Can coating complexities

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Out of the frying pan and out of the fire: the indispensable role of exposure science in avoiding risks from replacement chemicals

JUDY S. LAKIND[a] AND LINDA S. BIRNBAUM[b]

Exposure Science Digest

Journal of Exposure Science and Environmental Epidemiology. 2010. 20(2):115-6.

Can coatings for foods and beverages: issues and options

Judy S. LaKind

Outline

Why can foods?

Why coat cans?

What does a food/beverage can and lining have to do?

Framework for comparing coatings

Why can food?

No longer live in world where we rely on local, seasonal foods for year-round consumption: canned foods - integral part of international food supply

Need form of packaging that:

- maintains food quality and safety (durable; keep out insects or other substances that can cause food spoilage; protect against food changes due to exposure to light)

- Cost-effective (tin-plated steel or aluminum cans) (high speed of production - relatively small facility can produce 2–3 million cans per day – 1800 cans per minute (Discovery Channel https://www.youtube.com/watch?v=V4TVDSWuR5E)

- Lightweight: conserve materials and energy required for shipping while maintaining structural integrity

- Interchangeable to meet needs of multiple food manufacturers (universality)

- provide food security, i.e. because of long shelf life, one bad crop year does not equal food shortages

Why coat cans?

Not all cans have an organic coating – depends on food/beverage

STEEL:
light-colored fruits and fruit juices: tin coating only; oxidation of tin helps prevent fruit darkening and flavor changes during storage

Other foods/beverages:

contact with tin → tin corrosion → food contact with underlying steel → food attacks steel → pitting corrosion → hydrogen production → can swelling → potential can damage

ALUMINUM:

Contact with air/water → form thin Al_2O_3 film → low/high pH/high NaCl increases film solubility → corrosion of the aluminum

What does a food/beverage coating have to do?

Coatings protect can integrity

Coating function: ensure that food/beverage does not corrode the metal, allowing for entry of microbes – even under harsh conditions

Consumer expectation of long shelf life: coatings formulated to protect against microbial food sickness for years

Tough enough to protect can's integrity if bent or dinged

Survive can manufacture and ambient and food processing conditions (e.g. physical handling, temperature changes) without degradation or peeling off the metal substrate

Coatings protect food taste and odor

Food/beverage and can metal interaction: alter product’s taste - unpalatable to the consumer

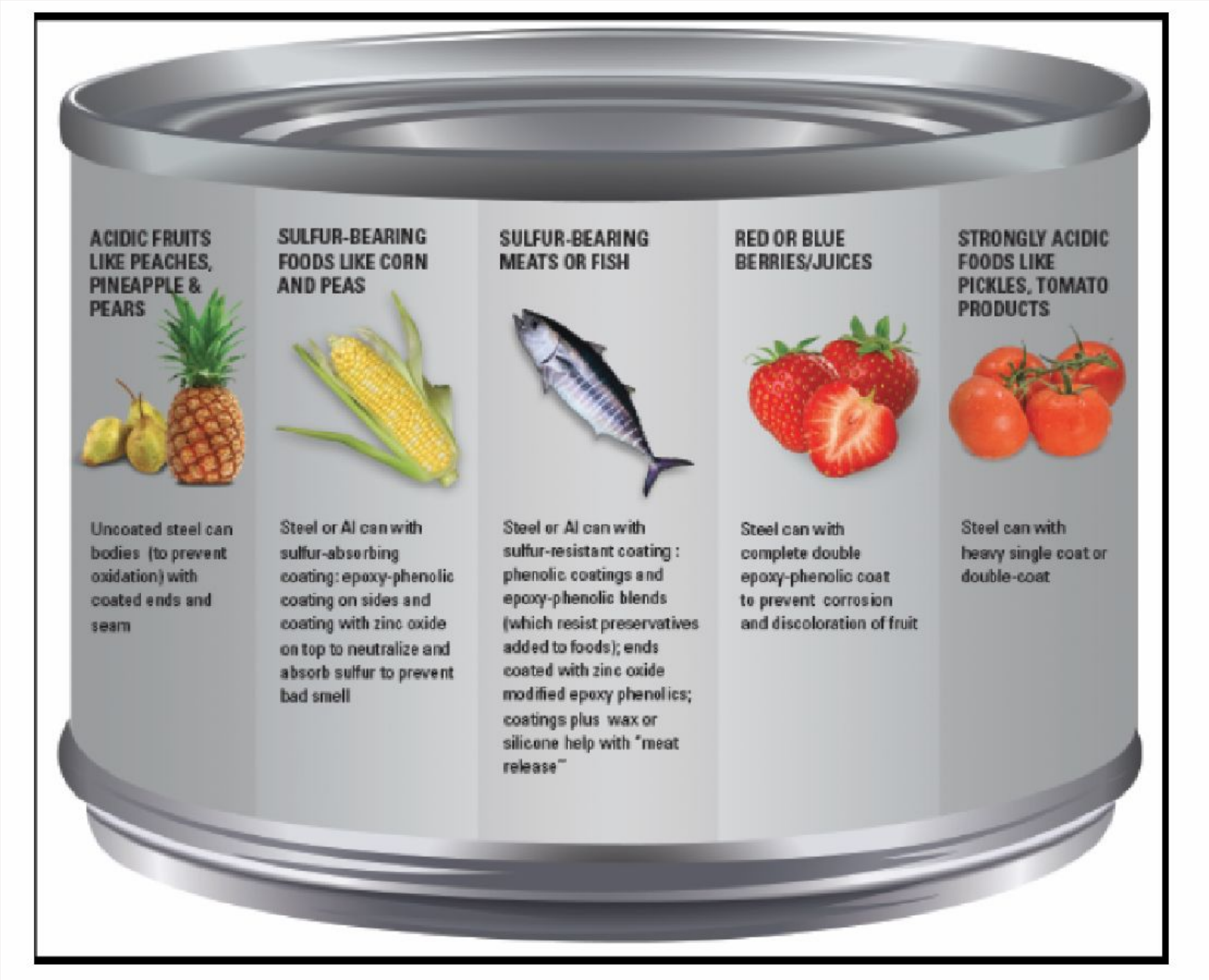
Organoleptic issues may seem secondary, off-flavors can give consumer a sense of feeling sick

Coatings and food appearance

Coatings improve visual appearance of can and product

Coatings prevent interaction between sulfur compounds in foods and beverages (from proteins, preservatives or pesticide residues) and metal substrate, leading to formation of iron sulfide or tin sulfide staining, which is objectionable to consumers

Aluminum beer can coatings protect beer from low levels of Al that produce unacceptable cloudiness



Ideally, a process or formulation change made to enhance one of these features should not adversely impact another.

Framework for comparing coatings

USEPA Design for the Environment: process for evaluating chemical alternatives

maintain desired functionality
minimize likelihood of unintended negative consequences

Technological feasibility

Consumer acceptance

Toxicity: Coating should have minimal environmental and health impact

Discuss later today

Technological feasibility

Corrosion resistance:

Each food/beverage has an inherent intensity and type of corrosiveness, as do processing and storage environments.

Pack tests:
coated cans filled with product
kept for time equal to and exceeding expected shelf life of product (can exceed 2 years)
successive cans are opened and examined for: coating removal, presence of corrosion, changes in appearance and flavor of food or beverage, changes in appearance to can such as staining.

Abuse test:
coated can filled with aggressive product, sealed, damaged near the seam and then exposed to a bath of water containing pathogens; if coating is not sufficiently durable, pathogens will enter the can and cause can to blow.

Aggressive: celery, rhubarb, tomato concentrate
Low-aggressive: apricots, beans

Technological feasibility

Fabrication: mechanical process of can formation

Metal is subjected to stresses

- Alteration of cylindrical can shape (e.g. flanging for attachment of can ends)
- Neck of cylinder is thinned to decrease the size of the lid and can headspace
- Additional deformations required to finish can production

Coating must be flexible and tough: ability of coating to be bent or flexed and to withstand large stress forces without flaking, cracking, shattering, tearing, losing adhesion, or failing in some other manner

Technological feasibility

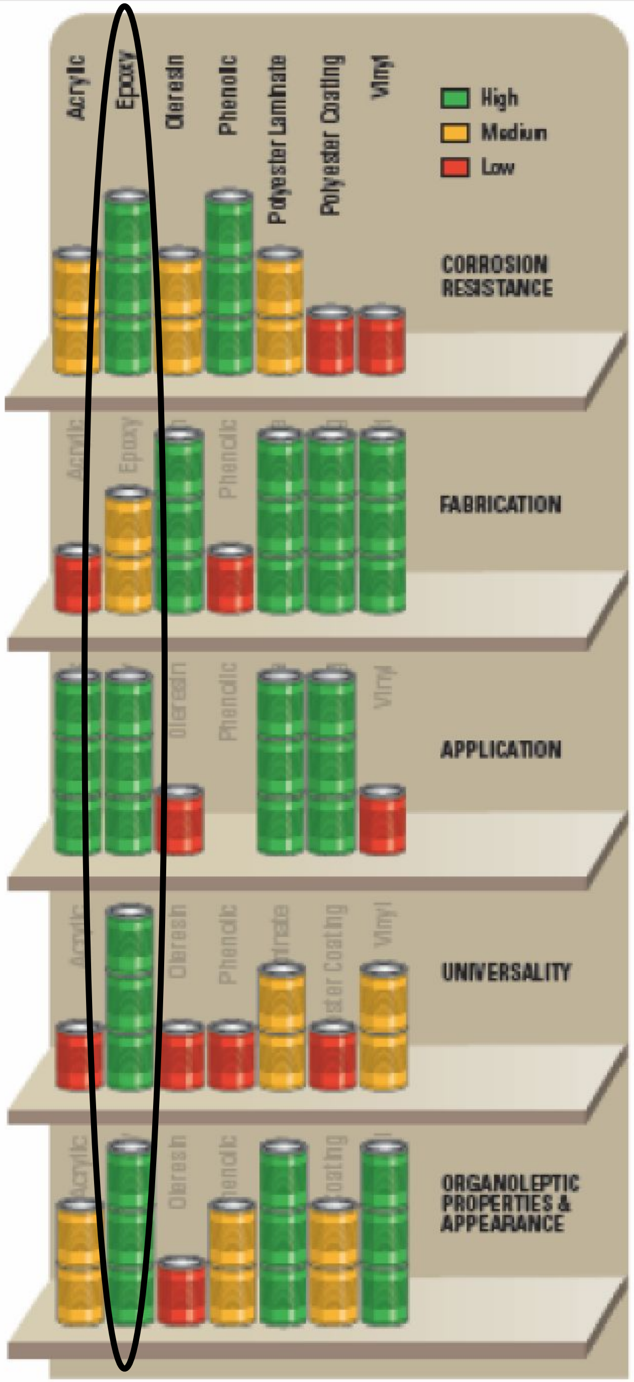
Application: easy to use and adheres strongly to the metal substrate

Otherwise, coating can lift off can interior causing reactions between the food/beverage and the metal, leading to can failure.

Universality: A resin that functions well with a wide range of food and beverage types

Foods and beverages have wide range of chemical characteristics that influence their corrosivity and contain many compounds that accelerate corrosion
(e.g. O_2, anthocyanin pigments, synthetic coloring, nitrates, sulfur compounds, trimethylamines).

Economically advantageous to manufacture a multi-purpose can type appropriate for as many foods and beverages as possible



Epoxy:

most widely used polymers for coating Al and steel cans (~95% of food contact can coatings)

Corrosion resistance: strong and flexible and excellent chemical resistance

Fabrication: good mechanical properties but when used alone (i.e. unblended) they fail during fabrication of drawn-and-redrawn two-piece food cans

Application: adhere well to metal substrates

Universality: compatible with more food and beverage types than other currently available resins

Organoleptic/appearance: do not impart flavor to foods; retain their appearance

Summary

For almost all foods and beverages, uncoated cans are not an option

Each new food/beverage/coating/processing combination must be tested:
- can it withstand fabrication and processing?
- what are failure mechanisms?
- will it have desired shelf life to maintain product quality, nutritional value and flavor?

How much lead-time time is needed?
- development of a new coating can take 1–3 years
- testing period takes 2–3 years
- commercialization: up to 2 years (need to adapt can-making technology to fit with new resins)

Summary

Given complexity and length of time required to develop and test new coating formulations that possess the necessary characteristics, need a consistent, systematic and lasting approach towards evaluation of can coating options

Need to ask whether alternatives:

- commercially available
- technologically feasible
- same or better value in cost and performance
- have an improved health and environmental profile
- have the potential for lasting change (i.e. alternative not likely to be targeted for restrictions shortly after its selection)