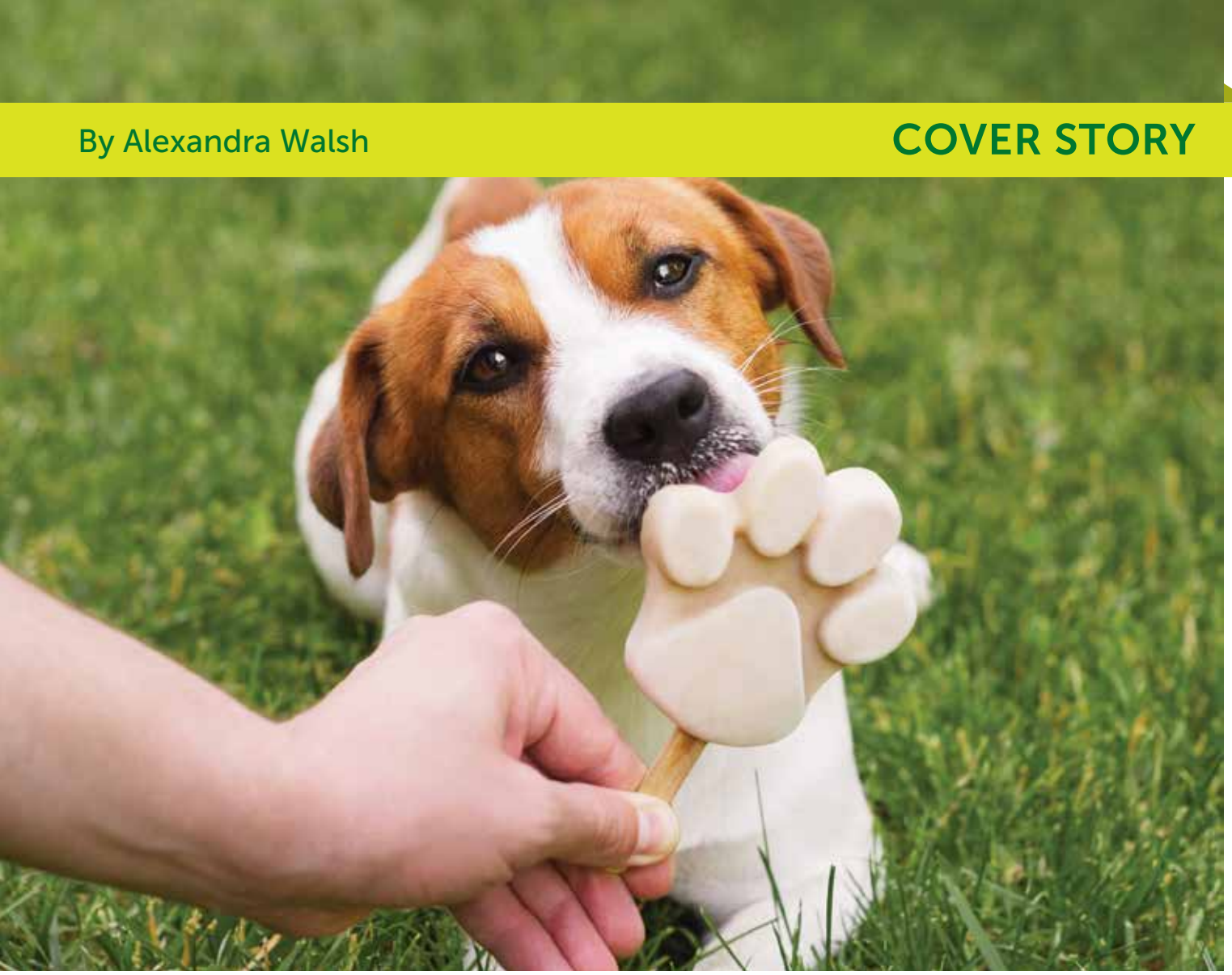
By Alexandra Walsh



THE THINGS WE MOVE AND STORE

From pet food and pandas to priceless paintings and seasick baby eels, today's temperature-controlled 'products' run the gamut.

GLP-1 weight-loss drugs have rapidly moved into the mainstream, and their impact has begun to reach far beyond the pharmacy, reshaping supply chains. Their impact spans manufacturing, cold-chain logistics, grocery retail, and food production, driven in part by shifts in consumer eating habits.

Surging demand has forced food manufacturers to rethink production, retailers to adjust product mixes and portion sizes, and pharmaceutical companies to expand cold-chain capacity and output.

These drugs require strict handling. They must be kept between 35°F and 46°F, demanding reliable cooling, careful planning, detailed documentation, and expanded temperature-controlled storage and packaging. Companies are also rethinking warehouse processes, from packaging to inventory management.

As a result, operators are broadening their definition of temperature-sensitive cargo beyond traditional food and beverage products.

Transportation Challenges

The most pressing challenge in pharmaceutical temperature-sensitive supply chains is maintaining uninterrupted temperature integrity across the entire chain.

What's compounding the challenge right now is scale says Dr. Janeth Gabaldon of the University of Arkansas and a member of the GCCA's Council of Scientific Advisors (CSA) specializing in emerging supply chain technologies. She believes the explosive demand for GLP-1 has outpaced the cold chain infrastructure designed to support it. "We're seeing strain at every node (manufacturing, distribution, and dispensing). GLP-1 is manageable in controlled environments but becomes risky across complex, multi-modal supply chains."

Dr. Gabaldon points out that's why visibility is also a critical gap. Real-time temperature monitoring, IoT-enabled sensors, and data logging have improved significantly, but adoption is uneven across the supply chain. She says the weakest links tend to be the handoff points between parties, where temperature drops can occur.

Security is another growing concern due to the high market value of these medications. Cargo theft, counterfeit products, and diversion risks are increasing pressures across pharmaceutical logistics networks.

"This requires stronger chain-of-custody controls, tracking technologies, and secure transportation protocols, which increase operational costs for companies," says Dr. Gabaldon. "The Drug Supply Chain Security Act (DSCSA) was designed to address this through serialization and traceability requirements, but implementation has been uneven, and enforcement is still catching up."

The most challenging best practice for transporting glucagon-like peptide -1 (GLP-1) meds is preventing temperature excursions and corresponding heat or freeze damage during the unpredictable last-mile delivery to a patient's doorstep, explains Dr. Patrick Brecht with PEB Commodities and CSA expert in refrigerated transportation. "The final leg of transit from the carrier's delivery vehicle to the patient retrieving the package is the highest-risk phase. Packages left in direct sunlight, on hot porches, or in freezing mailboxes during the summer or winter can experience temperature excursions that can destroy the peptide structure."

Dr. Brecht says to lessen the risk of damage to GLP-1 medications during the last mile, they should be shipped in validated, insulated containers combined with pre-conditioned phase-change materials (PCMs) or frozen gel packs tailored for the 2 C to 8 C range. Recipients (patients) should transfer the medication to the middle shelf of their refrigerator immediately upon receipt.

According to Dr. S. Paul Singh of Michigan State University and SAC packaging and labeling expert, the International Safe Transit Association (www.ista.org) has, with participation from major pharmaceutical companies, developed a test protocol to qualify packaging systems that require strict temperature control in the single parcel shipping environment of UPS and FedEx. In addition, participating packaging companies have developed insulated packaging that can provide such strict temperature control during shipping.

Seasick Eels

Baby eels can experience motion sickness and disorientation during transport. Their inner ear structures, called the utricle and saccul, are fully developed and actively detect motion from birth. They can lose their balance, swim erratically, and show signs of severe stress. Fluctuations in ammonia, nitrite, and dissolved oxygen levels compound the physical trauma of the trip, potentially causing severe health issues or even death. To suppress travel sickness and extreme stress, approved sedatives are sometimes used. Baby eels should be transported at temperatures between 15°C and 23°C with high dissolved oxygen. When transporting live eels, it is essential to control the temperature, oxygen and water chemistry to ensure their survival. *(Courtesy of Dr. Brecht)*

Beyond Food and Pharma

"There is some fascinating nontraditional 'cargo' beyond pharmaceuticals and vaccines that are stored and transported under temperature control such as baby eels that can get seasick, live escargot, honeybees, blood plasma, historic artifacts and paintings, Christmas trees, cut flowers, zoo animals like polar bears and pandas, volatile/self-reactive and flammable chemicals and more," notes Dr. Brecht.

Dr. Singh adds other products that require temperature and humidity control during storage extend to antique furniture, cigars, flavors, aroma alcohols, musical instruments, precious art and rare books. "Some items such as wood, paper, and cigars, have to be preserved at low humidity to avoid mold as well as physical deformation (warping)."

Dr. Gabaldon notes the list is longer than most people expect. Her examples of temperature-sensitive products requiring transport

Flammable Chemicals

Transporting temperature-sensitive, self-reactive, and flammable chemicals requires a strict, multi-layered approach to prevent explosions, accidental ignition, or material degradation. Since a single temperature spike or static spark can potentially be catastrophic, safe transit relies on very strict handling protocols and best practices. For self-reactive chemicals, a control temperature of at least 10 C below the Self-Accelerating Decomposition Temperature (SADT) is required. *(Courtesy of Dr. Brecht)*

and storage include fine wine, biological specimens such as organs or tissue samples, seeds, agricultural genetics, certain industrial chemicals, electronic components sensitive to thermal cycling such as composites and adhesives, cosmetics, and personal care products with active biologicals.

"Each has its own temperature, humidity, handling requirements, regulatory oversights, and security concerns, which is part of what makes the temp-sensitive chain such a rich and complex field," says Dr. Gabaldon.

Purpose-Build or Retrofit

Can traditional cold storage warehouses be retrofitted to accommodate non-food temp-controlled products? Yes, but …

"Retrofitting would likely require investment in monitoring systems, qualified personnel, backup power redundancy, controlled-access zones, audit systems, and regulatory compliance protocols," explains Dr. Gabaldon.

For archival documents and fine art, the environmental requirements differ substantially. Dr. Gabaldon points out these are niche but real applications, and purpose-built art storage facilities exist. "A food warehouse retrofit is theoretically possible but would require careful assessment. Temperature is only one factor in these supply chains; humidity control, vibration minimization, lighting exposure, and contamination prevention are equally important."

Refrigerated trailers can maintain exact and uniform temperature tolerances for pharma items when software is used to properly program the trailer's microprocessor.

"The refrigerated trailer must undergo precise empty and loaded validation mapping studies to ensure that there are no hot or cold microenvironments within the cargo. Mapping, validation and empirical studies are systematic evaluations that are used to record and analyze temperature variations throughout a refrigerated trailer's cargo space," notes Dr. Brecht. "These studies ensure that pharmaceuticals and vaccines are uniformly chilled or frozen during the entire trip thereby meeting or exceeding strict regulatory and quality standards."

Regulatory Differences

Transporting temperature-sensitive pharmaceuticals are regulated by multiple agencies. United States Pharmacopeia (USP): USP Chapter 1079 outlines, in part, specific

Feeding Our Best Friends

United States Cold Storage began providing cold storage services for pet food products within the last five years, specifically for a pet food company operating within its network. Since then, the company received several additional inquiries about pet food storage, indicating the growing interest in this segment of the market.

In addition to pet food, US Cold also stores raw materials for manufacturing operations because of its strategic proximity to several manufacturing facilities. It also handles storage for gel packs and related products, which are food-adjacent but not technically food products themselves.

"The business has shown encouraging early growth and market interest since it first brought on these pet food customers," says Natalie Larson, Senior Manager, Customer Experience & Key Accounts at US Cold. "However, because this is still a relatively new category for both our customer and our organization, it is probably too early to definitively label it a major success."

While demand and customer expectations for future growth appear positive, there have also been challenges, including product aging and disposal issues that naturally come with managing frozen and refrigerated inventory. "At this stage, the business is still evolving, and its long-term performance remains somewhat to be determined," Larson says.

In many ways, handling pet food products is very similar to handling human food products because the pet food products are human-grade and held to comparable standards. Larson says the biggest distinction is the potential for increased e-commerce fulfillment and direct-to-consumer shipment opportunities, including sample shipments. She says while USCS is not currently performing those services, they have had discussions around expanding into that area.

"Additionally, because many of the products are meat-based, we also perform blast freezing services," says Larson. "However, blast freezing is already a capability we provide for existing customers, so it was not a completely new operational requirement specifically for pet food.

"We evaluated considerations such as allergen risks, storage compatibility with dairy products like yogurt and ice cream, and the ability to transport pet food alongside other food products. After working through those compliance discussions internally and with customers, we determined that there were no major differences beyond standard food safety and allergen protocols already in place."

No significant facility reconfiguration or additional space was required to support pet food storage operations. During onboarding, US Cold Storage did extensive due diligence to determine whether any physical or operational changes would be needed. In the end, they found existing infrastructure and processes were already well-suited to accommodate the pet food products without major modifications.

Ultimately, these products are human-grade food that is marketed for pets, and the operations, regulations, and storage and transportation requirements closely mirror those of traditional food products.

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Cool Bears

Polar bears can be seriously affected by elevated temperatures during transport. They are extremely prone to overheating (hyperthermia) because they are uniquely adapted to the extreme Arctic cold. The polar bears' bodies are built to trap and retain heat using thick layers of blubber and dense fur. Accordingly, the polar bears are transported in specialized shipping containers in climate-controlled trucks or cargo planes. The transport vehicles are often equipped with redundant refrigeration systems. To prevent overheating the polar bears, the transport environment is precisely maintained between 7.2 C and 15 C with temperatures legally prohibited from exceeding 23.9 C for more than four hours.

(Courtesy of Dr. Brecht)

temperature ranges for storage and shipping such as controlled room temperature/room temperature, refrigerator, cooler and freezer medications.

The U.S. Food and Drug Administration (FDA) regulates the transportation of pharmaceuticals through enforcement of Good Distribution Practices (GDP) and Title 21 of the Code of Federal Regulations (CFR). The FDA's regulatory oversight during transit focuses on temperature control, traceability, security and chain of custody, sanitation, and recordkeeping.

The Drug Supply Chain Security Act (DSCSA) requires tracking and tracing of prescription drugs across the distribution supply chain.

The International Maritime Dangerous Goods (IMDG) Code applies to any pharmaceutical product transported by sea that meets the criteria for classification as a hazardous material or dangerous goods. "Although pharmaceuticals are highly regulated, the points and counterpoints for more regulations and corresponding economic, human safety, and logistical hurdles are hotly deliberated," Dr. Brecht points out.

Dr. Gabaldon's view is that the gap is not in the volume of regulation, but in the consistency of enforcement and the speed of regulatory adaptation to new realities. "For example, the GLP-1 distribution, home delivery of specialty medications, and AI-driven monitoring systems are all outpacing the regulatory frameworks meant to govern them," she says. "I would advocate for smarter, faster-adapting regulation over more regulation, particularly standards that address last-mile accountability and real-time excursion reporting."

A Reconfigured Cold Chain

Dr. Gabaldon believes the cold chain is already reconfigured from the impact of GLP-1 medications. She explains that historically, many pharmaceutical cold chains were designed around seasonality, episodic demand, or specialty demand. The demand trajectory for GLP-1 medications is unlike anything the pharmaceutical cold chain has experienced in terms of volume, velocity, and geographic breadth.

"These aren't specialty medications for small patient populations anymore; they're becoming mass-market products with patient populations in the millions. GLP-1 is introducing sustained, large-scale consumer demand that resembles a hybrid of pharmaceutical and retail distribution. In many ways, it is pushing the cold chain toward becoming more consumer-facing, data-driven, and resilient," Dr. Gabaldon says.

She points out it also strengthens the case for purpose-built last-mile solutions for temperature-sensitive pharmaceuticals, including smart lockers, temperature-controlled delivery vehicles, and pharmacy-to-patient logistics networks.

"From a research perspective, I find this moment fascinating: the human systems dimension, including patient behavior, provider workflows, delivery personnel training, and regulatory compliance culture, will determine whether the technology investments translate into safe, reliable delivery," says Dr. Gabaldon.

Precious Paintings

Historical artifacts and paintings are transported by climate-controlled reefer trailers and containers to maintain museum-grade environments. The reefers are programmed to maintain a desired fine-art standard, which is generally 10 C to 22 C with a percent relative humidity of 50 to 55%. The reefer trailers utilize air-ride suspensions to dramatically reduce the effects of rough roads and various forces on the condition of the valuable artifacts and paintings.

(Courtesy of Dr. Brecht)

ALEXANDRA WALSH is a Senior Publishing Consultant with Association Vision and Editor-in-Chief of *COLD FACTS.*

EMAIL: awalsh@associationvision.com