. Alternative lower risk-based packaging options include using a higher abrasion resistance inner layer.

Risk Assessment	Rationale
PFAS Presence Low Risk	Minimal fat resistance required
Microplastics Presence Low-Medium Risk	Abrasive filling operation may generate microplastics

6.2.3.7 *Plastic Molding Tray*

Manufacturer B uses a plastic molding tray, most likely made of polycarbonate, to mold the chocolate into various shapes. The PFAS risk was identified as low because polycarbonate is a rigid plastic with high chemical resistance. The microplastic risk was identified as low since polycarbonate is not a brittle plastic. No alternative risk-based packaging was recommended, provided the molding trays remain undamaged. Any microlevel chipping of plastic could increase the risk of microplastics. If faster release is a concern, silicone may be considered as an alternative.

Risk Assessment	Rationale
PFAS Presence Low Risk	Polycarbonate is a rigid plastic High chemical resistance No releasing agents are required
Microplastics Presence Low Risk	Polycarbonate is a rigid plastic

6.2.3.8 *Plastic Transportation Tray*

Manufacturer B uses a plastic transportation tray, likely made of polycarbonate, to transport the product on conveyor belts and throughout the facility. The PFAS risk was identified as low because polycarbonate is a rigid plastic with high chemical resistance. The microplastic risk was identified as low since polycarbonate is not a brittle plastic. No alternative risk-based packaging options were identified.

Risk Assessment	Rationale
PFAS Presence Low Risk	Polycarbonate is a rigid plastic High chemical resistance No releasing agents are required
Microplastics Presence Low Risk	Polycarbonate is a rigid plastic

6.2.3.9 Plastic Lined Bag/Pouch

Manufacturer B uses plastic lined bags/pouches, most likely made of PET or LLDPE, as part of the final packaging for smaller products. The PFAS risk was identified as low while the microplastics risk was identified as medium. LLDPE is a soft polymer which can abrade when in direct contact with sharp objects, potentially generating microplastics that may transfer to the product. The inner bag should be inspected for abrasion after shipment to minimize this risk. Alternatively, lower-risk packaging options could include a more rigid food-contact layer, such as PET or metalized film.

Risk Assessment	Rationale
PFAS Presence Low Risk	PC is a rigid plastic High chemical resistance No releasing agents are required
Microplastics Presence Medium Risk	LLDPE is a soft polymer Abrasion of LLDPE can generate microplastics

6.2.3.10 Bubble Wrap

Manufacturer B uses bubble wrap, most likely made of PE or PP, as an insulator and to prevent product damage throughout transport. The PFAS risk was identified as low since no releasing agent is needed with PE. The microplastics risk was identified as low-medium due to the softness of bubble wrap; punctured bubbles could cause the plastic to tear since bubble wrap is soft and the punctured bubbles could cause the plastic to tear, potentially generating microplastics. An alternative risk-based packaging option would be to integrate added cushioning into the box design using an additional layer of corrugate or with corrugate panels. However, alternatives containing recycled content paperboard would increase the risk of PFAS cross-contamination.

Risk Assessment	Rationale
PFAS Presence Low Risk	No releasing agents are required
Microplastics Presence Low-Medium Risk	Punctured bubbles can generate microplastics

6.2.3.11 Polypropylene Bag

Manufacturer B uses polypropylene bags (PP) as part of the final packaging for foil wrapped chocolates and unwrapped chocolates. The PFAS risk and microplastics risk were identified as low for foil-wrapped chocolates since there is limited food contact. The PFAS risk and microplastics risk were identified as medium for unwrapped chocolates since there is direct food contact but the condition of use temperature is low and PP is a more crystalline (less open to migration) structure at cooler temperatures. It is recommended to work with suppliers and manufacturers to identify no PFAS use.

Risk Assessment	Rationale
PFAS Presence Low Risk	Foil-wrapped chocolates: limited food contact
PFAS Presence Medium Risk	Unwrapped chocolates: direct food contact
Microplastics Presence Low Risk	Foil-wrapped chocolates: limited food contact
Microplastics Presence Medium Risk	Unwrapped chocolates: direct food contact At low temperatures, PP is less open to migration of microplastics

6.2.3.12 Production Bleached Recycled Paper

Manufacturer B uses production bleached recycled paper, 100% post-consumer recycled fiber, as part of the secondary packaging for the final product. The PFAS risk was identified as medium. While the risk of PFAS transfer to the product is low, the use of recycled content in the packaging increases the potential risk. Although there is no direct food content, consumer handling of the wrapper before reaching the product adds to the risk. The foil barrier inside the outer wrapper is considered a functional barrier by the FDA. The microplastics risk was identified as low, as the recycled paper is uncoated. An alternative lower-risk packaging option could include using non-recycled paper content.

Risk Assessment	Rationale
PFAS Presence Medium Risk	Recycled paper content Consumer handling increases risk
Microplastics Presence Low Risk	Uncoated recycled paper

6.2.3.13 Paperboard Box

Manufacturer B uses a paperboard box, made of solid bleached sulfate with an acetate layer inside, as part of its final packaging for products. Since there’s no recycled content, the PFAS risk was identified as low. Typical paperboard includes a clay-coated surface for high-quality printing and a top layer of bleached virgin hardwood fibers for smoothness. The remaining layers consist of bleached virgin softwood or a blend of softwood and hardwood fiber. Because it is a white sheet, solid bleached sulfate is the preferred material for food packaging and premium retail products. The microplastics risk was identified as high since the high oil resistance indicates a high likelihood of plastic coating. An alternative lower-risk packaging option could include a plastic free coated paperboard.

Risk Assessment	Rationale
PFAS Presence Low Risk	No recycled paper content
Microplastics Presence High Risk	High oil resistance Potential plastic coating

6.2.3.14 Plastic Tray

Manufacturer B uses a plastic tray, most likely made of PET, as part of the final packaging for the products. The PFAS and microplastics risks were identified as low. PET is not brittle and has a high chemical resistance. Plastic trays are typically placed inside printed paperboard and have direct food contact. PET is a common primary source of microplastics, primarily due to improper disposal. Labeling the tray as recyclable would assist in ensuring its recyclability. No alternative lower-risk packaging options were recommended.

Risk Assessment	Rationale
PFAS Presence Low Risk	PET is not brittle High chemical resistance
Microplastics Presence Low Risk	Improper disposal may generate microplastics

6.2.3.15 Mini Paper Cups

Manufacturer B uses mini paper cups, most likely made of coated paper, as part of the final packaging for products. The PFAS risk was identified as low while the microplastics risk was identified as high. The high oil and water resistance of the wrapper indicates the likelihood of a plastic coating. The paper coating, which is soft like plastic or wax, can easily be removed. Plastic components with coatings can be replaced with more durable plastics or a metalized liner.

Risk Assessment	Rationale
PFAS Presence Low Risk	No recycled paper content
Microplastics Presence High Risk	High oil and water resistance Potential plastic coating Paper coating easily removable

6.2.3.16 Presentation Paper

Manufacturer B uses presentation paper, which is uncoated paper, as part of the final packaging for products. PFAS and microplastics risks were identified as low since the packaging material is uncoated. No alternative packaging options were recommended.

Risk Assessment	Rationale
PFAS Presence Low Risk	Uncoated packaging material
Microplastics Presence Low Risk	Uncoated packaging material

6.2.3.17 Paper Bag

Manufacturer B uses a paper bag, made of recycled natural kraft paper lined with a PLA compostable (American Society for Testing and Materials (ASMT) D6400 film), as part of the final packaging for products. PLA is a plant-based renewable polymer that can easily abrade. The PFAS risk was identified as low since the paper is uncoated while the microplastics risk was identified as medium. PLA requires additives and under certain conditions (e.g., blended with other additives or not managed in optimal composting environments) microplastics could be potentially released. An alternative lower-risk packaging option could include a single-layer resistant polymer such as PET. With the current packaging, it is recommended to remove the tin tie prior to composting the material.

Risk Assessment	Rationale
PFAS Presence Low Risk	Uncoated packaging material
Microplastics Presence Medium Risk	Certain conditions could potentially release microplastics

6.2.4 Case Study B Pollution Prevention Packaging Summary

As Manufacturer B continues to evaluate environmentally conscious alternatives, additional modifications can be made to help mitigate PFAS and microplastics from entering the environment from packaging. A summary of the recommendations are described below:

- Review recommended alternative lower risk-based packaging options and consider implementing alternatives in the process.
- Prioritize replacing packaging with high PFAS or high microplastics risk that have a high litter potential or high potential to enter the organics stream.
- Letters should be obtained directly from the manufacturers and production plants of the packaging using for ingredients, as a blanket statement may not provide sufficient assurance.
- Request FDA approval for the PLA lined paperboard bag. PLA may be compostable, however, the paper is not certified as compostable. Biodegradable Products Institute or Technischer Überwachungsverein (TUV), also translated to Technical Inspection Association, certification is needed for the PLA-lined bag. The PLA liner would need to be removed from the paper bag prior to composting the PLA liner.

- It should be confirmed that releasing agents are not used on plastic jugs.
- For molds, if releasing agents are needed, replace polycarbonate molds with silicone and ensure trays are inspected for abrasion for both polycarbonate and silicone molds.
- For corrugated cases, verify that no PFAS is present in the recycled content of the corrugated cases.
- For PE, LDPE, and LLDPE bags, ensure they are single-use whenever possible and ensure bags are not abraded on the inside.
- For reusable material such as pails, ensure there are no abrasions on the inside.

6.4 Case Study C – Specialty Coffee Roastery

6.4.1 Facility Overview

Case Study C was conducted at a coffee manufacturing and supplying company. The manufacturer in Case Study C (also identified as Manufacturer C) is part of a 58,266-square foot lot that includes multiple commercial businesses. Manufacturer C's suite includes general office space, retail space, dining space, manufacturing floor, packaging room, and inventory room.

6.4.2 Generalized Production and Packaging Process

The main raw material Manufacturer C uses for specialty coffees are coffee beans. Coffee beans are received on pallets inside a jute bag lined with a plastic liner. Jute bags mitigate toxins and degradation of the raw material from moisture fluctuations. Raw coffee beans are placed in Brute® containers, potentially Rubbermaid® which is a common reference, and scooped into smaller Brute® containers which are then loaded into the coffee roaster to develop the aromatic and gustatory qualities of coffee. The coffee beans are subjected to high temperatures over a period depending on the type of light or dark roast desired. After roasting, the coffee beans are left whole for distribution or are ground through a series of serrated or scored rollers set at progressively smaller gaps. Coffee beans are placed in interim storage as needed which includes a Brute® or Sterilite® totes. Ground or whole roasted coffee beans are poured into packaging containers or bags, typically hermetically sealed, to prevent air and moisture exposure to the coffee. Manufacturer C previously used compostable bags for final packaging methods; however, recent studies identified that the compostable bag manufacturer was producing bags that broke down into microplastics. Compostables were abandoned in favor of aluminum lined bags which provide an effective oxygen and vapor barrier for the product.

Off-specification products or unacceptable products are composted with compostable bags.

In preparation for shipment, bags or containers are placed in larger cardboard boxes. The typical packaging used at Manufacturer C's facility is provided in Table 3. The corresponding photos of each packaging material are provided in Appendix E.

Table 3. Manufacturer C's Typical Packaging and Risk Assessment

Packaging Stage	Packaging	Package Material	Product in Packaging	Direct Food Contact	Photo ID	Packaging Risk Assessment		Litter Potential	Potential to Enter Organics Stream	Alternative Lower Risk Packaging
						PFAS Presence	Microplastics Presence			
Raw Material	Jute Sack	Fiber	Coffee Beans	No	4, 5, 18, 19	Low	None	Low	Low	None recommended
	Plastic Liner in Jute Sack	LDPE	Coffee Beans	Yes	17	Low	High	Low	Low	Plastic free liners
Intermediate Packaging	Brute® Containers	HDPE/LDPE	Coffee Beans	Yes	6, 7, 8	Medium	Medium	Low	Low	More rigid containers
	Sterilite® Totes	HDPE/LDPE	Coffee Beans	Yes	7, 8	Medium	Medium	Low	Low	More rigid containers
Consumer-Facing Packaging	Plastic Bags	Multilayer	Roasted Coffee Beans / Coffee Grounds	Yes	10, 11, 12, 13, 14, 15	Low	Low-Medium	Medium	Medium	More rigid polymer; metalized film
	Cardboard Box	Recycled Paperboard	Bagged Roasted Coffee Beans / Coffee Grounds	No	N/A	Low-Medium	Low	Low	Low	Work with suppliers and manufacturers to identify no PFAS use
	Aluminum Cans	Aluminum	Liquid Coffee	Yes	9	Low	Low	High	Low	None recommended
	Label on Aluminum Cans	Unknown	Liquid Coffee	No	9, 20	Low	Low	High	Low	None recommended
Compost	Food Scrap Liner	PLA and additives	Compost coffee	Yes	1, 2, 16,	Low	High	Low	High	No use of compost bags

6.4.3 Levels of Risk Assessment

Using the rationale and criteria discussed in the Level of Risk Assessment section, Manufacturer C's typical packaging (Table 3) was further evaluated to identify PFAS and microplastics risk, litter potential, potential to enter the organics stream, and alternative lower risk-based packaging. Additional information related to the reasoning and rationale behind the risk assessment is provided below.

6.4.3.1 Jute Sack

Manufacturer C receives coffee in lined jute sacks, most likely made of fiber. The jute sack does not have direct food contact with the coffee beans. The PFAS risk was identified as low since the packaging material does not require oil or grease resistance. Since the packaging does not contain any plastic there is no risk concern for microplastics. No alternative risk-based packaging was recommended.

Risk Assessment	Rationale
PFAS Presence Low Risk	No oil or grease resistance
Microplastics Presence No Risk	Material does not contain plastic

6.4.3.2 Plastic Liner in Jute Sack

A plastic liner is used in the jute sack, most likely made of LDPE, and has direct contact with raw coffee beans. The PFAS risk was identified as low since the raw packaging material does not require oil or grease resistance; however, the microplastics risk assessment was identified as high. PE is a soft material, and the abrasive nature of coffee beans increases the risk of microplastics. Abrasion was observed on the evaluated sample, further highlighting this risk. While the material is recyclable, it is recommended to switch to plastic-free liners. Implementing this recommendation may be challenging since some providers may be located outside of the country and purchasers have little control over package modification suggestions.

Risk Assessment	Rationale
PFAS Presence Low Risk	No oil or grease resistance
Microplastics Presence High Risk	PE is a soft material Potential abrasion can generate microplastics

6.4.3.3 Brute® Containers

Manufacturer C uses Brute® containers, most likely made of HDPE or LDPE, as intermediate packaging for coffee beans as they proceed through the roasting process. HDPE plastics are produced using manufacturing methods with potential PFAS releasing agents, and potentially the use of PFAS to improve the barrier property. Although the packaging material does not require oil or grease resistance, the PFAS risk was identified as medium. The microplastics risk was identified as medium since the abrasive nature of coffee beans increases the risk of microplastics. It is recommended to check the containers for evidence of abrasive etching. Alternative lower risk-based packaging options include using more rigid containers such as PC or PE.

Risk Assessment	Rationale
PFAS Presence Medium Risk	No oil or grease resistance HDPE is potentially produced with PFAS releasing agents
Microplastics Presence Medium Risk	PE is a soft material Potential abrasion can generate microplastics

6.4.3.4 Sterilite® Totes

Manufacturer C uses Sterilite® totes, most likely made of HDPE or LDPE, as intermediate packaging for the coffee beans. HDPE plastics are produced using manufacturing methods with potential PFAS releasing agents, and potentially the use of PFAS to improve the barrier property. Although the packaging material does not require oil or grease resistance, the PFAS risk was identified as medium. The microplastics risk was identified as medium since the abrasive nature of coffee beans increases the risk of microplastics. It is recommended to check the containers for evidence of abrasive etching. Alternative lower risk-based packaging options include using more rigid containers such as PC or PE.

Risk Assessment	Rationale
PFAS Presence Medium Risk	No oil or grease resistance HDPE is potentially produced with PFAS releasing agents
Microplastics Presence Medium Risk	PE is a soft material Potential abrasion can generate microplastics

6.4.3.5 Plastic Bags

Manufacturer C uses plastic bags, most likely made of multilayer materials including PE, foil, and reverse printed PET/PP, with PE, as the final packaging for roasted coffee beans or grounds. The

PFAS risk was identified as low since it doesn't require any oil or grease resistance. The microplastics risk was identified as low-medium. Given the limited contact time and small filling operation, the coffee beans are unlikely to abrade the inner layer of PE during filling. However, if coffee beans are shipped whole, abrasion may occur during transit, especially when off-gassing takes place. Alternative lower risk-based packaging options include using a more rigid polymer for direct food contact or a metalized film.

Risk Assessment	Rationale
PFAS Presence Low Risk	No oil or grease resistance
Microplastics Presence Low Risk	Small filling operation Limited contact time Abrasion unlikely
Microplastics Presence Medium Risk	Off-gassing can occur during transport of product Potential for abrasion

6.4.3.6 Cardboard Box

Manufacturer C uses cardboard boxes, most likely made of recycled paperboard, as part of its secondary packaging for shipping products. The PFAS risk was identified as low-medium due to the recycled content making the PFAS content variable. The microplastics risk was identified as low due to the minimal use of corrugated plastic coating on these cardboard boxes. It is recommended to ensure no cross-contamination exists. Recycled paperboard should be limited to when the source of recycled fibers is known and for certain FDA conditions of use. It is recommended to work with suppliers and manufacturers to identify no PFAS use.

Risk Assessment	Rationale
PFAS Presence Low-Medium Risk	Recycled paperboard content
Microplastics Presence Low Risk	Minimal use of plastic coating

6.4.3.7 Aluminum Cans

Manufacturer C uses aluminum cans as part of the final packaging for liquid coffee products. The PFAS and microplastics risks were identified as low. No alternative risk-based packaging was recommended.

Risk Assessment	Rationale
PFAS Presence Low Risk	No use of paper
Microplastics Presence Low Risk	No use of plastic coating

6.4.3.8 Label on Aluminum Cans

Manufacturer C uses an unknown material to label the aluminum cans that are used for the final packaging of liquid coffee products. The PFAS and microplastics risk was identified as low since there was no contact with the product and the label is unlikely to enter the organics stream. No alternative risk-based packaging was recommended.

Risk Assessment	Rationale
PFAS Presence Low Risk	No food contact
Microplastics Presence Low Risk	No food contact

6.4.3.9 Food Scrap Liner

Manufacturer C uses a food scrap liner, most likely made of PLA and additives, to compost coffee grounds that are used to make the liquid coffee products. The PFAS risk was identified as low. PLA requires additives and under certain conditions (e.g., blended with other additives or not managed in optimal composting environments) microplastics could be potentially released. The microplastics risk was identified as high since PLA could potentially release microplastics that may contaminate coffee grounds and compost. An alternative risk-based option would be to not bag the compost.

Risk Assessment	Rationale
PFAS Presence Low Risk	No recycled paper content
Microplastics Presence High Risk	Certain conditions could potentially release microplastics

6.4.4 Case Study C Pollution Prevention Packaging Summary

As Manufacturer C continues to evaluate environmentally conscious alternatives, additional modifications can be made to help mitigate PFAS and microplastics from contaminating food and beverage packaging. A summary of the recommendations are provided below:

- Review recommended alternative lower risk-based packaging options and consider implementing changes in processes.
- Prioritize replacing packaging with high PFAS or high microplastics risk that have a high litter potential or high potential to enter the organics stream.
- Letters should be obtained directly from the manufacturers and production plants of the packaging using for ingredients, as a blanket statement may not provide sufficient assurance.

- For PE liners and containers, ensure they are not abraded on the inside.
- Since PLA releases microplastics, it is recommended to not bag compost.

7.0 EVALUATING OPERATIONS AT YOUR FACILITY

Facilities can independently evaluate and conduct a thorough assessment of packaging materials by following the steps outlined below.

1. **Define the objective of the assessment.**
   Clearly define your facility's objective for conducting the assessment. Objectives may include:
   a) Reducing PFAS and microplastics exposure
   b) Enhancing environmental sustainability (e.g., compostability or waste reduction)
   c) Improving recyclability
   d) Safeguarding human health
   e) Ensuring regulatory compliance

2. **Conduct a targeted inventory.**
   Once the goal is defined, perform a targeted inventory of your facility's raw, interim, and consumer-facing packaging materials, prioritizing those most relevant to the goal. For example, if the goal is to reduce exposure to a specific contaminant, focus on materials likely to contain the contaminant and enter the environment.

3. **Document the rationale for using current packaging**.
   Document all types of raw, interim, and consumer facing packaging types and the. This will help identify viable alternatives that can meet the same objectives. Common rationale for current packaging may include:
   a. Cost
   b. Product shelf life
   c. Product stability
   d. Product barriers or resistance (e.g., water vapor barrier, oxygen barrier, aroma barrier, or grease/oil resistance)
   e. Environmental sustainability (e.g., recycled content, recyclability, or compostability)
   f. Appearance/marketing

4. **Evaluate and assign risk values.**
   Evaluate the documented packaging materials and assign risk values based on potential hazards, such as exposure to contaminants or environmental impact.

5. **Prioritize high-risk packaging.**
   Prioritize packaging types with the highest risk for further evaluation.

6. **Establish communications and partnerships.**
   Establish communications and partnerships with ingredient suppliers and packaging companies. This collaboration will allow for transparency in packaging ingredients, provide access to detailed material information, enable health and toxicity assessments, and facilitate the acquisition of necessary disclaimers.

7. **Determine highest risk(s).**
   Review all collected information and determine which packaging materials present the highest risk. There may be data gaps particularly regarding uncertainty about the packaging material ingredients. If budget permits, consider sampling the higher-risk materials to verify risk assumptions.

8. **Identify and implement alternative packaging materials.**
   Prioritize higher-risk materials and identify alternative packaging that meets the same objectives. Consider implementing these alternatives as appropriate.

Facilities should evaluate a range of tradeoffs and clearly define their objectives when performing these assessments. If the primary goal is to minimize environmental impact, the first priority should be minimizing packaging that environmental systems must handle, followed by reducing food waste, and adopting the principles of reduce, reuse, and recycle. As an example, while composting may present certain environmental benefits, it's important to note that just because a material is compostable doesn't necessarily mean it's made of non-fossil fuel sources or that it is safe to use the compost generated from the material.

By prioritizing these considerations, facilities can conduct a thorough evaluation of their packaging materials, leading to the identification of more sustainable alternatives that align with their objectives.

8.0 SUMMARY AND CONCLUSIONS

This report outlines a comprehensive strategy for evaluating and preventing potential pollution associated with packaging materials within Vermont's food and beverage manufacturing sector. Funded by a U.S. EPA Pollution Prevention grant and supported by VTDEC, this voluntary initiative aimed to identify and mitigate the risks of PFAS and microplastic contamination in the food waste system, with a focus on protecting both consumer health and the environment.

A key component of this initiative was performing facility evaluations and assessments, which provided critical insights into the potential risks of PFAS and microplastic contamination in ingredient and consumer-facing packaging, along with manufacturing processes. This initiative also provided manufacturers with the tools to assess and document their packaging material, identify viable alternatives that align with Vermont's new law prohibiting intentionally added PFAS in food packaging.

Through this project, manufacturers were supported in addressing PFAS and microplastic contamination within their supply chains. By following the outlined steps, manufacturers can enhance the safety and sustainability of their products and endeavor to align with state regulations.

It's important to note that research on the connection between packaging, PFAS, microplastics, and their potential presence in food waste is still emerging. The industry is actively working to understand and address these concerns, alongside other challenges they face. Our conclusions should be viewed as provisional, based on current knowledge, with future developments likely to inform alternative approaches to this study. Facilities will need to consider a range of trade-offs and clarify their ultimate objectives in managing environmental concerns.

If you have any questions, comments, or require additional information, please do not hesitate to contact either of the undersigned.

Sincerely,

CIVIL & ENVIRONMENTAL CONSULTANTS, INC.

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Enclosures: Appendix A – Study Engagement and Facility Questionnaire
Appendix B – Study Engagement and Facility Questionnaire Graphics
Appendix C – Facility A Photolog
Appendix D – Facility B Photolog
Appendix E – Facility C Photolog

References

ATSDR, 2024. Human Exposure: PFAS Information for Clinicians – 2024. Retrieved from: https://www.atsdr.cdc.gov/pfas/hcp/clinical-overview/properties.html

California Water Boards, 2024. PFAS; Per- and Polyfluoroalkyl Substances. Retrieved from: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/pfas.html

Department of Toxic Substances Control (DTSC), 2021. Product – Chemical Profile for Plant Fiber-Based Food Packaging Containing Perfluoroalkyl or Polyfluoroalkyl Substances. Retrieved from: https://dtsc.ca.gov/wp-content/uploads/sites/31/2021/06/Profile_PFASs-in-Food-Packaging_Appendix_FINAL_compliant.pdf

Ekta B. Jadhav, Mahipal Singh Sankhla, Rouf Ahmad Bhat, D.S. Bhagat, 2021. Microplastics from food packaging: An overview of human consumption, health threats, and alternative solutions, Environmental Nanotechnology, Monitoring & Management, Volume 16, 2021,100608, ISSN 2215-1532, https://doi.org/10.1016/j.enmm.2021.100608. Retrieved from: https://www.sciencedirect.com/science/article/pii/S2215153221001835

FDA, 2024. Authorized Uses of PFAS in Food Contact Applications. Retrieved from: https://www.fda.gov/food/process-contaminants-food/authorized-uses-pfas-food-contact-applications

FDA, 2024. FDA Announces PFAS Used in Grease-Proofing Agents for Food Packaging No Longer Being Sold in the U.S. Retrieved from: https://www.fda.gov/food/hfp-constituent-updates/fda-announces-pfas-used-grease-proofing-agents-food-packaging-no-longer-being-sold-us

FDA, 2024. Microplastics and Nanoplastics in Food. Retrieved from: https://www.fda.gov/food/environmental-contaminants-food/microplastics-and-nanoplastics-foods

FDA, 2025. Market Phase-Out of Grease-Proofing Substances Containing PFAS. Retrieved from: https://www.fda.gov/food/process-contaminants-food/market-phase-out-grease-proofing-substances-containing-pfas

FDA, 2025. Per- and Polyfluoroalkyl Substances (PFAS). Retrieved from: https://www.fda.gov/food/environmental-contaminants-food/and-polyfluoroalkyl-substances-pfas

GESAMP, 2015. Sources, Fate and Effects of Microplastics in the Marine Environment: a Global Assessment. 1996. IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection.

Geueke, B., Parkinson, L.V., Groh, K.J. et al., 2024. Evidence for widespread human exposure to food contact chemicals. *J Expo Sci Environ Epidemiol* (2024). https://doi.org/10.1038/s41370-024-00718-2. Retrieved from: https://rdcu.be/d0doe

Interstate Technology & Regulatory Council (ITRC), 2023. PFAS – Per- and Polyfluoroalkyl Substances. Retrieved from: https://pfas-1.itrcweb.org/2-5-pfas-uses/

Litesmith, 2024. Plastic Container Guide. Retrieved from: https://www.litesmith.com/plastic-container-guide/

Maine State Legislature. 2021. An Act to Stop Perfluoroalkyl and Polyfluoroalkyl Substances Pollution. 130LR0942(05). Retrieved from: http://www.mainelegislature.org/legis/bills/getPDF.asp?paper=HP1113&item=5&snum=130.).

National Institute of Environmental Health Sciences (NIH), 2024. Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS). Retrieved from: https://www.niehs.nih.gov/health/topics/agents/pfc

New Hampshire (NH) Department of Health & Human Services (DHHS), 2024. Poly-and Per-fluoroalkyl Substances (PFAS). Retrieved from https://www.dhhs.nh.gov/programs-services/environmental-health-and-you/poly-and-fluoroalkyl-substances-pfas

NYDEC, 2024. PFAS in Food Packaging Law. Retrieved from: https://dec.ny.gov/environmental-protection/recycling-composting/businesses/pfas-in-food-packaging

Organisation for Economic Co-operation and Development (OECD), 2022. PFAS and Alternatives in Food Packaging (Paper and Paperboard): Hazard Profile. Retrieved from: https://one.oecd.org/document/env/cbc/mono(2022)2/en/pdf

Perkins Coie, 2023. PFAS and Food Packaging: The State of Regulation. Retrieved from: https://perkinscoie.com/insights/update/pfas-and-food-packaging-state-regulation

Porterfield, K., Hobson, S., Neher, D., Niles, M. & Roy, E. (2023). Microplastics in composts, digestates and food wastes: A Review. Journal of Environmental Quality, 1–16. doi:10.1002/jeq2.20450

Rangika Bandara, G.M. Indunil, 2022. Food packaging from recycled papers: chemical, physical, optical properties and heavy metal migration, Heliyon, Volume 8, Issue 10, 2022, e10959, ISSN 2405-8440, https://doi.org/10.1016/j.heliyon.2022.e10959. Retrieved from: https://www.sciencedirect.com/science/article/pii/S2405844022022472

Sand, C. K., 2023. In Pursuit of Clean Packaging with No Chemicals of Concern. Food Safety Magazine. Retrieved from: https://www.food-safety.com/articles/8204-in-pursuit-of-clean-packaging-with-no-chemicals-of-concern

Sand, C. K., 2023. Promising Practices are Being Used to Tackle PFAS in Food Packaging. Food Safety Magazine. Retrieved from: https://www.food-safety.com/articles/9109-promising-practices-are-being-used-to-tackle-pfas-in-food-packaging

Siddiqui, S.A. et al., 2023. Chapter Eight - Migration of microplastics from plastic packaging into foods and its potential threats on human health, Advances in Food and Nutrition Research, Academic Press, Volume 103, 2023, Pages 313-359, ISSN 1043-4526, ISBN 9780323988353, https://doi.org/10.1016/bs.afnr.2022.07.002. Retrieved from: https://www.sciencedirect.com/science/article/pii/S1043452622000493

Smith, E.A., Dziewatkoski, M., Henrie, T., Seidel, C., & Rosen, J. "Microplastics: What Drinking Water Utilities Need to Know." Journal - American Water Works Association (AWWA), 111(11), 26-37, doi: 10.1002/awwa.1393, 2019.

SNRE, 2024. An Ecological Perspective on Microplastics in the Great Lakes. Retrieved from: https://www.northeastmichiganwatersheds.org/downloads/microplastics_msu_great_lakes_conference_daley.pdf

U.S. EPA, 2024. Designation of Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) as CERCLA Hazardous Substances. Retrieved from: https://www.epa.gov/superfund/designation-perfluorooctanoic-acid-pfoa-and-perfluorooctanesulfonic-acid-pfos-cercla

U.S. EPA, 2024. Per- and Polyfluoroalkyl Substances (PFAS). Final PFAS National Primary Drinking Water Regulation. Retrieved from: https://www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas

VT Department of Health, 2023. PFAS Guidance for Manufacturers, Suppliers, and Distributors. Retrieved from: https://www.healthvermont.gov/sites/default/files/document/env-ecp-pfas-guidance.pdf

APPENDIX A – STUDY ENGAGEMENT AND FACILITY QUESTIONNAIRE

Respondent #1

1.) What is your desired level of participation? (select one)
    a. Direct technical assistance (which may include facility site visit, customized pollution prevention evaluation, meetings with other participating businesses).
2.) For direct technical assistance, how would you like to participate? (select all that apply):
    a. Site visit at your business (2-3 hours)
    b. Video conference call
3.) What questions are you hoping this project will answer for your business? (select all that apply)
    a. What types of food packaging potentially contain PFAS?
    b. Does my business' packaging potentially contain PFAS?
    c. What types of packaging are unlikely to or do not contain PFAS?
    d. What types of packaging have the potential to generate microplastic contamination?
    e. Does my business' packaging have the potential to generate microplastic contamination?
    f. What alternative packaging options are available to my business?
    g. What alternative packaging materials will not release microplastics?
    h. Other (please specify):
    i. What about waste plastics going into landfills?
4.) How does your business manage food products that are not able to be sold? (select all that apply)
    a. Compost of unpackaged, raw ingredients or final food products
    b. We donate to a food shelf
5.) What types of food products does your company currently package? (write in)Please list types of food products:
    a. Soups, Sauces, meat products.
6.) What types of packaging materials are you currently using at your business? (select all that apply)
    a. Paper - cardboard
    b. Plastic - HDPE
    c. Uncoated Paperboard
    d. polyethelene & nylon.
7.) Why is your company using the packaging type(s) indicated above? (select all that apply)
    a. Cost
    b. Product stability
    c. Recyclability
    d. Appearance/marketing

e. To date it is the only feasible option.

8.) Please rate your current knowledge (news articles, scientific literature, etc) about PFAS in food or food packaging? (0 being no knowledge, 5 being an expert on the topic)
    a. 1

9.) Please rate your current knowledge (news articles, scientific literature, etc) about microplastics in food waste from packaging impacting food waste or the environment? (0 being no knowledge, 5 being an expert on the topic)
    a. 2

Respondent #2:

1.) What is your desired level of participation? (select one)
    a. Direct technical assistance (which may include facility site visit, customized pollution prevention evaluation, meetings with other participating businesses).

2.) For direct technical assistance, how would you like to participate? (select all that apply):
    a. Site visit at your business (2-3 hours)
    b. Video conference call

3.) What questions are you hoping this project will answer for your business? (select all that apply)
    a. What types of packaging are unlikely to or do not contain PFAS?
    b. What types of packaging have the potential to generate microplastic contamination?
    c. Does my business' packaging have the potential to generate microplastic contamination?
    d. What alternative packaging options are available to my business?
    e. What alternative packaging materials will not release microplastics?

4.) How does your business manage food products that are not able to be sold? (select all that apply)
    a. Compost of unpackaged, raw ingredients or final food products
    b. Depackaging of packaged, off-spec, or expired food products
    c. Disposal of unused/unusable food packaging
    d. We donate to a food shelf

5.) What types of food products does your company currently package? (write in)Please list types of food products:
    a. chocolate confections, ice cream, marshmallows

6.) What types of packaging materials are you currently using at your business? (select all that apply)

   a. Paper - wax
   b. Paper - coated
   c. Paper - cardboard
   d. Plastic - LDPE
   e. Glass
   f. Multi-Material Package
   g. Uncoated Paperboard

7.) Why is your company using the packaging type(s) indicated above? (select all that apply)
   a. Cost
   b. Recyclability
   c. Appearance/marketing
   d. Compostability
   e. whats readily available on the market

8.) Please rate your current knowledge (news articles, scientific literature, etc) about PFAS in food or food packaging? (0 being no knowledge, 5 being an expert on the topic)
   a. 4

9.) Please rate your current knowledge (news articles, scientific literature, etc) about microplastics in food waste from packaging impacting food waste or the environment? (0 being no knowledge, 5 being an expert on the topic)
   a. 3

<u>Respondent #3</u>

1.) What is your desired level of participation? (select one)
   a. Direct technical assistance (which may include facility site visit, customized pollution prevention evaluation, meetings with other participating businesses).

2.) For direct technical assistance, how would you like to participate? (select all that apply):
   a. For direct technical assistance, how would you like to participate? (select all that apply):
   b. Site visit at your business (2-3 hours)
   c. Video conference call
   d. Phone call

3.) What questions are you hoping this project will answer for your business? (select all that apply)
   a. What types of food packaging potentially contain PFAS?
   b. Does my business' packaging potentially contain PFAS?
   c. What types of packaging are unlikely to or do not contain PFAS?

   d. What types of packaging have the potential to generate microplastic contamination?
   e. Does my business' packaging have the potential to generate microplastic contamination?
   f. What alternative packaging options are available to my business?
   g. What alternative packaging materials will not release microplastics?

4.) How does your business manage food products that are not able to be sold? (select all that apply)
   a. We do not generate any food waste from our processes
   b. We do not generate any packaging waste from our process
   c. Our consumers are pleased with the current shelf-life of the product and do not create food waste

5.) What types of food products does your company currently package? (write in)Please list types of food products:
   a. Maple syrup, maple sugar & spices & cocoa, maple cream, granola

6.) What types of packaging materials are you currently using at your business? (select all that apply)
   a. Paper - cardboard
   b. Plastic - HDPE
   c. Glass
   d. film bags

7.) Why is your company using the packaging type(s) indicated above? (select all that apply)
   a. Cost
   b. Maintain product shelf life
   c. Oxygen barrier
   d. Not many choices of packaging

8.) Please rate your current knowledge (news articles, scientific literature, etc) about PFAS in food or food packaging? (0 being no knowledge, 5 being an expert on the topic)
   a. 1

9.) Please rate your current knowledge (news articles, scientific literature, etc) about microplastics in food waste from packaging impacting food waste or the environment? (0 being no knowledge, 5 being an expert on the topic)
   a. 1

<u>Respondent #4</u>

1.) What is your desired level of participation? (select one)

a. Direct technical assistance (which may include facility site visit, customized pollution prevention evaluation, meetings with other participating businesses).

2.) For direct technical assistance, how would you like to participate? (select all that apply):
   a. Site visit at your business (2-3 hours)
3.) What questions are you hoping this project will answer for your business? (select all that apply)
   a. What types of food packaging potentially contain PFAS?
   b. Does my business' packaging potentially contain PFAS?
   c. What types of packaging are unlikely to or do not contain PFAS?
   d. What types of packaging have the potential to generate microplastic contamination?
   e. Does my business' packaging have the potential to generate microplastic contamination?
   f. What alternative packaging options are available to my business?
   g. What alternative packaging materials will not release microplastics?
4.) How does your business manage food products that are not able to be sold? (select all that apply)
   a. Compost of unpackaged, raw ingredients or final food products
   b. Compost of packaged, off spec or expired food products
   c. Depackaging of packaged, off-spec, or expired food products
   d. Disposal of unused/unusable food packaging
   e. We donate to a food shelf
5.) What types of food products does your company currently package? (write in)Please list types of food products:
   a. Roasted coffee, prepared coffee beverages to go, fresh pastries to go
6.) What types of packaging materials are you currently using at your business? (select all that apply)
   a. Metal
   b. Multi-Material Package
   c. Plastic Coated Paperboard
   d. Most of our packaging is multi-material. A mix of metal and plastic. We also use "compostable" to go wares that are not accepted at local compost facilities.
7.) Why is your company using the packaging type(s) indicated above? (select all that apply)
   a. Product stability
   b. Recyclability
   c. Water vapor barrier
   d. Oxygen barrier

8.) Please rate your current knowledge (news articles, scientific literature, etc) about PFAS in food or food packaging? (0 being no knowledge, 5 being an expert on the topic)
    a. 2
9.) Please rate your current knowledge (news articles, scientific literature, etc) about microplastics in food waste from packaging impacting food waste or the environment? (0 being no knowledge, 5 being an expert on the topic)
    a. 3

Respondent #5

1.) What is your desired level of participation? (select one)
    a. Direct technical assistance (which may include facility site visit, customized pollution prevention evaluation, meetings with other participating businesses).
2.) For direct technical assistance, how would you like to participate? (select all that apply):
    a. Site visit at your business (2-3 hours)
3.) What questions are you hoping this project will answer for your business? (select all that apply)
    a. What types of food packaging potentially contain PFAS?
    b. Does my business' packaging potentially contain PFAS?
    c. What types of packaging are unlikely to or do not contain PFAS?
    d. What alternative packaging options are available to my business?
    e. What alternative packaging materials will not release microplastics?
4.) How does your business manage food products that are not able to be sold? (select all that apply)
    a. Disposal of unpackaged, raw ingredients or final food products
    b. Compost of unpackaged, raw ingredients or final food products
    c. We do not generate any packaging waste from our process
    d. Our consumers are pleased with the current shelf-life of the product and do not create food waste
5.) What types of food products does your company currently package? (write in)Please list types of food products:
    a. Fresh Cranberry ,cranberry juice, selzer
6.) What types of packaging materials are you currently using at your business? (select all that apply)
    a. Paper - cardboard
    b. Glass
    c. Metal

7.) Why is your company using the packaging type(s) indicated above? (select all that apply)
    a. Product stability
    b. Recyclability
    c. Appearance/marketing
    d. Environmental sustainability
8.) Please rate your current knowledge (news articles, scientific literature, etc) about PFAS in food or food packaging? (0 being no knowledge, 5 being an expert on the topic)
    a. 1
9.) Please rate your current knowledge (news articles, scientific literature, etc) about microplastics in food waste from packaging impacting food waste or the environment? (0 being no knowledge, 5 being an expert on the topic)
    a. 1

Respondent #6

1.) What is your desired level of participation? (select one)
    a. Receive general information generated by the project.
2.) For direct technical assistance, how would you like to participate? (select all that apply):
    a. Phone call
3.) What questions are you hoping this project will answer for your business? (select all that apply)
    a. What types of food packaging potentially contain PFAS?
    b. What types of packaging are unlikely to or do not contain PFAS?
    c. What types of packaging have the potential to generate microplastic contamination?
    d. What alternative packaging options are available to my business?
4.) How does your business manage food products that are not able to be sold? (select all that apply)
    a. Compost of unpackaged, raw ingredients or final food products
    b. Disposal of unused/unusable food packaging
    c. Our consumers are pleased with the current shelf-life of the product and do not create food waste
5.) What types of food products does your company currently package? (write in)Please list types of food products:
    a. Vegan eggrolls, which are packed either in a 5-pack freezer-safe sleve, or in a bulk 30-pack

6.) What types of packaging materials are you currently using at your business? (select all that apply)
    a. Paper - cardboard
    b. Plastic – LDPE
7.) Why is your company using the packaging type(s) indicated above? (select all that apply)
    a. Grease/oil resistance
    b. Maintain product shelf life
8.) Please rate your current knowledge (news articles, scientific literature, etc) about PFAS in food or food packaging? (0 being no knowledge, 5 being an expert on the topic)
    a. 4
9.) Please rate your current knowledge (news articles, scientific literature, etc) about microplastics in food waste from packaging impacting food waste or the environment? (0 being no knowledge, 5 being an expert on the topic)
    a. 4

Respondent #7

1.) What is your desired level of participation? (select one)
    a. Direct technical assistance (which may include facility site visit, customized pollution prevention evaluation, meetings with other participating businesses).
2.) For direct technical assistance, how would you like to participate? (select all that apply):
    a. Site visit at your business (2-3 hours)
3.) What questions are you hoping this project will answer for your business? (select all that apply)
    a. Does my business' packaging potentially contain PFAS?
    b. What types of packaging are unlikely to or do not contain PFAS?
    c. What types of packaging have the potential to generate microplastic contamination?
    d. What alternative packaging options are available to my business?
    e. What alternative packaging materials will not release microplastics?
    f. A training presentation PFAS 1010 for management would be great
4.) How does your business manage food products that are not able to be sold? (select all that apply)
    a. Compost of unpackaged, raw ingredients or final food products
    b. Depackaging of packaged, off-spec, or expired food products
    c. Upcycling of unpackaged raw ingredients
5.) What types of food products does your company currently package? (write in)Please list types of food products:

   a. Chocolate truffles

6.) What types of packaging materials are you currently using at your business? (select all that apply)
   a. Paper - wax
   b. Paper - cardboard
   c. Paper - compostable
   d. Plastic - PTFE
   e. Plastic - HDPE
   f. Plastic - LDPE
   g. Multi-Material Package
   h. Uncoated Paperboard
   i. I will gather specifications prior to site visit - I'm six months at this company and have not analyzed our food contact materials or secondary packaging/other potential PFAS waste
7.) Why is your company using the packaging type(s) indicated above? (select all that apply)
   a. Product stability
   b. Recyclability
   c. Environmental sustainability
   d. Maintain product shelf life
   e. Water vapor barrier
   f. Aroma barrier
   g. Reduced or optimized packaging material
8.) Please rate your current knowledge (news articles, scientific literature, etc) about PFAS in food or food packaging? (0 being no knowledge, 5 being an expert on the topic)
   a. 0
9.) Please rate your current knowledge (news articles, scientific literature, etc) about microplastics in food waste from packaging impacting food waste or the environment? (0 being no knowledge, 5 being an expert on the topic)
   a. 0

Respondent #8

1.) What is your desired level of participation? (select one)
   a. Direct technical assistance (which may include facility site visit, customized pollution prevention evaluation, meetings with other participating businesses).
2.) For direct technical assistance, how would you like to participate? (select all that apply):
   a. Site visit at your business (2-3 hours)
   b. Video conference call

   c. Phone call
3.) What questions are you hoping this project will answer for your business? (select all that apply)
   a. What types of food packaging potentially contain PFAS?
   b. Does my business' packaging potentially contain PFAS?
   c. What types of packaging are unlikely to or do not contain PFAS?
   d. What types of packaging have the potential to generate microplastic contamination?
   e. Does my business' packaging have the potential to generate microplastic contamination?
   f. What alternative packaging options are available to my business?
   g. What alternative packaging materials will not release microplastics?
4.) How does your business manage food products that are not able to be sold? (select all that apply)
   a. Compost of unpackaged, raw ingredients or final food products
   b. Compost of packaged, off spec or expired food products
   c. Disposal of unused/unusable food packaging
   d. Upcycling of unpackaged raw ingredients
   e. We donate to a food shelf
5.) What types of food products does your company currently package? (write in)Please list types of food products:
   a. pies, donuts, quiche, grab n go meals, sandwiches, raw meats, cooked meats, sauces
6.) What types of packaging materials are you currently using at your business? (select all that apply)
   a. Paper - wax
   b. Paper - coated
   c. Paper - cardboard
   d. Metal
   e. Multi-Material Package
   f. Uncoated Paperboard
   g. I am unsure of the type of plastic, but we use a lot
7.) Why is your company using the packaging type(s) indicated above? (select all that apply)
   a. Cost
   b. Product stability
   c. Grease/oil resistance
   d. Appearance/marketing
   e. Maintain product shelf life

f. Water vapor barrier
g. Oxygen barrier
h. Aroma barrier

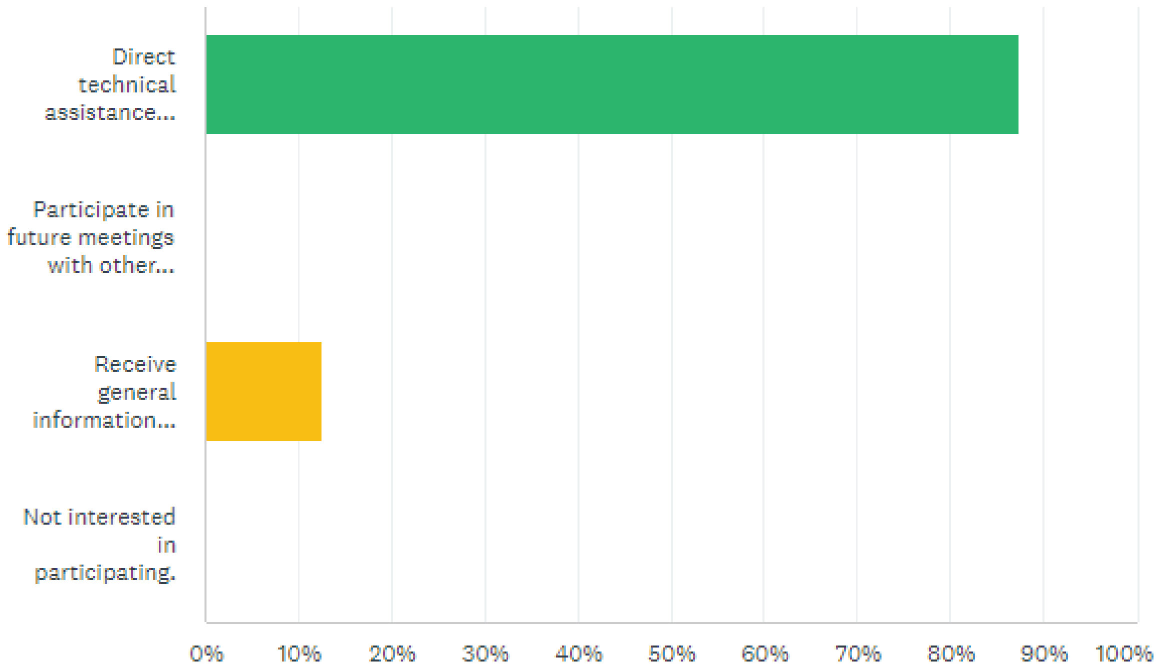
8.) Please rate your current knowledge (news articles, scientific literature, etc) about PFAS in food or food packaging? (0 being no knowledge, 5 being an expert on the topic)
   a. 2

9.) Please rate your current knowledge (news articles, scientific literature, etc) about microplastics in food waste from packaging impacting food waste or the environment? (0 being no knowledge, 5 being an expert on the topic)
   a. 3

APPENDIX B – STUDY ENGAGEMENT AND FACILITY QUESTIONNAIRE GRAPHICS

What is your desired level of participation? (select one)

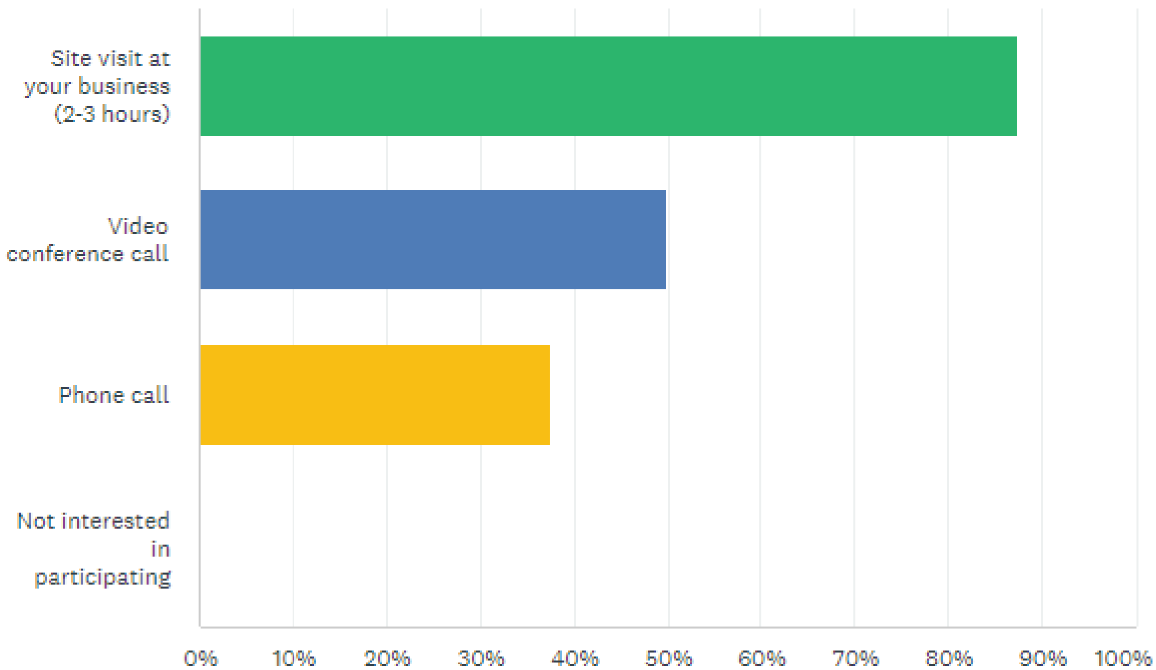
Answered: 8 Skipped: 0



ANSWER CHOICES	RESPONSES	
Direct technical assistance (which may include facility site visit, customized pollution prevention evaluation, meetings with other participating businesses).	87.50%	7
Participate in future meetings with other participating businesses.	0.00%	0
Receive general information generated by the project.	12.50%	1
Not interested in participating.	0.00%	0
TOTAL		8

For direct technical assistance, how would you like to participate? (select all that apply):

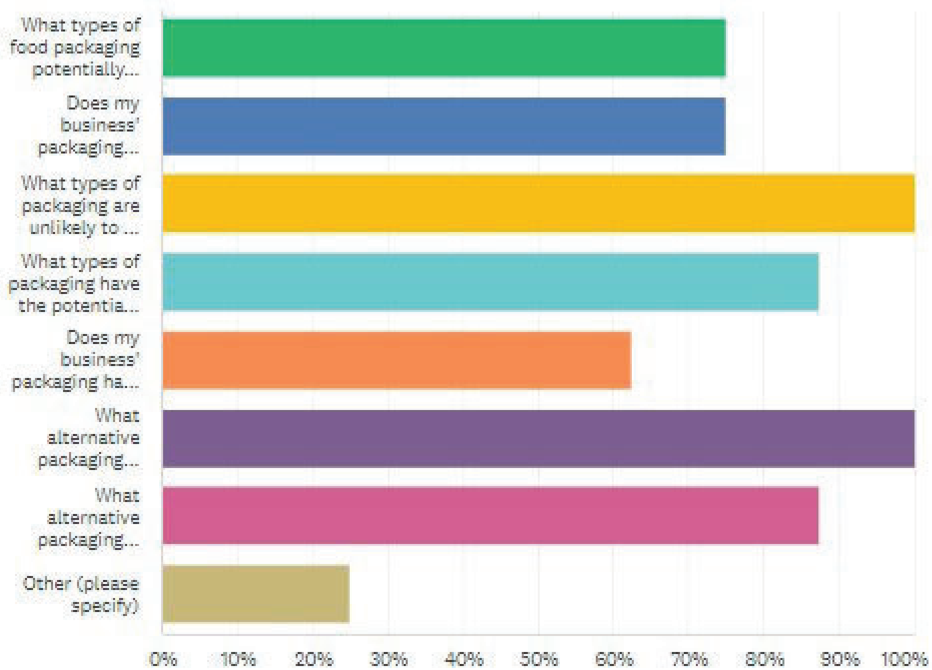
Answered: 8 Skipped: 0



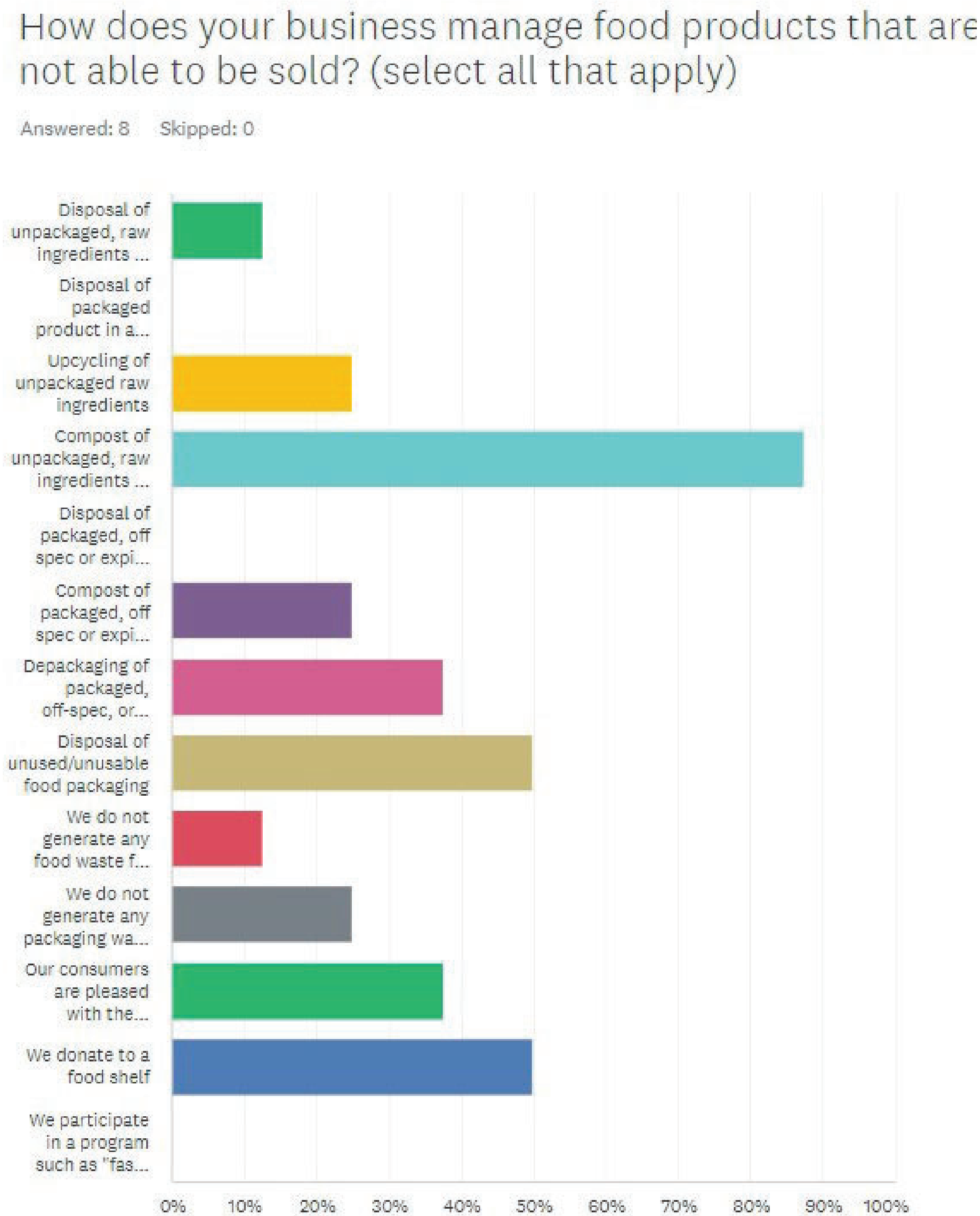
ANSWER CHOICES	RESPONSES	
Site visit at your business (2-3 hours)	87.50%	7
Video conference call	50.00%	4
Phone call	37.50%	3
Not interested in participating	0.00%	0
Total Respondents: 8		

What questions are you hoping this project will answer for your business? (select all that apply)

Answered: 8 Skipped: 0



ANSWER CHOICES		RESPONSES	
What types of food packaging potentially contain PFAS?		75.00%	6
Does my business' packaging potentially contain PFAS?		75.00%	6
What types of packaging are unlikely to or do not contain PFAS?		100.00%	8
What types of packaging have the potential to generate microplastic contamination?		87.50%	7
Does my business' packaging have the potential to generate microplastic contamination?		62.50%	5
What alternative packaging options are available to my business?		100.00%	8
What alternative packaging materials will not release microplastics?		87.50%	7
Other (please specify)	Responses	25.00%	2
Total Respondents: 8			


How does your business manage food products that are not able to be sold? (select all that apply)
Answered: 8 Skipped: 0
Disposal of unpackaged, raw ingredients ...
Disposal of packaged product in a...
Upcycling of unpackaged raw ingredients
Compost of unpackaged, raw ingredients ...
Disposal of packaged, off spec or expi...
Compost of packaged, off spec or expi...
Depackaging of packaged, off-spec, or...
Disposal of unused/unusable food packaging
We do not generate any food waste f...
We do not generate any packaging wa...
Our consumers are pleased with the...
We donate to a food shelf
We participate in a program such as "fas...
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

ANSWER CHOICES	RESPONSES	
Disposal of unpackaged, raw ingredients or final food products	12.50%	1
Disposal of packaged product in a dumpster or large trash receptacle of unpackaged, raw ingredients, or final food products	0.00%	0
Upcycling of unpackaged raw ingredients	25.00%	2
Compost of unpackaged, raw ingredients or final food products	87.50%	7
Disposal of packaged, off spec or expired food products in a trash receptacle	0.00%	0
Compost of packaged, off spec or expired food products	25.00%	2
Depackaging of packaged, off-spec, or expired food products	37.50%	3
Disposal of unused/unusable food packaging	50.00%	4
We do not generate any food waste from our processes	12.50%	1
We do not generate any packaging waste from our process	25.00%	2
Our consumers are pleased with the current shelf-life of the product and do not create food waste	37.50%	3
We donate to a food shelf	50.00%	4
We participate in a program such as "fast fresh" to allow consumers to buy food that is almost past its shelf life at a lower cost	0.00%	0
Total Respondents: 8		

What types of food products does your company currently package? (write in)Please list types of food products:

Answered: 8 Skipped: 0

pies, donuts, quiche, grab n go meals, sandwiches, raw meats, cooked meats, sauces

6/3/2024 11:36 AM

Chocolate truffles

5/30/2024 02:20 PM

Vegan eggrolls, which are packed either in a 5-pack freezer-safe sleve, or in a bulk 30-pack

5/28/2024 11:19 AM

Fresh Cranberry ,cranberry juice, selzer

5/23/2024 10:03 AM

Roasted coffee, prepared coffee beverages to go, fresh pastries to go

Maple syrup, maple sugar & spices & cocoa, maple cream, granola

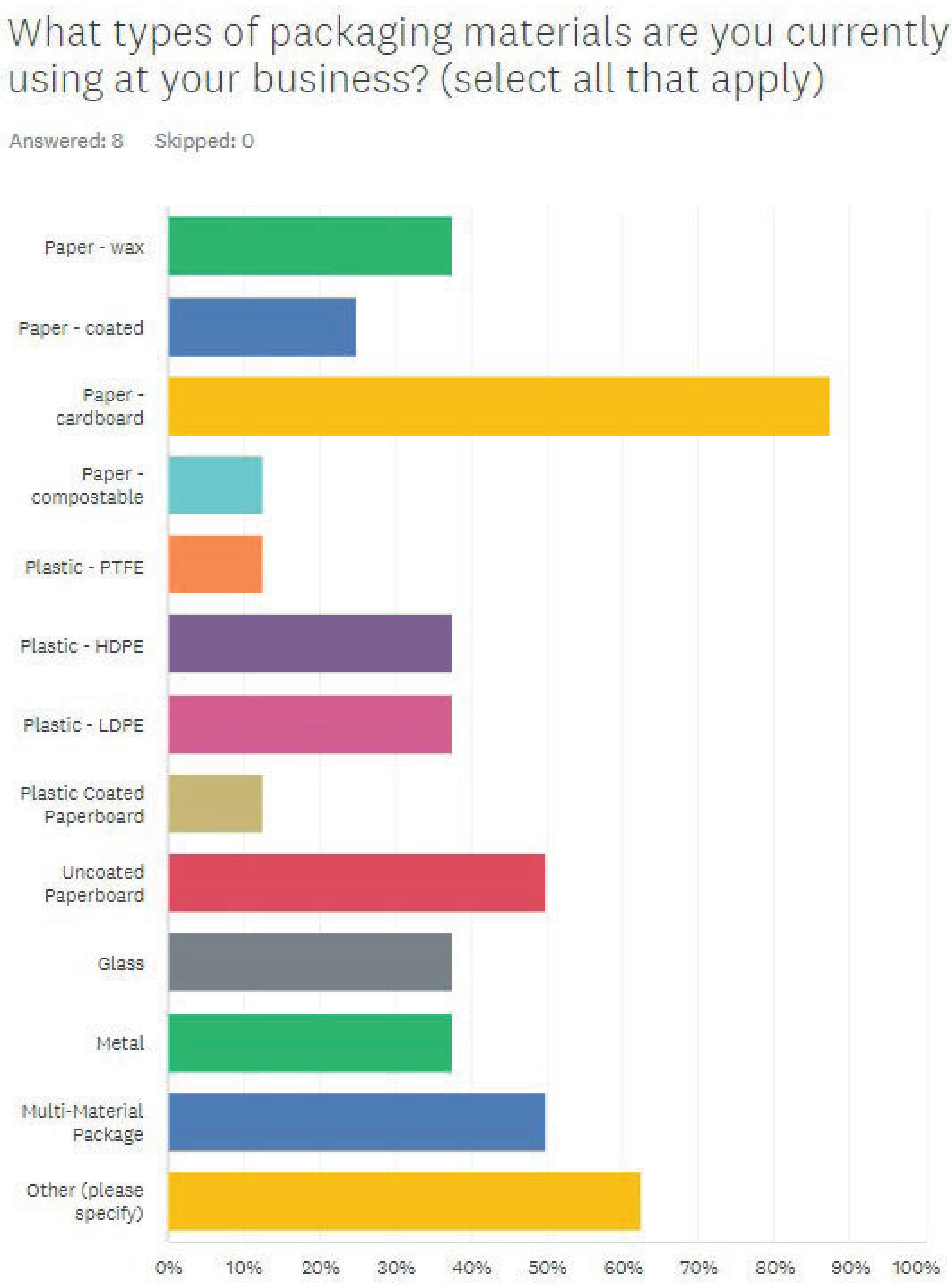
5/23/2024 09:05 AM

chocolate confections, ice cream, marshmallows

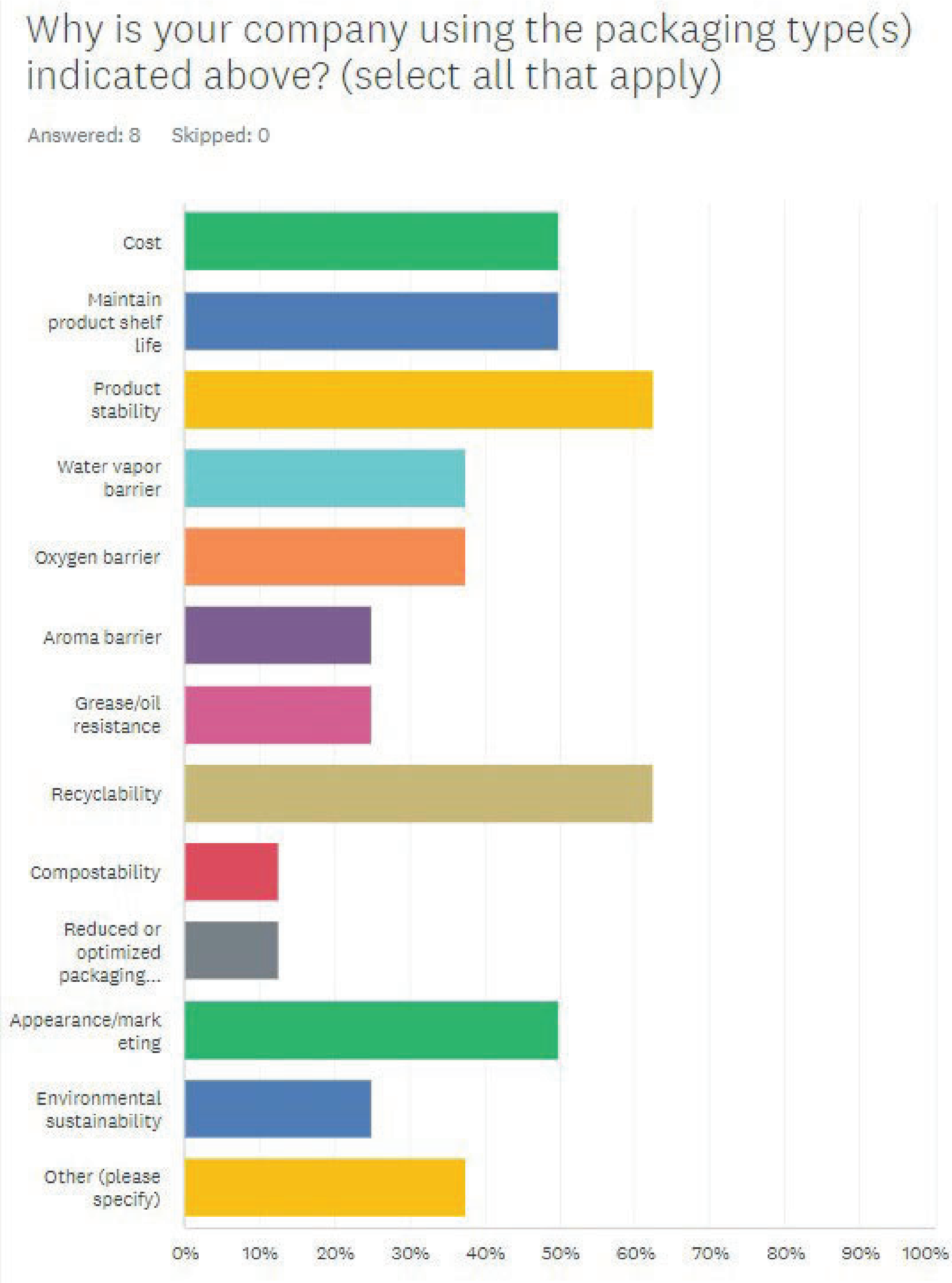
5/21/2024 10:39 AM

Soups, Sauces, meat products.

5/21/2024 07:16 AM


What types of packaging materials are you currently using at your business? (select all that apply)
Answered: 8 Skipped: 0
Paper - wax
Paper - coated
Paper - cardboard
Paper - compostable
Plastic - PTFE
Plastic - HDPE
Plastic - LDPE
Plastic Coated Paperboard
Uncoated Paperboard
Glass
Metal
Multi-Material Package
Other (please specify)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

ANSWER CHOICES		RESPONSES	
Paper - wax		37.50%	3
Paper - coated		25.00%	2
Paper - cardboard		87.50%	7
Paper - compostable		12.50%	1
Plastic - PTFE		12.50%	1
Plastic - HDPE		37.50%	3
Plastic - LDPE		37.50%	3
Plastic Coated Paperboard		12.50%	1
Uncoated Paperboard		50.00%	4
Glass		37.50%	3
Metal		37.50%	3
Multi-Material Package		50.00%	4
Other (please specify)	Responses	62.50%	5
Total Respondents: 8			


Why is your company using the packaging type(s) indicated above? (select all that apply)
Answered: 8 Skipped: 0
Cost
Maintain product shelf life
Product stability
Water vapor barrier
Oxygen barrier
Aroma barrier
Grease/oil resistance
Recyclability
Compostability
Reduced or optimized packaging...
Appearance/marketing
Environmental sustainability
Other (please specify)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

ANSWER CHOICES		RESPONSES	
Cost		50.00%	4
Maintain product shelf life		50.00%	4
Product stability		62.50%	5
Water vapor barrier		37.50%	3
Oxygen barrier		37.50%	3
Aroma barrier		25.00%	2
Grease/oil resistance		25.00%	2
Recyclability		62.50%	5
Compostability		12.50%	1
Reduced or optimized packaging material		12.50%	1
Appearance/marketing		50.00%	4
Environmental sustainability		25.00%	2
Other (please specify)	Responses	37.50%	3
Total Respondents: 8			

Please rate your current knowledge (news articles, scientific literature, etc) about PFAS in food or food packaging? (0 being no knowledge, 5 being an expert on the topic)

Answered: 8 Skipped: 0

2

6/3/2024 11:36 AM

0

5/30/2024 02:20 PM

4

5/28/2024 11:19 AM

1

5/23/2024 10:03 AM

2

5/23/2024 09:05 AM

1

5/23/2024 09:05 AM

4

5/21/2024 10:39 AM

1

5/21/2024 07:16 AM

Please rate your current knowledge (news articles, scientific literature, etc) about microplastics in food waste from packaging impacting food waste or the environment? (0 being no knowledge, 5 being an expert on the topic)

Answered: 8 Skipped: 0

3

6/3/2024 11:36 AM

0

5/30/2024 02:20 PM

4

5/28/2024 11:19 AM

1

5/23/2024 10:03 AM

3

5/23/2024 09:05 AM

1

5/23/2024 09:05 AM

3

5/21/2024 10:39 AM

2

5/21/2024 07:16 AM

APPENDIX C – FACILITY A PHOTOLOG

Photo 1: A1 – Raw chocolate ingredient.

Photo 2: A1 – Raw chocolate ingredient.

Photo 3: Sea Salt.

Photo 4: Food coloring.

Photo 5: Gallon plastic jugs for flavorings

Photo 6: Individual chocolate truffles

Photo 7: 1,000L IBC for corn syrup

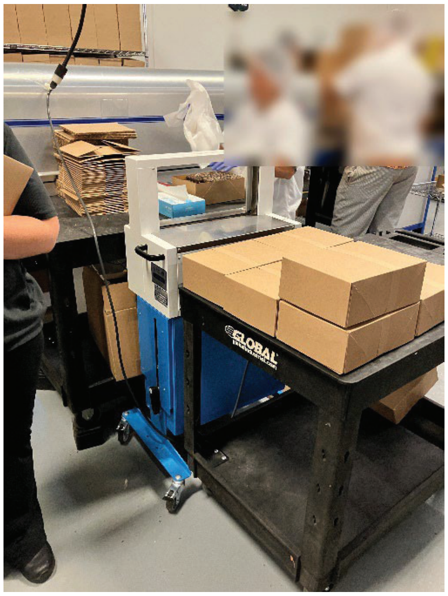


Photo 8: A7 – deli paper, A5 – Brown Kraft Box,

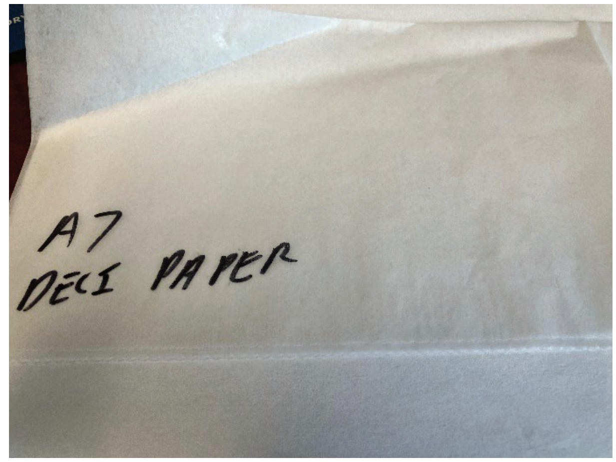


Photo 9: A7 – deli paper

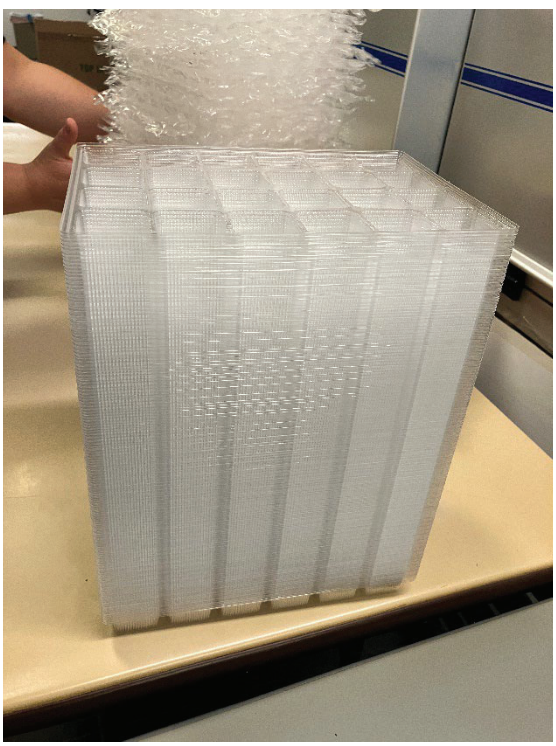


Photo 10: A2 – plastic tray and A3 – bubble wrap

Photo 11: A2 – plastic tray

Photo 12: A3 – bubble wrap

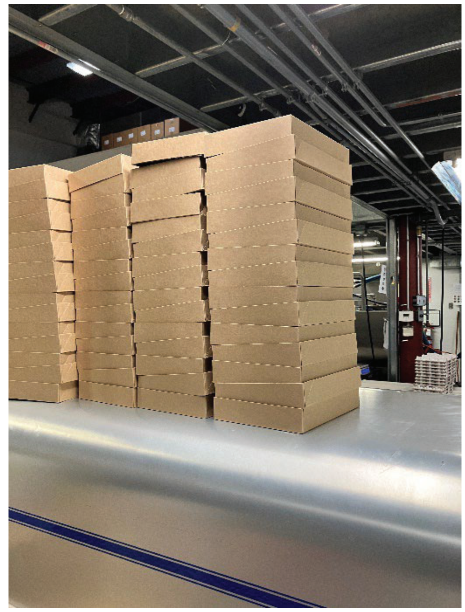


Photo 13: A4 – Brown Kraft Box

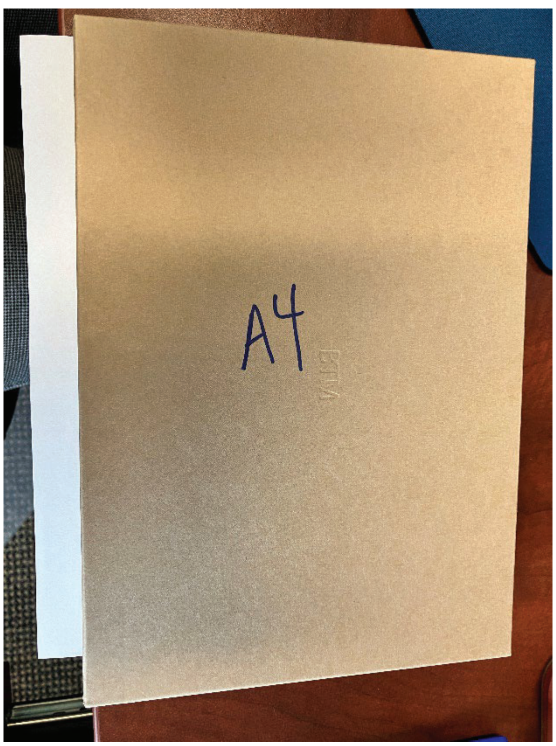


Photo 14: A4 – Brown Kraft Box

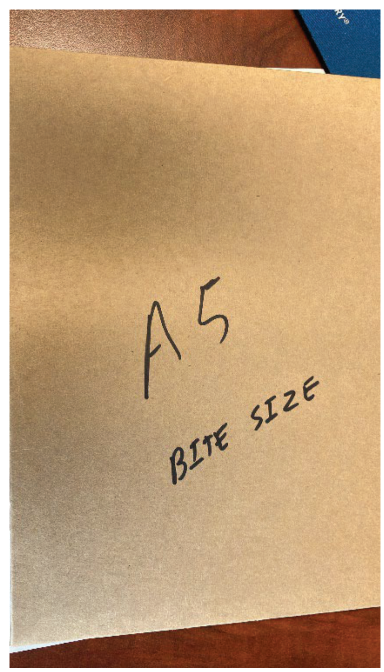


Photo 15: A5 – Brown Kraft Box

Photo 16: Cow box packaging

Photo 17: Cow box packaging

Photo 18: Assembled packaging - A6 – layered paperboard pad, A2 plastic tray, A3 – bubble wrap – and A4 – brown craft box

Photo 19: A6 – side view of A6 layered paperboard pad

Photo 20: A8 – gift box

Photo 21: A8 – gift box

Photo 22: A9 – gift box liner

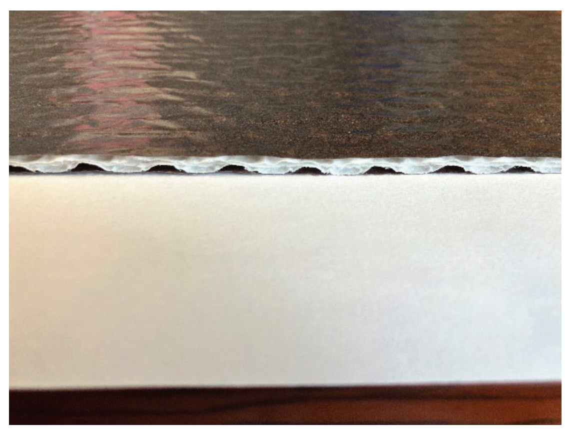


Photo 23: A9 – side view of gift box liner

Photo 24: A10 – individual wrapping

Photo 25: Plastic wrap system

Photo 26: Plastic wrapped boxes

Photo 27: Plastic molding tray

APPENDIX D – FACILITY B PHOTOLOG

Photo 1: Finished packaged products

Photo 2: Finished packaged product. B7 – presentation paper and B5 – mini paper cups

Photo 3: Corrugated boxes for shipping

Photo 4: Flavorings

Photo 5: Flavorings

Photo 6: Toffee and almond ingredients

Photo 7: Raw ingredient brown sugar packaging

Photo 8: Bleached paper and foil rolls

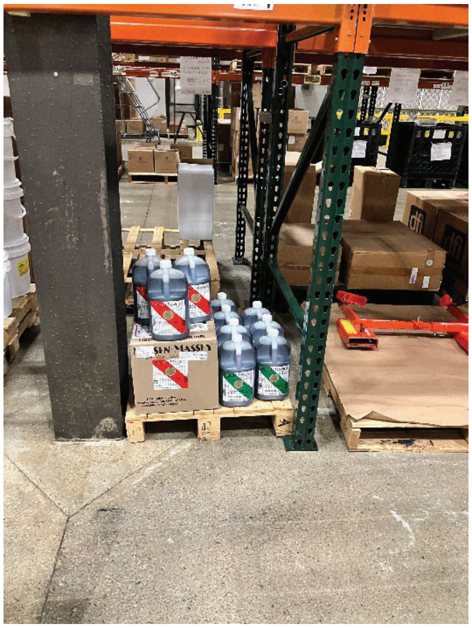


Photo 9: Flavoring

Photo 10: Raw ingredient packaged in glass jar.

Photo 11: Flavoring

Photo 12: Raw ingredient – cereal

Photo 13: Raw ingredient – canola oil and citric acid.

Photo 14: Raw ingredient packaging

Photo 15: Interim packaging – foil wrapped chocolates

Photo 16: Labels

Photo 17: B1 – Paperboard Box - SBS

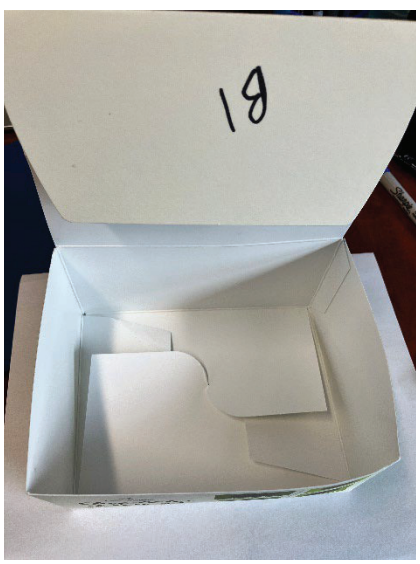


Photo 18: B1 – Paperboard Box - SBS 1 -

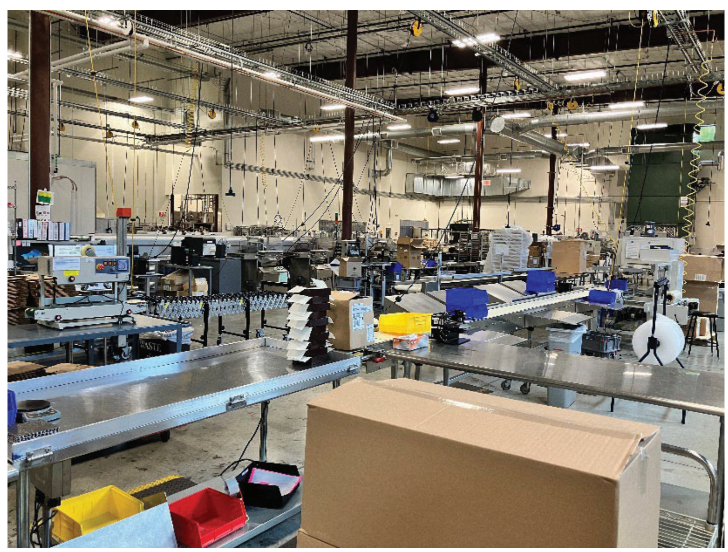


Photo 19: Manufacturing floor

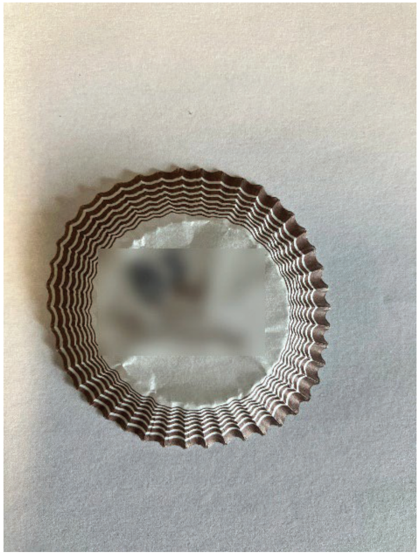


Photo 20: B5 – mini paper cups

Photo 21: B5 – mini paper cups

Photo 22: B7 – Presentation paper

Photo 23: B7 – presentation paper

Photo 24: Plastic wrap process

Photo 25: Bubble wrap

Photo 26: Manufacturing process at facility B.

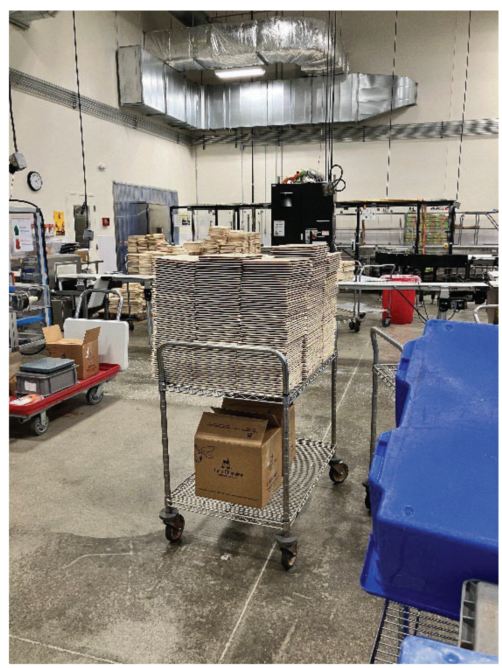


Photo 27: Plastic plates for transporting chocolates throughout the process

Photo 28: Conveyor belt

Photo 29: Molding trays

Photo 30: Tempering machines

Photo 31: Manufacturing supplies

Photo 32: Mixing machine

Photo 33: Manufacturing equipment

Photo 34: Melter tank

Photo 35: Plastic trays

Photo 36: Raw chocolate ingredient

Photo 37: Raw chocolate ingredient

Photo 38: B8 – production recycled paper

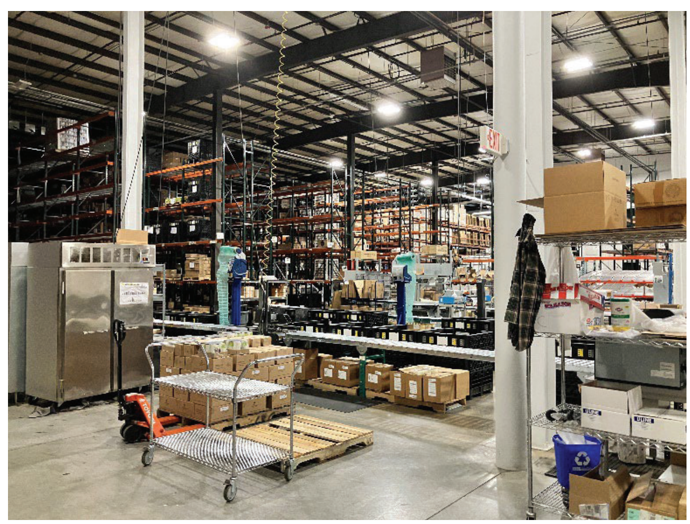


Photo 39: Shipping department

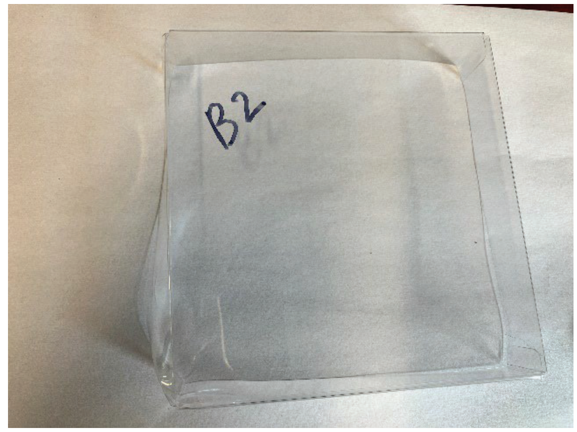


Photo 40: Shipping department

Photo 41: B2 – Plastic tray

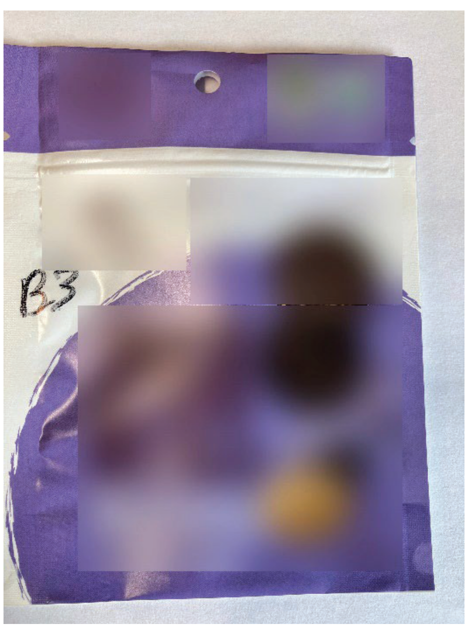


Photo 42: B3 - Pouch

Photo 43: B3 - Pouch

Photo 44: B4 – Cellophane bag

Photo 45: B4 – Cellophane bag

Photo 46: B6 – Paper bag

Photo 47: B6 – Paper bag

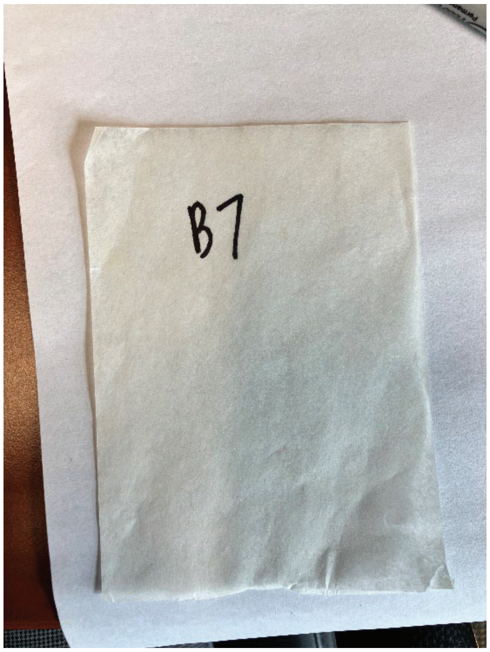


Photo 48: B7 – Presentation paper

Photo 49: B8 – Production recycled paper

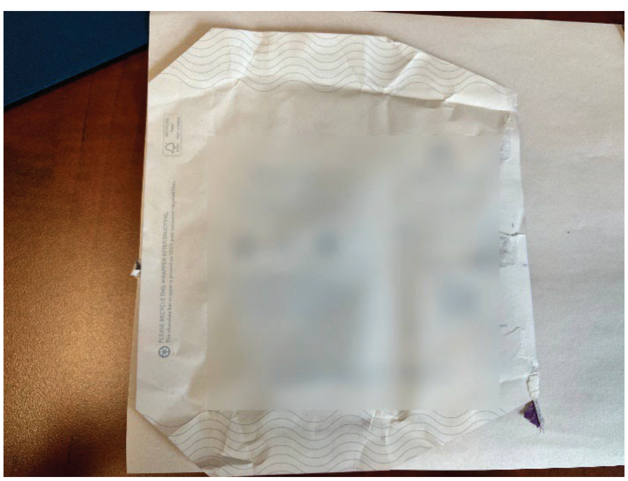


Photo 50: B8 – Production recycled paper

Photo 51: B8 – production recycled paper and B9 - foil

Photo 52: B9 - foil

APPENDIX E – FACILITY C PHOTOLOG

Photo 1: C4 – Food scrap liner

Photo 2: 42 – Food scrap liner

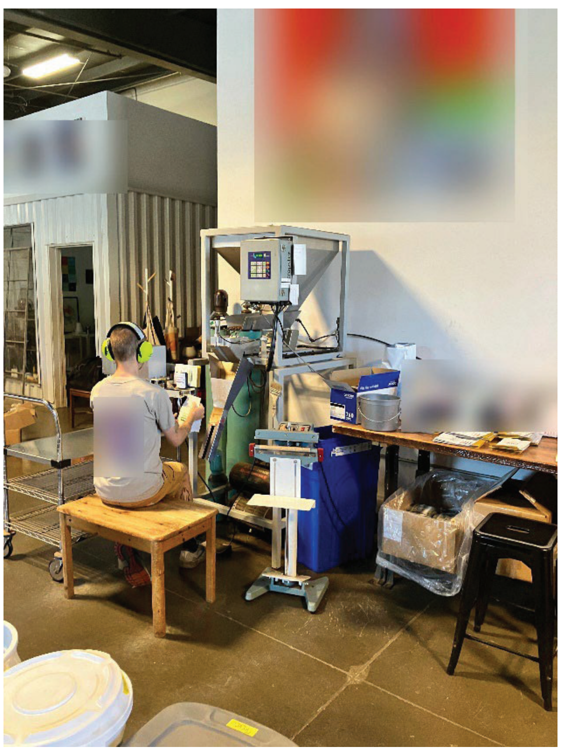


Photo 3: Coffee bag filling station

Photo 4: C6 – Jute sack with plastic liner and coffee

Photo 5: C6 – Jute sack

Photo 6: Interim coffee bean storage

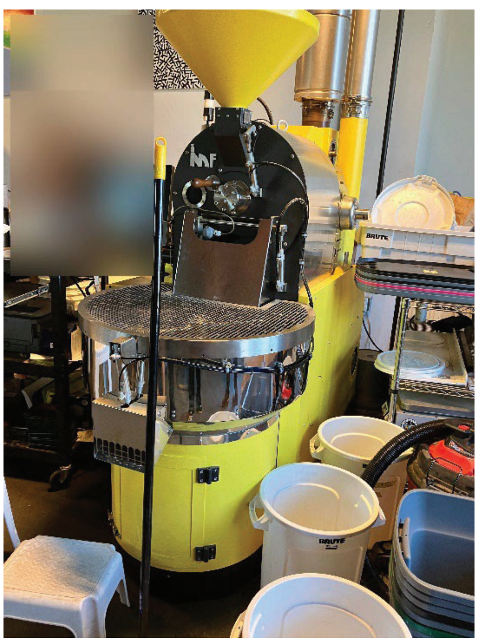


Photo 7: Coffee bean equipment

Photo 8: Coffee bean interim storage

Photo 9: Canned aluminum beverage

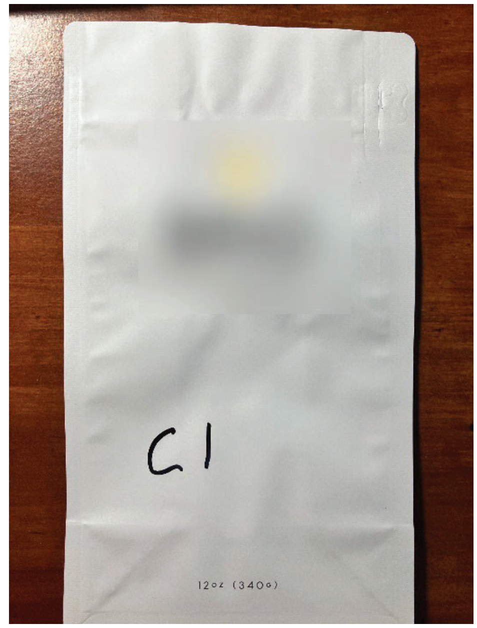


Photo 10: C1- 12 ounce bag

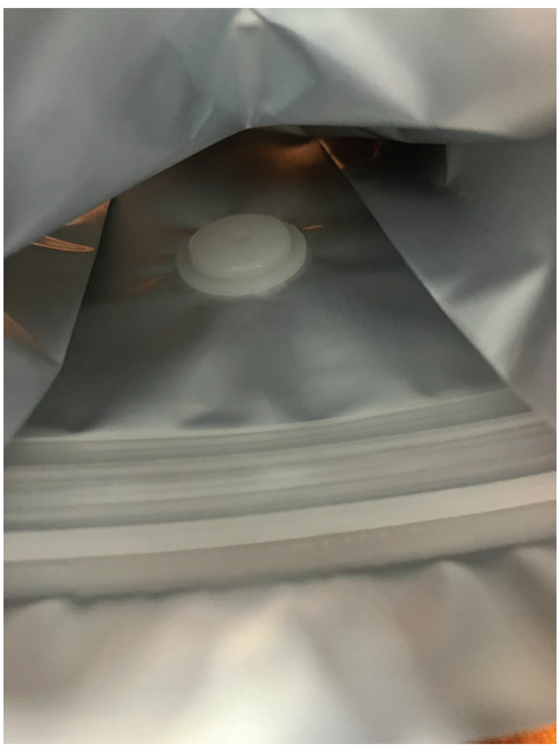


Photo 11: C1 – 12 ounce bag (inside)

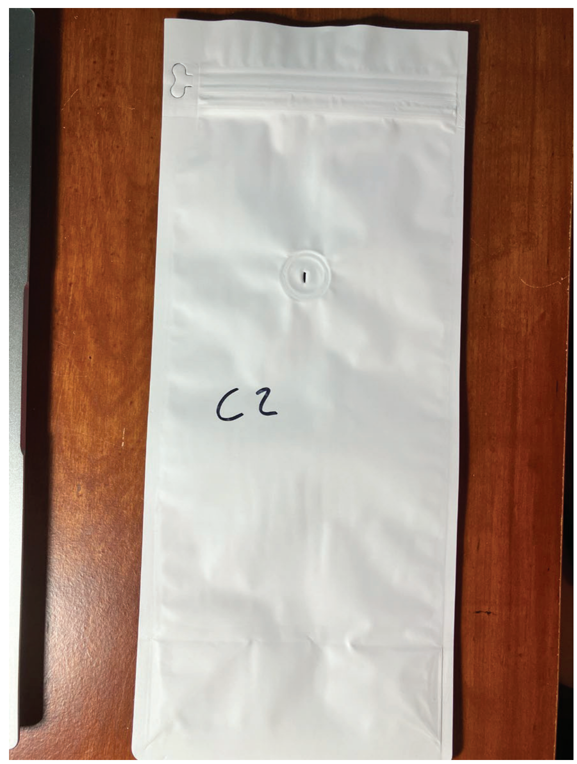


Photo 12: C2 – medium bag

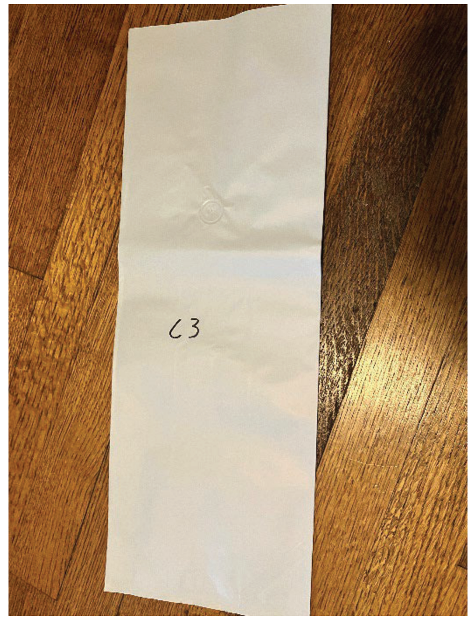


Photo 13: C2 – medium bag (inside)

Photo 14: C3 – large bag

Photo 15: C3 – large bag (inside)

Photo 16: C4 – Food scrap liner

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Photo 17: C5 – liner in jute sack

Photo 18: C6 – jute sack

Photo 19: C6 – jute sack

Photo 20: C7 – Label on aluminum cans

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VTDEC Pollution Prevention in Food and Beverage Packaging
Facility C
CEC Project# 330-842

Photographs Taken: July 26, 2024