Understanding the Science of Your Brew

AND ITS IMPACT ON FLAVOR QUALITY & PACKAGING

sponsored by ThermoFisher SCIENTIFIC
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Understanding the Science of Your Brew and Its Impact on Flavor Quality and Packaging

Glen Fox

Anheuser-Busch Endowed Professor Malting & Brewing Science
Quality!

- What is your definition of quality?
- What is your quality control program?
- All in-house?
- Outsource some validation testing?
Do you really understand the science of brewing and its impact on flavor quality and packaging?

- Raw materials (4 at least)
  - Malt quality (grain quality)
  - Hop quality
  - Yeast quality
  - Water quality

All contribute to flavor but how many flavor compounds in finished beer?
Malt

- Malt Certificate of Analysis
  - Moisture
  - Extract (soluble material: It than just sugars!)
  - FAN (amino acids but not proline!)
  - Color (always lighter than in the brewhouse)
  - Diastatic power (enzyme to produce fermentable sugars)
  - ?
  - ?
Composition of barley

- Starch (60%)
- Protein (12%)
- Non-starch polysaccharides (5%)
- Phenols and polyphenols (2%)
- Lipids (2%)
- Vitamins (<1%)
- Minerals (<1%)
- Other (?)

What’s modified during malting?

Participants or passengers?

Where does the flavor come from?
Some basic perceptions about malt

- Color
- Flavor
- Aroma
- Sugars
- Amino acids
- Proteins for foam
- ?

Any risky compounds?
Malt flavor

- How many flavor compounds?
- Maillard reactions (amino acids and sugars)
  - Maybe 400 Maillard compounds
- Strecker compounds (aldehydes)
  - Risks with flavor instability
Understanding the Science ……. 

Hops

- Bitterness (alpha acids)
- Aroma (? compounds)
- Proteins (yes, hop cones have proteins)
- Amino acids (yes, hop cones contribute amino acids)
- Phenols and polyphenols (yes similar chemicals to barley)
- Starch and sugars
Flavor and aromas

• How many compounds?
• Sensorial assessment
• Changes in hop processing
• Changes during brewing
Yeast

- Alcohol
- CO$_2$
- Flavor compounds
- Aroma compounds
- Proteins in finished beer
<table>
<thead>
<tr>
<th>Basic Testing</th>
<th>Additional Testing</th>
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<tbody>
<tr>
<td>• Gravity</td>
<td>• IBU</td>
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<tr>
<td>• ABV</td>
<td>• Total polyphenols</td>
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<tr>
<td>• pH</td>
<td>• Amino acids</td>
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<td>• Color</td>
<td>• Non-fermentable sugars</td>
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<td>• DO</td>
<td>• Micro?</td>
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<td>• Titratable acidity</td>
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Understanding the Science ……..

When to test

Prepackaging vs post packaging

• Will flavor change in the package?
• What is changing?
• Quality
Understanding the Science .......

Validation

- Confirmation of your theoretical calculations
- Testing non-typical traits
- Pre-empting issues
- Spending $100s even month or so, could save $1000s in the long run
Beer in Cans? Quality Control Issues & Considerations

BA Seminar: 2022

Gary Speedding, Ph.D. BDAS, LLC.

Understanding the science of your brew and its impact on flavor quality and packaging.
Overview

In 1991 a paper appeared dealing with can issues, metal content and flavor during storage of Lager Beer.

Little has been presented directly on the topic for brewers since.
That Lager Paper?


Exptl:

Lager > Glass Bottles, Steel and Al. Cans.

Fe, Al tested 0,1,3,4,6,9, & 12 mo.

All canned samples >> increases in **cabbage notes**/decreases in fruity, buttery & aromatic attributes. Bottles no similar trending.

Iron content < 0.03 mg/L (detection limit) in all packages up to 3 mo.

From 4 mo., on, **iron content** in 2 batches **steel cans** varied markedly from can-to-can – & average increases to 1.43 mg/L after 12 mo. storage.

**Aluminum levels in bottles & both types of can** (Iron & Al) **stayed below detection** levels of 0.1 mg/L.
Types of liner (epoxy shields) and integrity studies. The amount of metal exposed per metal can was determined.

Only flavor was really considered in such work.

Individuals sensitive to metallic notes might find objectionable lagers in steel cans stored over a length time (with steel cans with steel or Al ends).

Oxygen and staling factors were considered.

So, it would seem Al cans might be better for flavor/overall product stability – BUT are they?

LET’S MOVE ON THIRTY YEARS…
AND NOW

Miami Herald

Coors, Keystone beers 'voluntarily withdrawn' (recalled). 'Gelatinous' consistency noted

BY CHARLES NEAL
UPDATED: June 19, 2022 4:15 AM

Have you got a handle on the can? Can you survive a recall?

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A move to AI cans and New Liners

Cutting to the chase:

Little work done on newer types of beverage – e.g., sour beers in cans done.

Brewers got comfortable with brewing trad. style beers and putting them in cans – Mainly!

Sure, some haze, gushing/over-foaming issues were seen, but few complaints.

Today – Poor end cap seals, buckled ends, pin-prick leaks, exploding/exploded cans, severe gushing, product color changes, sulfury aromas/flavors, can liner degradation – chunks in the beer – yummy!

& more.

SO, WHAT GIVES?
Industry issues

Lack of QC.

We never had issues before, so we are OK.

But can liner changes and the chemistry of the products that are going into the cans.

No one doing forced testing – either in house (Simple tests) or the Can manufacturers – No longer their issue?

SO, POSING Q’s.
So, will it eat me?

Run QC tests to see if chunks of liner break off. We see great chunks of plastic-like/"cellophane-like" or gelatinous matter in canned beers from time to time.

Store beers cold/warm vs. controls and see what happened to beer upon pouring, and then slice the can open and look inside.

Sediments, hazes, floc, matter in the base, pin-prick leaks, odd sulfur notes, gushing beers, flavor issues?

What could these be due to?

No QC guides really exist for this – Secrets of the Can manufacturers?
SO, BEFORE YOU HEAD TO THE CAN

QC Checks follow…
TO CAN OR NOT TO CAN? THAT IS THE QUESTION

Does it GO WELL in a CAN?

No

DO YOU KNOW OR GUESS IT WILL?

No

ARE YOU REALLY SURE?

No

Test Novel Products Before Committing To The Can

Yes

Pin Prick Leaks Gushing Beer Exploding Cans We See it More and More!

Yes

Just because your traditional products have done OK does not mean novel products will. GET THE FACTS!

No

Can liner changes /defects and formulation changes to products are a potentially risky business these days.

No PROBLEM

No PROBLEM

No

WILL YOU RISK IT?

Yes

MAYBE

No safely packaged cans were harmed during the making of this note - only actual problem cases that exploded in our lab or show pin prick leaks are illustrated as culprits here.

www.bddtesting.com - Lexington KY & Denver CO Identities of products are hidden to protect the guilty. © 2021 Gary Spedding, BDAS, LLC & BDES

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Factors follow in this discussion

Then Act Accordingly

Pose Questions
To Can or to CAN NOT!? What can go Wrong?

Some physicochemistry of Al can corrosion.

The Spirit or beer beverage

Liner Coating Oxide Layer Forms the electrical Cathode

Aluminum alloy

Eventually - possible pin-prick leak!
Galvanic Corrosion – A Battery in a Can & Assault & Battery in a Can!

Some physiology of Al can corrosion.

The Spirit or beer beverage

Liner Coating
Oxide Layer forms the electrical Cathode

Aluminum alloy

An oxide film – combination of aluminum with oxygen Al₂O₃ & Al₂O₃·H₂O on material surfaces, is unstable in solutions with pH < 4.5. Accelerated corruptions occur with Cl⁻ & Cu²⁺ ions, O₂ and sanitizer residues. Certain preservatives are an issue too - Sodium benzoate is bad! #40 is pretty bad also.

As of 2012 we still do not know a lot about newer can/liner/product interactions. We still have a long way to go. The Covid year(s) have not aided us much in this respect.

Pin prick leaks can be hidden or "blocked" by an outer can sleeve but still leak in trade or in transit to a lab.

https://www.wired.com/2015/03/secret-life-aluminum-can-true-modern-marvel/

"Some beverages are so corrosive that no amount of coating will protect their cans. (Roughly one in seven new energy drinks are too corrosive to put in cans)."

The electrolysis - think battery - at the copper/aluminum interface corrodes the surface and can lead to the pin-prick leaks seen in many modern beverage products.

Galvanic corrosion may occur when dissimilar metals are in contact with each other and an electrolyte (beverage?) is present. For aluminum, which is a reactive metal in the galvanic series, this is the most common cause of corrosion (Galvanic: relating to or involving electric currents produced by chemical action). When aluminum comes into contact with a more cathodic material it acts as a sacrificial anode and becomes susceptible to corrosion.

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Galvanic Corrosion: The Factors

The rate of metal corrosion depends on the dissolved oxygen concentration, pH and salts, ions and molecules present, plus temperature (pigments & several species of metallic ions and sanitizer residues can be problematic).

Big Concerns:
- pH
- Acidity (Acidic Species)
- Chloride
- Copper

Galvanic corrosion may occur when dissimilar metals are in contact with each other and an electrolyte (beverage) is present. For aluminum, which is a reactive metal in the galvanic series, this is the most common cause of corrosion.

When aluminum comes into contact with a more cathodic material it acts as a sacrificial anode and becomes susceptible to corrosion.

Cl⁻
The very aggressive chloride ion is most responsible for pitting corrosion.

The small ions pass through small defects in the can liner/vernish and initiate and lead to growth of corrosion pits in aluminum alloys.

The new bisphenol (BPA) free liners or varnishes for cans have still not be adequately tested with novel or even traditional beverages in the opinion of this author. All types will have imperfections and spots where ions can start corrosion.
Summary I

STEEL or ALUMINUM CAN PROBLEMS

It is the combination of factors that makes things worse - so diligence and complete formula understanding is important, and testing cans/liners with new beverages is a MUST!

CAN LINERS

At BDAS, LLC we have been approached by several clients complaining of can liner failure. In these cases chunks of liner material break loose and many are quite notable - visually unappealing, and certainly detectable as they slip down a throat - like a piece of thin plastic film or gel. Some are notable only microscopically or as tiny specks noted upon cutting open a can and looking for tiny flecks of matter.
Chloride damage

Some reasons why your product might just not belong in a can

Schematic as to what kinds of damage may occur in Al Cans

Liner flecks another issue: some microscopic, some noted upon swallowing!

Copper ion damage

Conditions leading to damage:
- Copper Ions
- Chloride ions
- pH
- Acidity
- Type of Acid
- Oxygen level
- Carbonation

Acid-base catalysis? Oxidation and reduction metal ion catalysis & oxidation!

The Spill or beer beverage

Cite acid + H₂O → release of 1 highly acidic hydrogen ion:

\[ C_6H_5O_3^{-} + H_2O \rightarrow C_6H_5O_2^{-} + H_3O^+ \] (1)

\[ C_2H_3O_2^{-} + H_2O \rightarrow C_2H_3O_2^{-} + HOH^+ \] (2)

\[ C_6H_5CO_2^{-} + H_2O \rightarrow C_6H_5CO_2^{-} + HOH^+ \] (3)

https://www.csc.org/questions/what-is-the-equilibrium-constant-of-acetic-acid

Could flecks of liner or fruit pulp pose an issue for gushing?

See Dr. Fox’s Section for details on haze & gushing factors

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Characterization of Carbonated Beverages Associated to Corrosion of Aluminium Packaging

By Beatriz Maria Curtio Soares, 1,2* Carlos Alberto Rodrigues Anjos, 2 Taiane Bonfante Faria 1 and Silvia Tondella Dantas 1

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2 University of Campinas (UNICAMP), School of Food Engineering (FEA), Department of Food Technology (DTA), Rua Monteiro Lobato, 80 – Barão Geraldo, CEP 13083-902, Campinas, São Paulo, Brazil

The objectives of this study were to evaluate the characteristics of commercial soft drinks related to the corrosion process of the aluminium packaging and based on that, propose model solutions for future studies of beverage/package interaction and corrosion process of metal packages. Therefore, the pH, acidity, concentration of chlorides and copper in six types of soft drinks were determined, as well as the corrosion potential of the aluminium and the current density corrosion obtained in polarization curves using the beverages as electrolyte. Based on the results obtained, a solution of citric acid (pH = 3) containing chloride (250 mg/kg) and copper ions (250 µg/kg) is proposed. The obtained results are potentially useful for the industry and future studies regarding the interaction process between soft drinks and aluminium cans. Copyright © 2016 John Wiley & Sons, Ltd.
KEY PAPERS TO LOOK AT FOR THIS TOPIC - 2

Corrosion Resistance of Aluminum Beer Cans Containing Hand Sanitizer

Euan L. Thomson* and Andrew R. Bullied

*Rift Beer Labs, Calgary, Alberta, Canada; †Annex Ale Project, Calgary, Alberta, Canada

ABSTRACT

The COVID-19 crisis and ensuing supply chain disruptions prompted many breweries and distilleries to repurpose their facilities for the production of hand sanitizer, with the vast majority following the World Health Organization formulation (80% v/v ethanol, 1.45% v/v glycerol and 0.125% v/v hydrogen peroxide). The long term shift from bottling to canning among craft brewers left canning as the sole scalable option for many facilities to package hand sanitizer. With essential services desperate for hand sanitizer to help protect their staff, patients, and clients, many breweries moved to package these products in cans despite warnings that they are not designed to hold solutions containing high ethanol concentrations or strong oxidizers. The present study explores the resistance of ubiquitous can liners WB Modified Epoxy and BPANI Gen 2 to WHO formulated hand sanitizer. Shelf life observations and microscopic visualization show the WB Modified Epoxy liner withstands hand sanitizer with little observable disruption at room temperature, while BPANI Gen 2 liners permit package failure and liquid leakage within 30 days. Incubation at 37°C accelerated the rate of failure such that BPANI Gen 2 lined cans versus room temperature incubation, providing a basis by which to expect an approximately 72 day shelf life for WB Modified Epoxy lined cans. Because of the inherent risk to consumers presented by these data and despite lack of clear guidance from regulatory agencies, manufacturers should strive to cease packaging hand sanitizer in cans and instead find supplies of inert non-beverage containers.

NEW CAN LINERS WILL THEY STAND UP?

SEAMS SEALED?

EXPLODING CANS at THE BAR!!
STUDIES & METHODS TO LOOK AT THE ISSUES

As originally published in the SMTA Proceedings.

THE STUDY OF CORROSION BEHAVIOUR OF CU IN SOME COMMERCIAL BEVERAGES BY CHEMICAL AND ELECTROCHEMICAL MEASUREMENT

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Department of Chemical Engineering, University of Waterloo²
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ABSTRACT:
The corrosion behaviour of pure copper in 16 selected commercial beverages was studied. Experiments were also conducted in the presence of citric and phosphoric acids to investigate their role in the corrosion process in these beverages. Two experimental approaches were used to investigate the corrosion behavior: a chemical method in which the dissolved metal concentration was measured after immersion of a sample in a beverage and an electrochemical method using the Tafel extrapolation technique. The metal in the electronics industry. A typical PCB consists of a copper connection path integrated in a fiberglass reinforced epoxy polymer.

In the electronics industry, one of the most common reasons for failure of devices is metal corrosion. Numerous research reports related to metal corrosion behaviour have been published [1]. Metal corrosion is usually a very complex phenomenon. Different types of corrosion can occur simultaneously in the same media and under the same environmental conditions. Corrosion is affected by many factors that are related to the environment and to the metal.
STUDIES & METHODS TO LOOK AT THE ISSUES

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STUDY ON THE INTERACTION BETWEEN
THE FOOD MATRIX AND THE METAL FOOD CANS

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Abstract

The metal cans are used to preserve food and beverages for long periods of time, proving to be one of the most versatile packaging materials nowadays. Some of their vital functionalities are represented by ensuring that foods are not contaminated, providing physical protection and extending the shelf life of it.

Metal cans are protected on the inside by a thin coating layer, which can be affected by stroke. Thus, the canned food or beverage comes in direct contact with packaging metal. The coating is an epoxy lacquer that separates the liquid from the packaging material. Normally, the metal cans are affected by corrosion (primary, secondary or stress corrosion). However, there are several factors which can accelerate the corrosion processes.

Lacquered cans are a best practice solution – however they are still susceptible to residual chemical migration from the product or beverage.

90% of damaged cans, scratched or dented were found to have lost their lacquer integrity to some extent.

Shows us more studies needed!
Canny QC In-house? Or Third Party?

Examine inside cans for liner damage and major issues with the metal.

Electron microscopy might be needed – Third Party Lab.

Metal surface – examination. A specialist lab exists in Lexington

Look for hazes, sediments, mold, Fruit pulp and carbonation can be a bad thing.

Liner intact – small holes/tears?

Copper, chlorides, certain acids problematic.

Force test beverages with new products. Get can manufacturer to test YOUR product for stability.
END

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www.bdastesting.com
THANKS!