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A STUDY OF ALCOHOL LEVELS IN KOMBUCHA PRODUCTS IN BRITISH COLUMBIA

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Dr. Paula Brown and Dr. Michael Chan at the British Columbia Institute of Technology (BCIT) conducted ethanol testing at their facility in Burnaby, BC. Funding for testing at BCIT's Natural Health and Food Products Research Group (NRG) was provided through the Natural Sciences and Engineering Research Canada (NSERC) Research Chairs Program.

BCIT's Natural Health and Food Products Research Group (NRG) addresses issues of product quality, process improvement and human health using basic and applied science along with state of the art technology. NRG's goal is to ensure that all Canadians can achieve the potential health and economic benefits offered by medicinal plants, natural health products and the food industry.

Purchase of kombucha samples, supplies and additional testing conducted at the BC Centre for Disease Control (BCCDC) was funded by the BCCDC Foundation for Public Health with matching monetary support from the Liquor and Cannabis Regulation Branch.

BCCDC gratefully acknowledges participation from staff at the regional health authorities for this project. Environmental Health Officers visited and submitted samples from retail locations, restaurants, farmers markets and processors throughout BC.

BCCDC also partnered with the University of British Columbia Faculty of Land and Food Systems. We appreciate the work of Sally Chen who conducted her industry practicum at BCCDC to further the work in this project. We also acknowledge the support of her academic supervisor (Mira Laza), and reduced costs for organic acid analyses in the Mass Spectrometry Laboratory at the Wine Research Centre (Lufiani L. Madilao and Vivien Measday).

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EXECUTIVE SUMMARY

Kombucha is a mildly sweet and acidic beverage considered to be a healthy alternative to sugary soda drinks. However, kombucha may contain residual alcohol from the multi-step fermentation process that converts sugar to alcohol. People at greatest risk from low levels of alcohol consumption include: young children, people who are pregnant and their developing babies, those with underlying medical conditions or those taking prescription medications that should not be mixed with alcohol, those who wish to avoid all alcohol for personal or religious beliefs, those with occupational concerns such as drivers, and those with alcohol use disorder.

The purpose of this study was to determine if kombucha available for sale to the public in British Columbia contained levels of alcohol that could cause harm. This is a concern because kombucha that is manufactured and sold as a non-alcoholic beverage is not restricted for purchase as are alcoholic beverages which are only available in liquor stores and other licensed establishments. Kombucha is not labelled nor well known to consumers as potentially containing alcohol. In addition, when kombucha is sold as a raw, living, and unpasteurized beverage there is concern that alcohol may increase over its shelf-life or as a result of temperature abuse. There is currently no information about alcohol levels in kombucha products sold in BC. Other jurisdictions including the US, Australia, and New Zealand have found elevated alcohol in retail products exceeding regulatory values; peer-reviewed publications describe alcohol values in retail products typically ranging from 0.1 to 2% Alcohol By Volume (ABV) with some samples above 3% ABV.

Kombucha alcohol (ethanol) levels were assessed for compliance with BC regulations that define a beverage as liquor (alcoholic) when it contains greater than 1% ABV. Alcohol (or ethanol) levels were detected by headspace gas chromatography mass spectroscopy (HS-GCMS) at the BCIT Natural Health Products Laboratory. This method is extremely sensitive in detecting low levels of alcohol with a detection limit of 0.0002%. In total, 684 samples representing 53 processors were collected during 142 separate visits to a variety of retail, restaurant, processor, farmers' markets, and other BC locations. A broad range of brands and varieties were selected as representative of kombucha products available to consumers at these purchase points, however this may not have included all brands produced or sold in BC. Temperatures of kombucha products at these locations were taken and products were examined for labelling information.

Overall, 31.5% of kombucha samples exceeded BC regulations (i.e., contained levels of alcohol above the regulatory limit of 1% ABV). The highest level was found in BC restaurant kombucha (3.62% ABV). Over 70% of BC processors were identified as having a potential or definite problem with controlling alcohol in their products.[1] In comparison, 33% of kombucha imported into BC from other countries and provinces had potential or definite problems. Precautionary labels about alcohol were found for 54% of brands but often labels were in very small print; three brands displayed statements advising to avoid alcohol during pregnancy with only one including children in the warning. Illegible or unreadable best before dates were found in 5% of products sampled with place of business for the manufacturer poorly described. While 92% of products did advise to keep kombucha refrigerated no product labels explained that it was important to do this to avoid increases in alcohol content; one product advised that contents were under pressure and that the bottle may break if unrefrigerated.

Consumers have a right to know which products have alcohol in them, how much alcohol is present, and what practices may later increase alcohol content. BCCDC recommends that kombucha processors label actual alcohol content and ensure that alcohol content does not increase during a product's shelf-life or during mishandling. Kombucha processors should monitor alcohol in their products and address this hazard as a health concern. BCCDC further recommends that federal authorities require precautionary labelling on products that can contain alcohol to allow consumers to make an informed choice.

[1] A potential problem was defined as a processor who sometimes (in less than 20% of samples tested) had alcohol over 1% ABV in their kombucha and a definite problem was defined as a processor who often (greater than 20% of samples tested) had alcohol over 1% in their kombucha.

PURPOSE

Kombucha beverages may contain residual, low levels of alcohol from the multi-step fermentation process that converts sugar to alcohol (ethanol) and alcohol to acetic acid (vinegar). Live yeast cultures present in some kombucha may allow fermentation to continue after bottling which can lead to increases in alcohol content. Yet, kombucha is marketed as non-alcoholic and may not be recognized by the general population as a beverage that may contain alcohol. Reported values in the literature found alcohol levels in kombucha ranging from less than 0.1% to greater than 2% alcohol-by-volume (ABV), with rare values approaching 5% ABV.[1-3] Although alcohol levels may be low and an unintentional by-product of incomplete fermentation, these levels are potentially harmful to at-risk or vulnerable groups, including young children and exposed fetuses. Individuals who need or wish to avoid alcohol for personal reasons (e.g., addition issues), religious beliefs, medical reasons (e.g., interference with prescription medications), or occupation may also be unaware that these products can contain alcohol. The purpose of this study was to investigate the levels of alcohol in kombucha products in BC and assess the risk to BC consumers.

INTRODUCTION

Kombucha tea is a mildly sweet and acidic beverage that is considered by some to be a healthy alternative to sugary soda drinks.[4,5] Kombucha originated from East Asia in 220 B.C, and is believed to have been consumed in Manchuria, Northeast China during the Tsin Dynasty.[6] Six hundred years later in 414 A.D. the tea was used to treat Japanese Emperor Inkyo by a physician named Kombu. The beverage was later introduced into Russia and Europe and has further expanded world-wide in the last 100 years.[6,7] Kombucha beverages are prepared by fermenting sweetened black or green tea with a culture mixture of acetic acid bacteria, lactic acid bacteria, other bacterial groups and yeasts. This culture is referred to as a tea fungus or mushroom because of its appearance, as a 'mother' for its ability to reproduce, and as a symbiotic culture of bacteria and yeast (or SCOBY) by brewers. During fermentation, a white microbial mat of culture, also described as a pellicle or biofilm, forms and floats on top of the fermenting beverage. In Figure 1 below, a SCOBY mat is shown growing in the fermenting tea (left in box A, photo by Adam DeTour), and yeasts and bacteria are shown separating from the mat (right in box B, photo by Benjamin Wolfe, 2015).[8]

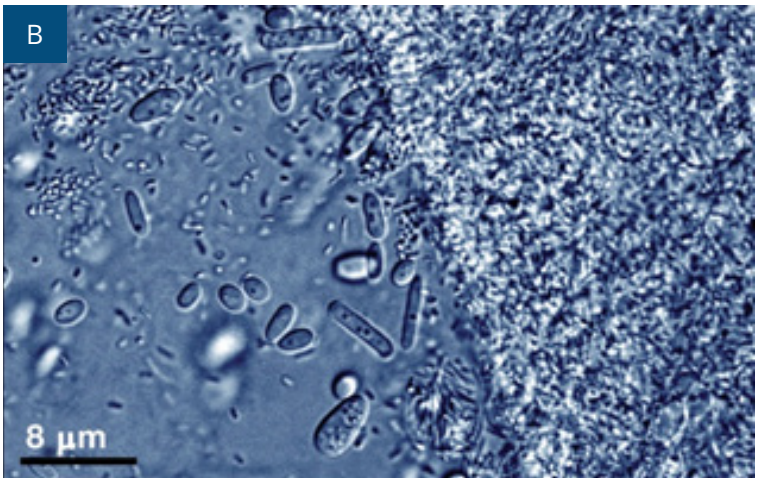


Figure 1. Kombucha tea fungus

The fermentation process for the sweetened tea mixture involves conversion of sugars into ethanol, followed by conversion of ethanol into acetic acid (vinegar) as shown in Figure 2 (adapted from Villarreal-Soto *et al*, 2018).[9] Sucrose (sugar) is metabolized by yeasts into glucose and fructose. Yeasts and bacteria covert these sugars into ethanol, gluconic and acetic acids, carbon dioxide, and water. At the end of a typical 10 to 14 day fermentation period the tea will be converted into a slightly sour, carbonated beverage with alcohol levels less than 1%.[9,10]

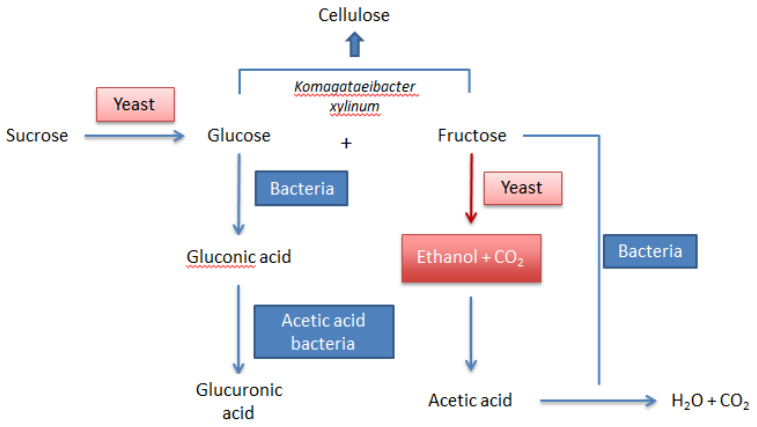


Figure 2. Pathways of kombucha tea fermentation (adapted from Villarreal-Soto et al, 2018)[9]

Kombucha tea is a live fermented product with bacteria and yeasts actively growing in the culture. It is probiotic, a functional food, and contains organic acids, B vitamins, vitamin C, antioxidants, and trace minerals.[9,11] It is often sold as a raw and living product although some brands are pasteurized. Kombucha may be consumed by people seeking health benefits, such as the protective effects arising from polyphenols that limit cancer, although no health claims of human benefit associated with kombucha have undergone rigorous examination.[7,11]

Kombucha beverages have become increasingly popular with consumers. According to market research companies, kombucha has been dominating the fermented beverage market since 2016, with global market values of kombucha estimated between 1.2 and 1.5 billion USD in 2018.[12,13] They predict double-digit growth rates in this food category as customers are increasingly choosing healthy functional foods containing probiotics.[13] Markets are expected to continue to expand in the double digits with expected global sales of $3.5 billion USD by 2025.[12]

LICENSING AND REGULATION

In BC, the *Liquor Control and Licensing Act* defines liquor as any product intended for human consumption that contains more than 1% alcohol by volume (ABV).[14] The Government of Canada defines alcoholic beverages in Division 2 of the Food and Drug Regulations as beverages containing 1.1% or more ABV.[15] The amount of alcohol that defines an alcoholic beverage varies between countries. In the United States, non-alcoholic beverages are required to have ABVs of less than 0.5% and must remain so after sale; in Australia and New Zealand beverages are required to have an ABV of less than or equal to 1.15%, and in the European Union and many other countries beverages are required to have an ABV of less than or equal to 1.2%.[16]

In BC and Canada, multiple governing agencies are tasked with overseeing and regulating the beverage industry as well as ensuring the safety of consumer products. The manufacture, distribution, sale and service of alcoholic and non-alcoholic beverages in BC, as for all food produced in food premises in BC, are regulated for food safety under the *Public Health Act's* Food Premises Regulation.[17,18] Non-alcoholic beverages manufactured and sold within the province of BC, such as kombucha, are inspected and permitted by the regional health authorities. Liquor in BC, along with being regulated for safety under the Food Premises Regulation, is also regulated under the Attorney General's *Liquor Control and Licensing Act* and the *Liquor Distribution Act* by the Liquor and Cannabis Regulation Branch (LCRB) and the Liquor Distribution Branch (LDB). The LCRB regulates the manufacturing of liquor in BC by way of a required manufacturing licence and also regulates the sale and service of liquor by way of a required licence for any establishment that sells or serves liquor. The LDB regulates the importation of liquor into the province and regulates what liquor products can be legally sold in BC and how they are distributed. Products manufactured outside of the province or outside of the country and sold in BC are overseen by the Canadian Food Inspection Agency (CFIA) through the *Safe Food for Canadians Act* and Regulations.[19,20] National policies on alcohol content and labelling practices are set by Health Canada and enforced by the CFIA.

ALCOHOL CONTENT AND TESTING

Specific guidance on the manufacture of fermented kombucha tea can be found in several documents,[5,10] including a food issue note posted by the BC Centre for Disease Control in 2015.[21] Ethanol as a chemical hazard can arise in several ways, including: when active yeasts and sugars are present; when there is incomplete fermentation of residual sugars and ethanol; when flavoring agents containing sugars are added to the tea following the fermentation stage; when no preservatives are added to the product to prohibit yeast activity; and when there is an absence of pasteurization of the final fermented product allowing yeast survival. General guidance to avoid over-production of alcohol is to ensure refrigeration and bottling of the finished fermented tea, to limit yeast activity by pasteurization of the product, by adding inhibitors such as sodium benzoate or potassium sorbate before bottling, and for industry to monitor ethanol content periodically to ensure their product meets regulatory requirements.[5,10,21] The kombucha industry has recognized alcohol formation from continued fermentation in the bottle as an issue.[1] Yet, very few published reports of alcohol levels in kombucha tea have been published. Results from a recent method validation study conducted in Burnaby, BC at the British Columbia Institute of Technology in 2017 found five of six samples (83%) above 1% ABV, with ABV values exceeding 2% in two fruit flavoured kombucha teas.[2] Anecdotal evidence of elevated ABV in kombucha teas sold in the Maritime Provinces in Eastern Canada was also communicated to a National working group; however, these data were unavailable for review.[2]

[2] Ethanol issues in kombucha were reported to the chair of the fermented foods national working group (L. McIntyre from BCCDC)

Testing for alcohol in kombucha tea is more difficult than testing for alcohol in beers, wines, ciders or spirits for two reasons:

1. Kombucha tea is unfiltered; it contains live microbes and a culture that creates interference when measuring alcohol with methods that rely on the use of light scattering (refraction). While this is normal and expected in this product, the SCOBY particulate matter present in the beverage hinders these methods.

2. Because the alcohol levels being measured are quite small (less than 5% ABV), the limit of detection for the method is not sensitive enough (the method cannot differentiate between low levels of ethanol).

Figure 3. SCOBY culture floating at the top of newly opened bottle of kombucha tea

For example, the refractometer method used in the beer and wine industry can only provide an approximation of alcohol in kombucha teas, and is not recommended by at least one international kombucha brewers association (Kombucha Brewers International, KBI).[22] Other methods, such as the use of a hydrometer that estimates alcohol based on initial sugar content, could only provide an estimate of the highest alcohol content.

However, this would not account for changes in the alcohol content following conversion of alcohol by *Acetobacter* spp. bacteria into the end product of acetic acid (vinegar). Methods recommended by KBI include headspace gas chromatography (GC) combined with flame ionization detection (HS-GCFID) or mass spectrometry (HS-GCMS).[22] As the headspace method aerosolizes the tea components before testing, interference in the solutions is limited, and so this method can also provide an accurate limit of detection.

HEALTH CONCERNS AND CONSUMER KNOWLEDGE ABOUT POTENTIAL FOR ALCOHOL IN KOMBUCHA

Consumers of kombucha tea may not be aware that this product can contain low levels of alcohol. This may be of particular concern to people who are pregnant and to young children. Medical advice during pregnancy is to abstain from alcohol to avoid risk of fetal alcohol spectrum disorders and harms to the baby.[23-25] Alcohol intoxication in young children can also occur at low levels of ABV. Children, particularly smaller weight infants and toddlers, have a reduced capacity to eliminate alcohol because their livers do not metabolize ethanol as efficiently as adults. This can result in rapid alcohol intoxication leading to low blood sugar (a condition called hypoglycemia), even when only small amounts of ethanol are ingested.[26] A 15-year toxicology review found that hypoglycemia, rather than the direct influence of alcohol toxicity, is harmful in these susceptible groups.[27]

Predicting blood ethanol levels in children is imprecise and ethanol levels will vary depending on how quickly alcohol is consumed, how much food has been eaten, and individual biological factors. However, 375 mL of kombucha with 1% ABV, 150 mL of kombucha tea with 2.5% ABV or 75 mL of kombucha tea with a 5% ABV in a 10 kg or lower weight toddler could result in blood ethanol level approaching 50 mg/dL, which could lead to medical observation for effects of hypoglycemia including lethargy, shakiness, or other changes in behaviour. (See Appendix 1 for calculation of risk based on weight and dose).[29]

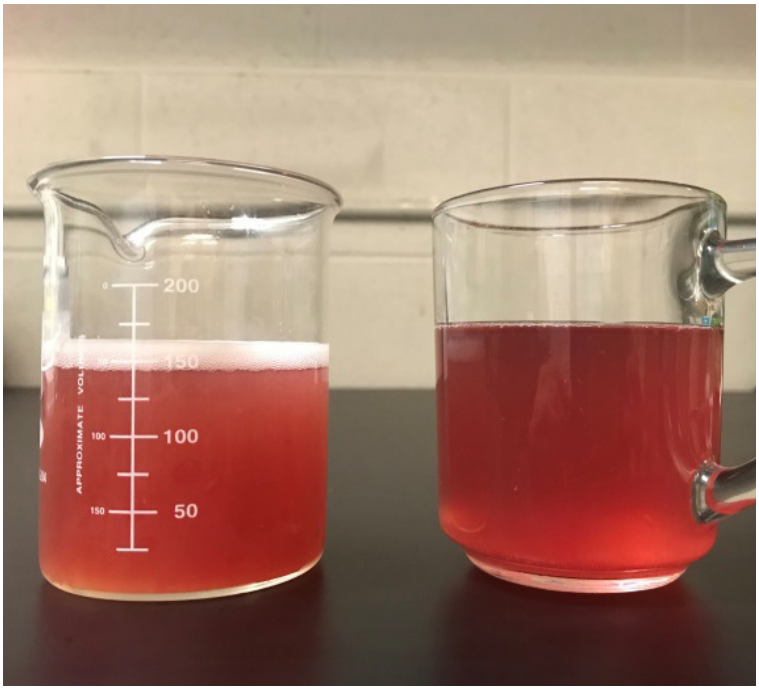


Figure 4. 150 mL may cause harm in toddlers if the beverage was to exceed 2.5% ABV

Regardless of health concerns for toddlers and fetuses during pregnancies there are other consumers who may want to avoid alcohol but who may also be unaware that kombucha can contain alcohol. These might include groups wishing to avoid and abstain from alcohol consumption for religious or personal beliefs, health reasons, or for occupational reasons, such as drivers.

As mentioned, labelling of consumer products is a federally mandated requirement. Foods and beverages are required to contain consumer information that includes nutrition facts tables, ingredient lists, allergen information, and best before dates for products meant to be consumed within 90 days. There are no required precautionary label statements for fermented beverages such as kombucha, which could provide warning statements that products may contain trace amounts of alcohol. Some, but not all, kombucha manufacturers have voluntarily added these statements to advise consumers of this risk.

METHODS

COLLECTION OF SAMPLES

Kombucha tea was collected by food safety specialists (FSS) and environmental health officers (EHOs) throughout BC from June 18, 2019 to October 22, 2019.

Kombucha tea was collected from a variety of premises in the metropolitan Vancouver area by FSS from BCCDC. The types of premises visited during the survey included retail stores, restaurants, cafes, farmers markets, recreational centres, and other premises where kombucha was sold and distributed. While sampling was not representative of processor types or sales locations, we did attempt to sample a broad range of brands available in the BC market. At each premises one sample of each brand found and all brand flavors was collected.

Figure 5. Kombucha tea samples under refrigeration at BCCDC

During collection the temperatures of coolers where kombucha tea was stored in the premises were also recorded. Keg or bulk samples of kombucha were collected in beverage containers provided by the premises and transferred to sterile 200 mL collection containers. All samples were refrigerated during transport then immediately placed under refrigeration at the BCCDC laboratory.

Figure 6. Samples received from regional health authority

Additional samples were collected by regional health authorities during routine inspections and through targeted sampling at premises known to manufacture or distribute kombucha. Kombucha tea samples were submitted to the BCCDC Public Health Laboratory in coolers with ice-packs using the province-wide sample courier system designed for sample delivery along with a chain of custody requisition specifically designed for the kombucha project.[30]

ETHANOL TESTING

Kombucha tea samples received by Environmental Health Services were refrigerated upon receipt. Approximately 30 mL of each kombucha sample was dispensed into a sterile tube and frozen for ethanol testing. Samples were delivered to the BCIT Natural Health Products Laboratory weekly in a cooler chilled with ice-packs using chain of custody criteria.

The BCIT laboratory used a head-space gas chromatography mass spectroscopy (HS-GCMS) method for ethanol testing. Diluted samples of kombucha were placed in sealed headspace vials that included a propanol standard. Vials were heated, agitated, and vapour was injected into the gas chromatograph, separated on a column and then read by a mass spectrometry detector. Each sample included a limit of detection. The method is extremely sensitive with a method detection limit of 0.0002% ABV. This method, currently in peer review, was validated using Association of Official Agricultural Chemists (AOAC) guidelines.

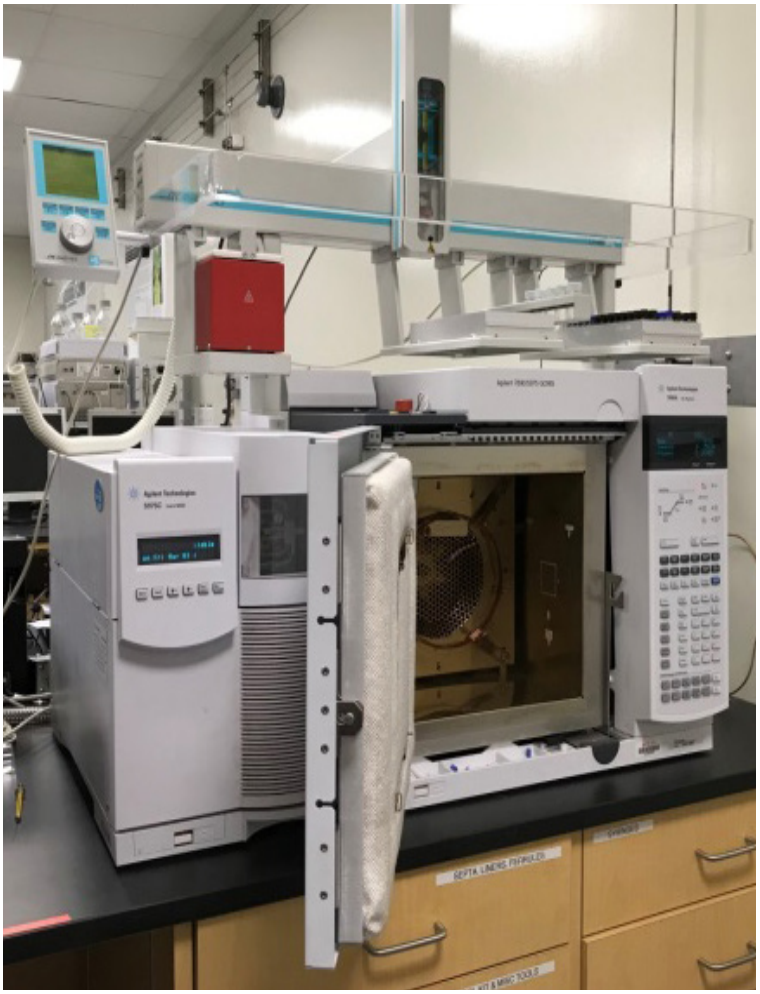


Figure 7. Headspace GC/MS instrument at BCIT used to measure ethanol levels in kombucha samples

ADDITIONAL TESTS AND INFORMATION COLLECTED

i. **pH**: all samples were tested for acidity using a pH meter (Scientific Instruments Model IQ150) following two-point calibration with pH 4 and pH 7 buffers (Oakton, Cole-Parmer). The pH meter instrument was recalibrated after every 10 measurements. The probe was rinsed with distilled water between individual readings.

ii. ***E. coli:*** some samples were tested for the presence of coliforms and *E. coli* using Petrifilm™ plates (3M Company) following the manufacturer's instructions and MFHPB-34 (July 2016).

iii. **Yeasts and organic acids**: other tests included an assessment of yeast activity and organic acid analyses. Yeast analyses were performed at BCCDC using Durham tubes and yeast-potato-dextrose broth. Organic acid analyses were performed at the University of British Columbia mass spectrometry laboratory at the wine research centre in the Faculty of Land and Food Systems.

iv. **Reporting:** participating agencies were kept informed of interim project results through a series of scheduled meetings. Additional results during the interim were sent to regional health authorities.

RESULTS

DESCRIPTION OF THE KOMBUCHA SAMPLES COLLECTED

A total of 684 individual kombucha tea samples were collected and tested for ethanol and pH. Bottled and canned kombucha products accounted for 80% of the samples collected, with the remainder collected from bulk or keg dispensaries

The majority of samples collected during the survey were from retail grocers (Figure 8) with many samples collected at restaurants, directly from processors and with a few samples collected from gyms, recreational centres, and at farmers' markets. In total, 142 premises were visited and inspected during collections of kombucha samples for this study.

Nearly half of kombucha tea products collected in this study (Figure 9) were manufactured in BC (49%) followed by products imported from the United States (32%), other provinces (Alberta, Quebec and Ontario) and one other country (Australia).

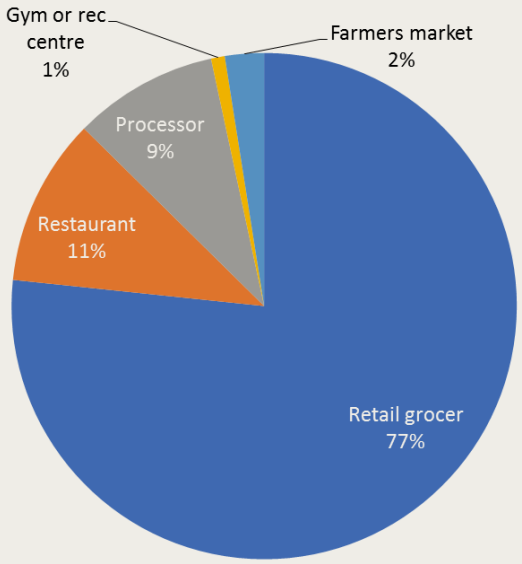


Figure 8. Premises where kombucha products were collected

There were 53 different kombucha processors identified through the survey. Some samples collected directly from restaurants, retail stores and processors were dispensed from kegs (kegs are large volume containers that hold 10 to 100 litres). All products of this type were produced in BC, and were sampled from retail grocers, restaurants, or from processors.

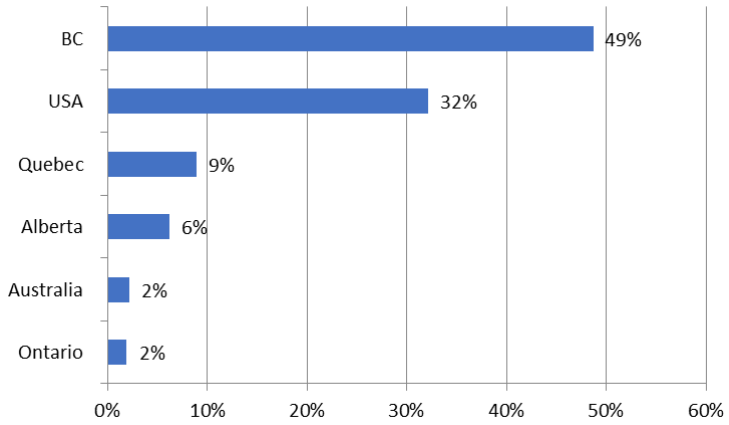


Figure 9. Origin of kombucha products

The majority of kombucha products collected in this survey were from retail stores in the metropolitan Vancouver area. Kombucha was also collected outside of Vancouver, in the Fraser valley, the BC interior, and on Vancouver Island.

LABEL INFORMATION ON THE KOMBUCHA SAMPLES

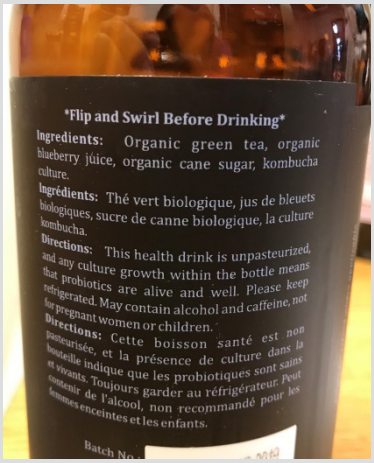
Label information was assessed on all bottled and canned kombucha products collected from 36 of the 53 processors. Note: 17 of the processors were excluded because those kombucha samples were taken from bulk kegs that did not have labelling information.

Four types of information that could be on labels were reviewed for each of the bottled and canned kombucha product brands:

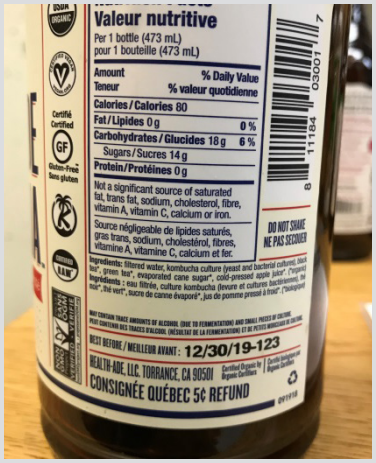
1. Precautionary statements about the presence of alcohol and advisory statements for consumers
2. Handling information important for kombucha safety, such as a requirement for refrigerated storage and cautions to minimize shaking if contents were under pressure
3. Required federal labelling information such as the presence of nutrition facts tables, list of ingredients, name and principal place of business, and best before dates (BBD).
4. Market labels that described the product, for example, “organic” or “Made in Canada”.

PRECAUTIONARY STATEMENTS

Precautionary label statements found on kombucha products are shown in Table 1. Precautionary statements for alcohol were found on approximately half of kombucha product brands (54%). One processor with two product brand lines included labelling on one brand line but not the most common brand line. Overall 8% of processor product brands had label statements recommending that pregnant women avoid drinking kombucha; only one processor and kombucha brand had a precautionary statement that included children on the label. Two processors also mentioned levels of caffeine in the product (e.g., one processor stated that caffeine content was 64 mg/450 mL). As caffeine is present in tea, which is a basic ingredient of kombucha, the presence of this statement was not unexpected. Statements about caffeine content, similar to statements about alcohol content, are not required on labels. Over 75% of kombucha processors from the US had precautionary label statements on their products versus 25% of BC kombucha processors.



10a. Sole brand that mentions not suitable for children



10b. Alcohol statement in small print above date

10c. Two alcohol statements made on label

Figure 10. Examples of precautionary statements and handling information

Figure 10 provides examples of precautionary statements found: the processor that includes a precaution for children and pregnant women is shown on the left (10a) and also mentions caffeine as a concern. In the middle (10b) a precautionary statement in very small print is located above the date label. On the right (10c) two statements are made about alcohol in this particular kombucha product: one says "Verified non-alcoholic", with an additional statement below that says "Contains trace amounts of alcohol."

TABLE 1. PRECAUTIONARY LABEL STATEMENTS FOR ALCOHOL

PRECAUTIONARY LABEL STATEMENTS ON AVOIDING ALCOHOL DISPLAYED ON KOMBUCHA PRODUCTS
<0.5% alc/vol
Contains <0.5% alcohol
Contains <0.5% alcohol by volume
Contains less than 0.5% alcohol by volume. Caffeine content: 64 mg/450 ml
Due to natural fermentation this product may contain a trace amount of alcohol.
Fermentation can create trace amounts of alcohol (less than 0.5%)
May contain alcohol and caffeine, not for pregnant women or children
May contain trace amounts of alcohol
May contain trace amounts of alcohol <1%
Naturally occurring alcohol <0.5%
Non-alcoholic beverage
Not recommended for pregnant or breast feeding mothers
Please note: Kombucha is a fermented tea that has naturally occurring alcohol. Do not consume if you are avoiding alcohol due to pregnancy, allergies, sensitivities or religious beliefs.
This product may contain a trace amount of alcohol
This product may contain a trace amount of alcohol (due to fermentation) and small pieces of cultures
This product may contain a trace amount of alcohol.
Verified non-alcoholic. ++ At bottom of bottle ++ Contains a trace amount of alcohol.

PRODUCT HANDLING INSTRUCTIONS

Recommended handling instructions for refrigeration as well as cautionary advice that described how to open or mix kombucha products were also assessed. The most common handling instruction stated on products was to "KEEP REFRIGERATED" in 92% of product brands, with 14% of processors product brands also specifying a storage temperature of 4°C. One processor, however, only included the temperature on bottled but not canned products. Of the three processors who did not have handling instructions for refrigeration, one product from Australia was found stored at room temperature at retail. This brand of product has likely been processed in a manner that allows room temperature storage without causing further fermentation in the bottle or can. The next most common handling statement was "DO NOT SHAKE", found in 53% of brands, with 22% of brands also providing advice on how to mix the kombucha before opening, for example, to flip, swirl and enjoy. One processor linked temperature to the build-up of pressure inside the container; however, no processors linked a lack of refrigeration or consumption of kombucha past the best before date to potential increases in alcohol.

TABLE 2. PRODUCT HANDLING STATEMENTS FOR KOMBUCHA

PRODUCT HANDLING STATEMENTS PROVIDING INSTRUCTIONS ON TEMPERATURE STORAGE AND OTHER ISSUES
KEEP REFRIGERATED. DO NOT SHAKE. How to drink: flip bottle upside down; gently swirl; flip bottle back up; twist off cap & enjoy
Pre-drink prep; flip-swirl-enjoy. KEEP REFRIGERATED. DO NOT SHAKE. This sediment is normal and full of good stuff.
CAUTION: CONTENTS UNDER PRESSURE. Bottle may break if unrefrigerated. Do not shake.
No refrigeration needed prior to opening; Refrigerate & Drink within 3 days after opening
KEEP REFRIGERATED. Do not shake. Natural sedimentation is normal. 1. Flip 2. Swirl. 3. Open & enjoy.
LIVE CULTURE ALERT: If not refrigerated, pressure builds inside the can due to active fermentation causing risk of rupture. Please refrigerate. Keep refrigeration below 4°C.
REFRIGERATE. DO NOT SHAKE. strands + sediment are natural in Kombucha
Flip and swirl before drinking. REFRIGERATE. DO NOT SHAKE.
Open slowly. SWIRL, DON'T SHAKE. KEEP REFRIGERATED.
KEEP REFRIGERATED. DO NOT SHAKE
Perishable. Swirl gently.
DO NOT SHAKE.
Handle with care, Do not Shake, Please keep refrigerated.
Drink chilled or over ice.
Keep cold. Open slowly.

NUTRITION FACTS, LIST OF INGREDIENTS, PLACE OF BUSINESS, AND BEST BEFORE DATES

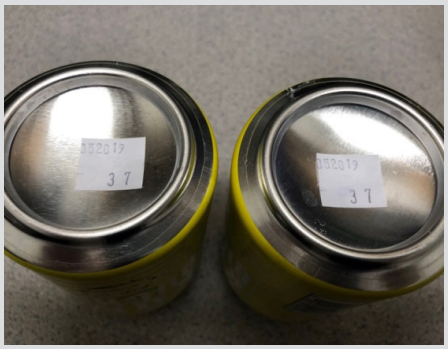
All kombucha products had labels that included a nutrition facts table and a list of ingredients, as required by federal legislation for food products. No allergens were noted in the ingredient lists and no allergen labelling was found on kombucha products. A variety of best before date labelling methods and styles were seen on kombucha products.

Products with a shelf-life of 90 days or less are required to have a BBD if they are packaged at a location that is not the retail store.[31] As the majority of kombucha products contain live microbes requiring refrigeration and since most kombucha is packaged at the processor location rather than the retail store this food product should have a BBD. There was no common location for the BBD: they were observed on caps, stamped onto the bottle label, directly onto the bottle and at the bottom of some bottles. Stickers and direct ink stamps were observed. There was also inconsistency between kombucha bottles of the same brand; a BBD visible in one location of a bottle may be absent in the same brand of another bottle. Stickers seemed to be problematic for these refrigerated products, as many bottles had no sticker — it may have rubbed off or been damaged during storage and handling. Unreadable BBDs also occurred when the date was stamped over the bar code of the bottle, or when the ink on the bottle had rubbed off. Examples of BBD issues are shown in Figure 11. A total of 28 bottles and cans of kombucha had unreadable or absent BBD, accounting for 5% of the products sampled in this survey.

Determining the principal place of business and who manufactured the food was challenging in some products. Complete addresses were not listed nor found on product web-sites. Addresses for products imported from the US were present with one exception. When other imported products were examined, including those manufactured in other provinces, 25% were listed in the Safe Foods for Canadians Registry, https://inspection.gc.ca/webapps/foodlicenceregistry/en/.

11a. Damaged BBD sticker on bottle

11b. BBD or lot number stamp present on left, absent on right of two bottles of the same brand



11c. BBD appears to be past the date of purchase

11d. Smudged in (left), stamp over label (right)

11e. Legible BBD (left), stamp over bar code (right)

11f. Compressed ink (left); legible BBD (right)

Figure 11. Examples of BBD label issues on kombucha products

MARKET LABELS AND CLAIMS

Kombucha is marketed as a healthy beverage containing live probiotic organisms and often made with organic ingredients. Claims were observed in the text on labels and in square and circle decal symbols that identified products as non-dairy, kosher, gluten-free, etc. Frequency of label claims of the 36 kombucha brands are shown in Table 3. No processors labelled their products as pasteurized while 72% claimed their product was raw or living. Several brands claimed their products contained probiotics, antioxidants, or organic acids, although no specific health claims were observed.

TABLE 3. FREQUENCY OF LABEL CLAIMS ON KOMBUCHA BRANDS COLLECTED IN THIS SURVEY

Raw+living	Organic	Non-GMO	Made in Canada	Gluten free	Non dairy	Kosher	Vegan
72%	69%	14%	55%	19%	8%	11%	11%

KOMBUCHA ETHANOL RESULTS

Overall, 68.5% of kombucha products tested had ABV values of 1% or less, meeting the regulatory requirements. However, the remaining samples had ABV values of >1%; one quarter (25.3%) of samples were between 1 to 2% ABV, and the remaining 6.2% of the samples were above 2% ABV (Figure 12).

When ethanol levels exceeded ABV 1%, they were most often found in products manufactured in BC, with some of the products originating from the US and Alberta (Figure 13).

When ethanol levels were sorted by site of collection (the food premises where the sample was taken from) the majority of samples taken at retail met regulatory levels of less than or equal to 1% ABV. Retail samples included products from all regions (BC, Alberta, Ontario, Quebec and the United States). Sampling at farmers' markets, restaurants, recreations centres and at processors only included BC products. Elevated ethanol levels were detected in samples taken directly from processors, restaurants, and at farmers' markets.

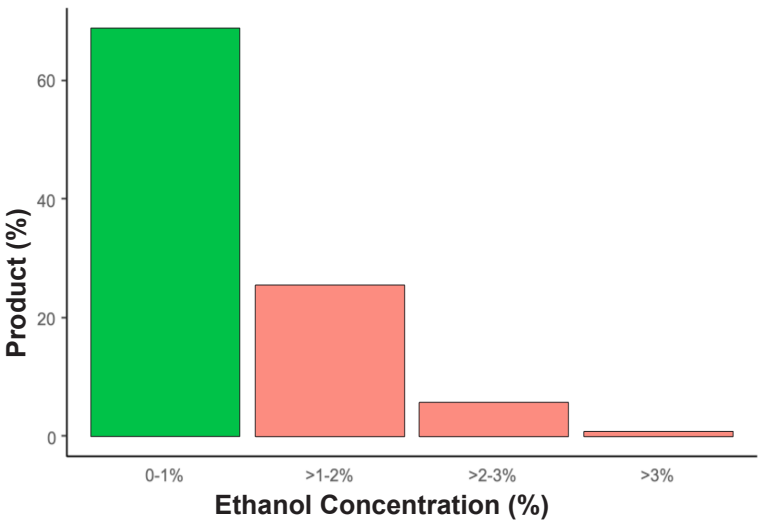


Figure 12. Alcohol (ethanol) levels found in kombucha during survey

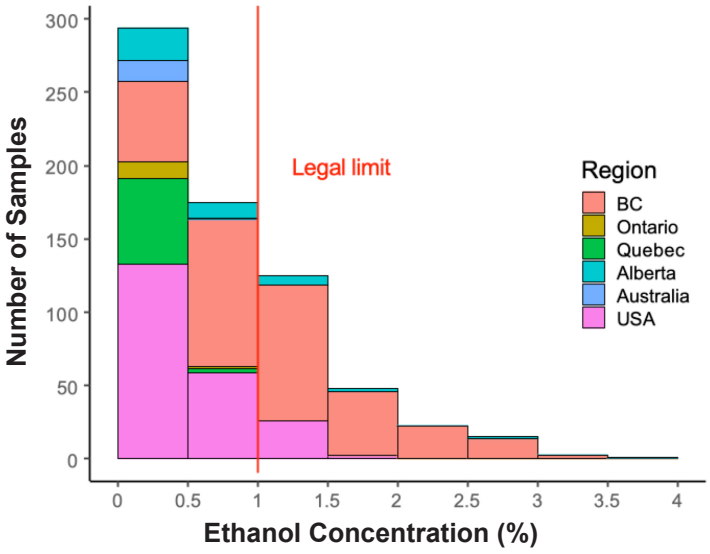


Figure 13. Histogram of ethanol levels by region of kombucha processor

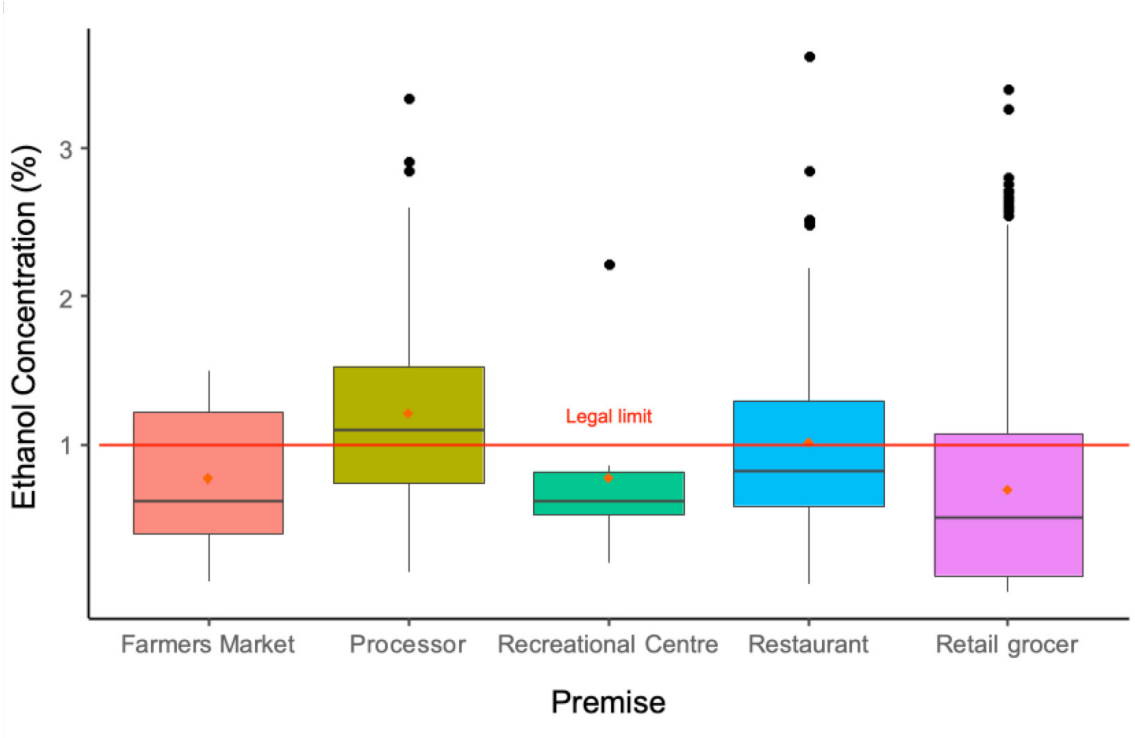


Figure 14. Ethanol levels in kombucha products by sample collection sites.

Note: ethanol values are represented by a rectangular box which signifies the interquartile range, a horizontal line inside box as the median, the red dot as the mean, vertical lines (whiskers) signify 95% confidence interval (2 standard deviations) and black points are actual data points

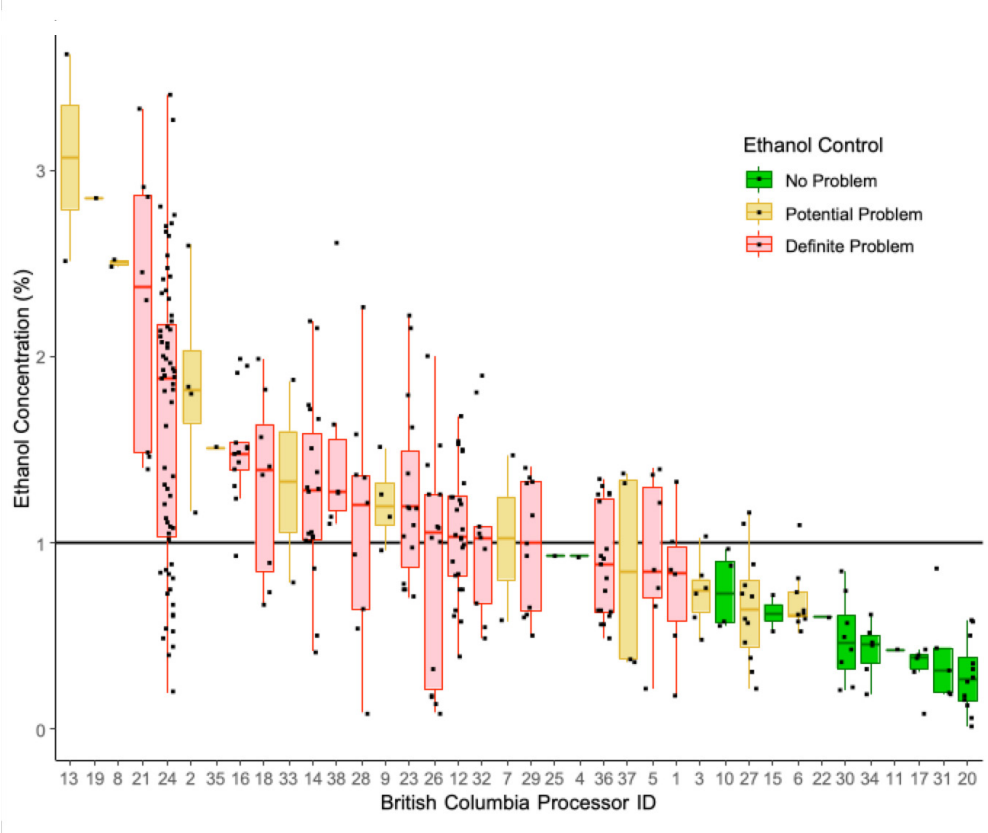


Figure 15. Ethanol levels by kombucha processor for products manufactured in BC.

Note: ethanol values for each processor are represented by a rectangular box which signifies the interquartile range, a horizontal line inside box as the median, vertical lines (whiskers) signify 95% confidence interval (2 standard deviations) and black points are actual data points from the processor.

The results for each processor show that some kombucha processors consistently have ethanol levels that exceed the 1% legal limit (>1% ABV) , while others have a manufacturing process in place that keeps ethanol levels under control in their product.

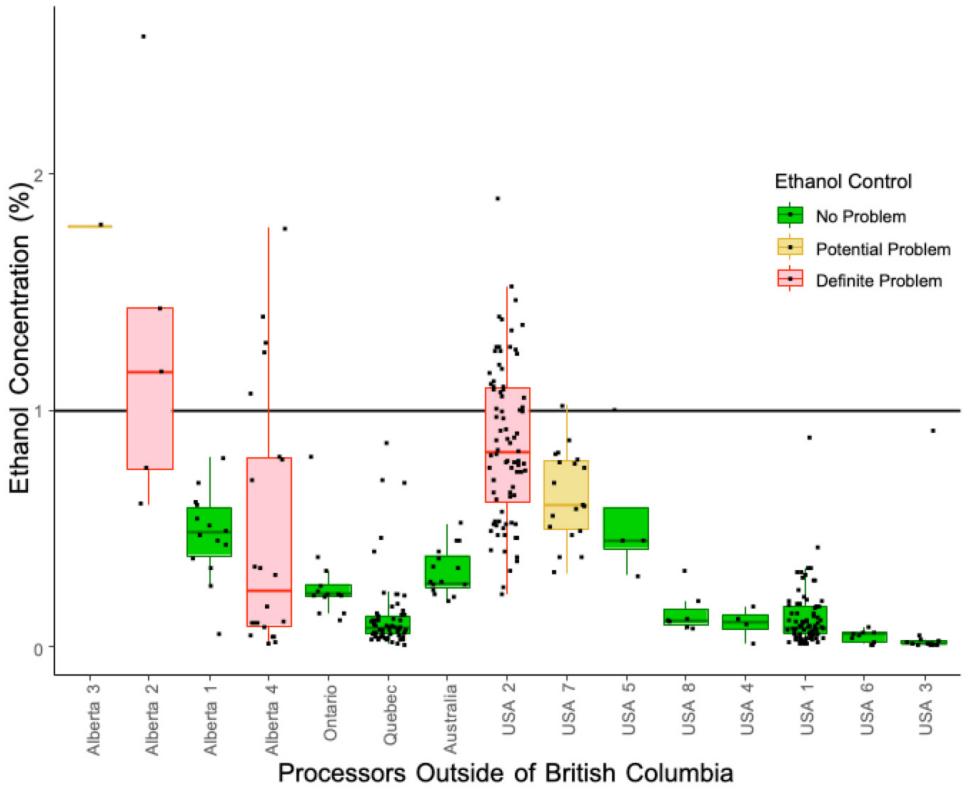


Figure 16. Ethanol levels by kombucha processor for products manufactured outside of BC.

Note: ethanol values for each processor are represented by a rectangular box which signifies the interquartile range, a horizontal line inside box as the median, vertical lines(whiskers) signify 95% confidence interval (2 standard deviations) and black points are actual data points from the processor.

Results for kombucha processors outside of BC demonstrate many have no problem with ethanol control. Those that have a potential or definite problem rarely have values that exceed 1.5% ABV, however.

There were 21 processors (40%) whose products were always under the regulatory limit. Some (nine) processors (17%) occasionally had ABV values exceeding 1% indicating a potential problem, and a few (ten) processors (19%) rarely met the regulatory limit, indicating a definite problem with control of ethanol. This was based on whether 20% or more of kombucha products tested were above or below the 1% limit. Processors with fewer than six samples tested were evaluated based on whether any sample exceeded 1% ABV and were considered to have a potential problem. The median and range of ethanol values by processor are shown in Figure 14 (BC processors), Figure 15 (non-BC processors) and in Table 4.

TABLE 4. ETHANOL LEVELS FOUND BY PROCESSOR AND ORIGIN

Region of Origin	Processor No.	Number of samples tested	Average ethanol level (ABV%)	Percent of samples >1% ABV	Maximum ethanol level (ABV%)	Ethanol control[1]
BRITISH COLUMBIA	BC-1	6	0.78	33.3	1.33	
	BC-2	4	1.85	100	2.6	
	BC-3	6	0.19	16.7	1.03	
	BC-4	1	0.93	0	0.93	
	BC-5	7	0.93	42.8	1.4	
	BC-6	9	0.69	11.1	1.10	
	BC-7	2	1.03	50.0	1.47	
	BC-8	2	2.50	100	2.52	
	BC-9	4	1.22	75.0	1.51	
	BC-10	4	0.75	0	0.97	
	BC-11	1	0.43	0	0.43	
	BC-12	26	1.06	57.7	1.68	
	BC-13	2	3.07	100	3.62	
	BC-14	19	1.27	84.2	2.19	
	BC-15	2	0.63	0	0.72	
	BC-16	13	1.51	92.3	1.99	
	BC-17	6	0.33	0	0.43	
	BC-18	8	1.30	75.0	1.99	
	BC-19	1	2.85	100	2.85	
	BC-20	12	0.29	0	0.59	
	BC-21	8	2.28	100	3.33	
	BC-22	1	0.6	0	0.6	
	BC-23	15	1.25	66.7	2.22	
	BC-24	67	1.67	80.6	3.40	
	BC-25	1	0.93	0	0.93	
	BC-26	14	0.90	57.1	2.00	
	BC-27	12	0.66	16.7	1.16	
	BC-28	9	1.11	55.6	2.27	
	BC-29	11	0.99	45.4	1.41	
	BC-30	8	0.49	0	0.85	
	BC-31	5	0.40	0	0.86	
	BC-32	9	1.06	55.6	1.9	
	BC-33	2	1.33	50.0	1.87	
	BC-34	6	0.43	0	0.61	
	BC-35	1	1.51	100	1.51	
	BC-36	19	0.90	31.5	1.34	
	BC-37	4	0.86	50.0	1.37	
	BC-38	6	1.51	100	2.61	

Continued next page

Region of Origin	Processor No.	Number of samples tested	Average ethanol level (ABV%)	Percent of samples >1% ABV	Maximum ethanol level (ABV%)	Ethanol control[1]
ALBERTA	AB-1	14	0.47	0	0.8	
	AB-2	5	1.30	60	2.58	
	AB-3	1	1.78	100	1.78	
	AB-4	22	0.49	22.7	1.77	
ONTARIO	ON-1	13	0.27	0	0.8	
QUEBEC	QC-1	61	0.13	0	0.86	
AUSTRALIA	AUST-1	15	0.32	0	0.52	
UNITED STATES	US-1	81	0.12		0.88	
	US-2	84	0.86	32.1	1.89	
	US-3	12	0.09	0	0.91	
	US-4	4	0.10	0	0.17	
	US-5	4	0.55	0	1.0	
	US-6	9	0.04	0	0.08	
	US-7	19	0.64	5.2	1.02	
	US-8	7	0.14	0	0.32	

[1] – Ethanol control colour code signal: green colour signifies that there is no problem, ethanol is always below 1% ABV; yellow indicates a potential problem where <20% of samples are above 1% ABV; red indicates a definite problem where >20% of samples are above 1% ABV. For processors with sample sizes of less than 6, any value over 1% ABV resulted in coding with yellow (potential problem).

TEMPERATURES WHERE KOMBUCHA WAS COLLECTED

During kombucha sample collection, temperatures were taken at coolers where kombucha was stored in retail stores, of refrigerators where kegs were stored, and/or display areas (Table 5). Average temperatures at the processor and retail stores were compliant with the requirement that refrigerated foods and beverages should be kept at a temperature of 4°C or less. Although a few samples were above this value (maximum temperatures found were at 6°C), median temperatures were at 4°C at the processors and 3.3°C at retail stores. Restaurant temperatures were slightly higher, although the median value was also at 4°C. Farmers' markets, recreational areas and gyms, and one sample taken from a vending machine, however, had temperatures above 4°C. The average temperatures of kombucha sampled at farmers' markets were of greatest concern, with average temperatures of approximately 11°C.

TABLE 5. TEMPERATURES OF COOLERS DURING COLLECTION OF KOMBUCHA SAMPLES

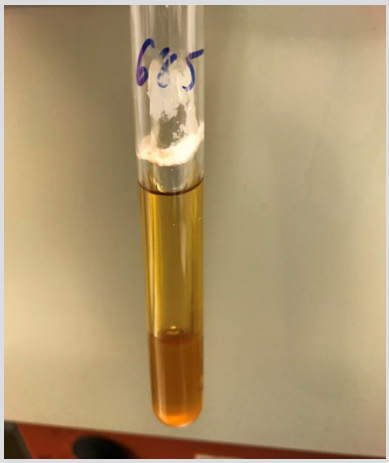
	Farmers Market	Processor	Retail store	Restaurant	Recreational Centre or Gym	Vending machine
No. of samples	6	47	46	30	2	1
Average (°C)	10.9	3.3	3.0	5.2	6.0	9.0
Median (°C)	11.5	4.0	3.3	4.0		
Min (°C)	4.0	-1.0	-2.0	0.3		
Max (°C)	16.8	6.0	6.0	12.7		

ADDITIONAL KOMBUCHA TESTS

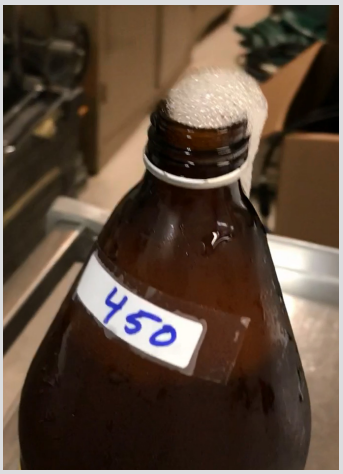
Additional tests performed on kombucha tea samples included assessment of the acidity of beverages (pH), the presence of bacterial indicators for poor sanitation (*E. coli*), and the relationship between ethanol presence in kombucha samples, organic acid analyses, and general observations of kombucha.

pH test results	All kombucha samples (n=684) were tested for acidity. Average pH = 2.86, median pH = 2.84, minimum pH = 2.14 and maximum pH = 3.85. No samples were above a pH of 4.2, the value where harmful bacteria may grow. However, 47 kombucha samples (6.9%) were below a pH of 2.5, the suggested value for consumption safety.[10]
***E.coli* results**	The first 47 keg (bulk) kombucha samples were tested. All samples were negative for *E. coli.*
Organic acid analyses	Organic acid concentrations were measured in 100 samples. Three organic acids appeared to correlate with ethanol levels (glucose, glycerol and succinic acid). These acids are formed during fermentation and are closely related with yeast activity and ethanol production.
Yeast activity	Yeast activity was observed when gas was formed in Durham tubes. The development of a SCOBY ring inside the tubes was also recorded (see Figure 17). 62 samples representing 16 processors were tested. When SCOBY development occurred gas was also produced in 68.7% of brands, indicating that the yeasts were active. In one brand no SCOBY or gas formation occurred.
General observations	Many kombucha bottles and cans were under pressure when opened, and contents leaked out of the bottles (Figure 17). One explanation could be that fermentation continued in the container after bottling. When cans of kombucha were left out at room temperature to observe if ethanol levels increased, all cans exploded after 3 to 6 weeks. Ethanol levels increased over this period.

17a. SCOBY ring with no gas development



17b. SCOBY ring with gas in Durham tube



17c. Kombucha bubbling out of glass bottle after opening

Figure 17. Gas and SCOBY observations in kombucha samples

DISCUSSION

STUDY RESULTS IN BC COMPARED TO OTHER STUDIES ELSEWHERE

In our study, 27 of 38 BC processors (71%) had potential or definite problems with alcohol in their kombucha products. In comparison to international (US, Australia) and all other provinces (Alberta, Ontario, Quebec) only 5 of 15 non-BC processors (33%) had potential or definite problems with alcohol in their kombucha products. *Overall, 31.5% of all samples tested contained alcohol levels that exceeded the BC regulations and contained greater than 1% ABV.* Other jurisdictions outside of BC have also detected low levels of alcohol in kombucha products. In the US, kombucha beverages with ABV of 0.5% or higher are subject to the US Government Tax and Trade Bureau (TTB) regulations, whether alcohol is detected at the time of bottling or afterwards, should alcohol levels rise at any time following bottling, even due to mishandling.[32] A routine audit of kombucha samples in Maine by the Department of Agriculture found alcohol levels that ranged from 0.5 to 2.5% ABV in 2016.[33] In 2016, seven samples collected in a market in Carmel, Indiana reported ABV levels up to 2.21% in flavoured kombucha.[2] In 2017, commercial products purchased in the US identified as GT's, Kevita, Live Soda, The Bu, and Holy brands found all products above the regulatory level of 0.5% with a maximum value above 2.0% ABV.[34] An industry kombucha expert suspects that alcohol levels in kombucha could range from 0.75 to 1.25% ABV during typical fermentations, but there are occasional instances of levels detected over 2% and up to 5% ABV.[1] Elevated alcohol was also found in Australian kombucha products during an Australian survey conducted in 2017-2018. In this survey, 22.9% of kombucha sampled had alcohol contents exceeding 1.15% ABV, which is very similar to BC's study findings.[35]

HEALTH CONCERNS

Findings in this study revealed that low levels of alcohol were present in some brands of kombucha. Notably, kombucha that is produced as a non-alcoholic beverage and marketed as non-alcoholic may still contain low levels of alcohol. Because this beverage is marketed as non-alcoholic, there is a risk that segments of the population who should not or who would not choose to drink any alcohol may be exposed. This may include young children, people who are pregnant or seeking to become pregnant, people with underlying medical conditions or those who are taking prescription medications whose consumption of alcohol is contraindicated, people in occupations where alcohol should be avoided, and other groups of people seeking to avoid or abstain from all alcohol for personal or religious beliefs. In order for the public to discern the potential risk of alcohol in a beverage that is marketed as non-alcoholic, we recommend that there be a requirement that kombucha products contain precautionary label statements. This will inform consumers of the potential presence of alcohol and allow for improved consumer choice.

Consumption of alcohol, even low levels of alcohol, during pregnancy is not recommended.[23] There is no known safe level for consumption of alcohol during pregnancy, and abstinence is recommended by the Canadian Centre on Substance Use and Addiction.[25] Fetal alcohol spectrum disorder or adverse events during pregnancy have not been shown following low level exposures to alcohol, defined as less than 32 grams per week of ethanol.[36] However, there is scant evidence from research into low levels of alcohol consumption that can reliably demonstrate risk.[36] Therefore, based on the results of this study, we recommend that the safest course for those who are pregnant or seeking to

become pregnant is to avoid drinking kombucha. Dr. Adam Sherk, an expert with the Canadian Institute for Substance Use Research (CISUR) expressed concerned for adults consuming kombucha that can contain alcohol regularly, as "adults exposed to a standard drink a day will increase their lifetime risk of cancer." Appendix 1 contains a review of alcohol concerns in kombucha beverages.[29]

Consumption of alcohol, even low levels of alcohol, for children is also not recommended, as it can result in serious illness and long term harms depending on the levels of alcohol consumed and the frequency of ingestion. Alcohol ingestion has a dose and weight relationship to severity of illness. Underweight children and toddlers are of particular concern. Children have underdeveloped livers and a lack of liver enyzmes (alcohol dehydrogenase) needed to metabolize alcohol. Though parents may consider kombucha to be a healthier, lower-sugar alternative to soda and pop, there is a risk of alcohol-related effects in small children consuming large amounts of kombucha. Dr. Sherk advices that young children who have a standard drink of alcohol, one beer for example, can suffer the effects of acute intoxication, resulting in a significant risk of injury in the short term. One beer would be equivalent to drinking a 500 mL bottle of kombucha at 3.5% ABV. The child's behaviour may be affected by alcohol ingestion and may go unrecognized by parents. It is also difficult to predict long term health effects for these children.

We also assessed acidity in all kombucha products sampled. Low numbers of samples were observed (6.9%) with a pH of less than 2.5. Hyperacidosis and lactic acidosis have been rarely reported as a result of consuming kombucha. In healthy individuals, ingestion of kombucha, even when it is acidic at a pH of 2.5 or lower should not be of concern. Individuals with underlying medical conditions associated with metabolic acidosis (e.g., diabetics) are advised to consult with their medical doctor about consumption of kombucha, particularly if they have any kidney function concerns.

LABELLING ISSUES

The Government of Canada has extensive labelling requirements for food products that include core labelling requirements (bilingual, common name of food, place of business, list of ingredients, nutritional information, etc.), claims and statements made by industry (health claims, trade-marks, logos, organic, etc.) and food-specific labelling requirements (dairy, snack foods, salt, etc.)[38] However, precautionary labelling is not listed as a requirement in the above categories. There are specific foods that are required to include precautionary labelling. For example, caffeinated energy drinks must include the statements "Do not consume more than a specified number of servings, and "Not recommended for children, pregnant or breastfeeding women and individuals sensitive to caffeine".[39] At this time, kombucha processors may voluntarily label their products

with precautionary statements, but are not required to do so. Products containing 1.1% or higher alcohol levels are required to be labelled with the % ABV.

Another labelling issue noted during the survey was lack of complete address labels on bottles and cans. The place of business on some BC kombucha was listed with only the city, i.e. "Vancouver". Most products do have websites but do not typically list their manufacturing place of business. Products imported from other provinces and countries were not listed on the Safe Foods for Canadians Licence Registry. Some effort was required to determine the place of manufacture for some of the kombucha products found at retail during this survey, highlighting the difficulty consumers would have in identifying who is making their food.

OTHER FERMENTED FOODS AND ALCOHOL

The presence of alcohol is not an issue in most categories of fermented foods. Kombucha is a raw and living product with live yeast and bacteria (the SCOBY or symbiotic culture of bacteria and yeast). The sugar added during the manufacture of kombucha, similar to the sugar added during wine and cider production, creates conditions for alcohol formation through the natural fermentation process. In the case of kombucha, similar to the way an apple cider vinegar is made, yeasts will convert the sugar (sucrose) to simpler forms of sugar (glucose and fructose). In combination with the yeasts, bacteria (*Acetobacter* and other families of bacteria) will convert these sugars into alcohol (ethanol) and to the end-product, vinegar (acetic acid). Complexity occurs from the interaction of yeasts and bacteria during the kombucha process. The culture may continue to ferment if given the right environmental conditions and opportunity. Management of the process should ensure the fermentation is complete and that ingredients and conditions during fermentation all the way through to bottling and consumer purchase do not create excess alcohol. Other beverages that may be at risk of alcohol formation include water kefir and ginger beer. The Australian survey (2017-2018) found 36.7% of water kefir had alcohol exceeding 1.15% ABV and 9.8% of other fermented beverages such as ginger beer had alcohol exceeding 1.15% ABV.[35] Other beverages and food items of concern mentioned in this work included jun (green tea and raw honey), kvass (rye bread), switchel (ginger sweetened with molasses, maple syrup, honey or sugar), apple cider vinegar, fruit vinegars containing yeast, and other microbiologically active beverages.

WHY IS ALCOHOL FORMED IN KOMBUCHA AND HOW CAN IT BE MINIMIZED?

In this study, kombucha alcohol concentrations and pH from various processors were measured. We found products that contained alcohol concentrations over the legal limit (1.0% ABV), but did not find any correlation of alcohol to pH levels. It was not possible to determine the specific cause of high (i.e. >1% ABV) alcohol concentrations in kombucha products. A review of kombucha alcohol levels suggests the quantity of sugar used can affect production of alcohol.[1] To find out the mechanism of alcohol production above the regulated limit it would also be necessary to know the activity and viable (living) counts of yeasts and bacteria in kombucha, and in particular, information about yeast strains. The characteristics of yeast strains are closely related to alcohol production.

The biological pathway of kombucha fermentation is well-studied with a variety of yeast strains found in kombucha cultures (*Zygosaccharomyces bailii, Schizosaccharomyces pombe, Torulospora delbreuckii, Rhodotorula mucilaginous, Brettanomyces bruxellensis*, and *Candida stellate*).[9,40] The profile of yeasts and bacteria used in the production of specific kombucha products provide taste and flavour and are unique to each product. *Torulaspora delbrueckii* is recommended in kombucha brewing because it produces alcohol relatively slowly when compared to other yeast strains.[41] Other factors that can limit alcohol production include brewing at a lower temperature and allowing the brew to be exposed to oxygen until fermentation is complete. Alcohol levels can rise after bottling as a secondary fermentation step, also described as bottle conditioning. Other factors that have been associated with alcohol include: the shelf-life when a product is sampled; natural carbonation via the fermentation process versus artificial addition; addition of flavours that include added sugar later in the fermentation (such as before bottling), and whether the SCOBY is included (unfiltered product) or filtered out.[42]

Most commercial processors do not release information about their process for kombucha production. Known processes to reduce alcohol over-production involve slowing yeast growth or removing yeasts from cultures. These include micro-filtration techniques to reduce the number of yeast cultures, low heat application to kill off residual yeast,[43] non-heat distillation,[44] increasing the surface area of the fermentation container to allow more oxygen for acetic acid bacteria, limiting yeast growth, and the use of weak tea.[45] Other options to reduce and limit alcohol production that limit yeast growth post-production include pasteurizing at bottling to kill off yeasts, refrigerating as a control throughout distribution and sales, sourcing out yeasts that will not grow at refrigeration temperatures and adding antifungal preservatives, such as 0.1% sodium benzoate and 0.1% potassium sorbate.[10]

Temperature control during the manufacturing process and through the distribution chain is important to control and limit production of alcohol. In our study, 63 samples were obtained directly from BC processors by Environmental Health Officers. The temperature of bottled and kegged kombucha samples taken at these BC processors was found to be at 4°C or less (Table 4). However, as seen in Figure 14, many of the samples taken from BC processors contained elevated levels of ethanol. This indicates that elevated ethanol is present in some BC produced kombucha before the product is released for further distribution to retailers and restaurants. Any further temperature abuse in the cold chain before the product reaches the consumer could create conditions that would further elevate the alcohol levels in these products. Consumers have no way of knowing if the kombucha they purchase has been temperature abused. These results demonstrate that some BC processors do not have control of alcohol in their kombucha products; in this survey 15 BC processors were found to have definite problems with control of alcohol with more than 20% of samples taken exceeding 1% ABV.

One of our further goals after completion of this research is to contact local processors to discuss their results and the possible approaches they could take to minimize alcohol production. For example, knowledge about the yeast strains

used will help inform overall risk for alcohol production during processing and following bottling over the product shelf-life. It was evident that some products from local BC processors showed higher ethanol concentrations than products from other provinces or countries. Therefore, we recommend that local processors review their processes to minimize alcohol concentrations in their kombucha products.

We also recommend that processors regularly analyze alcohol levels in their kombucha products during the fermentation process, at time of bottling, until the end of the product's intended shelf-life, and under circumstances of mishandling post-production. Methods to analyze alcohol should be validated and endorsed by a reputable authority. In the United States, the TTB uses AOAC reference 935.21, a distillation-specific gravity method, with a densitometer instead of a pycnometer. (Note: AOAC is the abbreviation for Association of Official Analytical Chemists, a world recognized leader and publisher of approved chemical methods). Although processors of non-alcoholic kombucha in the US are not required to keep records of alcohol testing, this is a recommended procedure that provides data about alcohol levels. Records should include alcohol levels during production to after bottling.[32] The kombucha brewers industry association (KBI) endorses headspace gas chromatography, flame ionization detection gas chromatography, and mass spectrometry.[22] This study, done in partnership with BCIT, used an HS-GCMS method that was validated using the principles of AOAC validation. It is a reliable and accurate method that allows detection of alcohol without interference from particulates in the kombucha.

SUMMARY OF RECOMMENDATIONS FROM THIS STUDY

1. All consumers have a right to know which products contain alcohol, how much alcohol is present, and what practices may alter alcohol content. BCCDC recommends that industry processors include labels on their products that state the amount of alcohol they contain.

2. BCCDC recommends that federal regulatory agencies require that labelling be applied to these products. Labelling of kombucha beverages would help inform consumers of the potential alcohol risks of consuming this type of live fermented beverage. As alcohol may be present in some brands of kombucha, and as alcohol levels may increase after bottling, during distribution, and following temperature abuse in these unpasteurized products, this would inform consumer choice, particularly for at risk populations, such as toddlers, people who are pregnant, those on prescription medicine who should avoid any alcohol, people who should not consume alcohol due to occupational reasons (drivers, for example), and anybody seeking to avoid alcohol for personal or religious beliefs. Precautionary labels are currently voluntarily added by some industry processors of kombucha in the form of "may contain" statements. It is preferable that processors state the amount of alcohol contained in their products.

3. BCCDC recommends that educational messaging be developed to inform consumers of the risks of alcohol from home prepared kombucha and from alcohol that may be present in some commercial brands of kombucha. This could occur through outreach using social media campaigns and health messaging at appropriate sites.

4. BCCDC recommends that processors test for alcohol using an approved method for kombucha. Testing records for alcohol should be available for review to regulatory agencies upon request. Industry processors of kombucha should monitor alcohol in their products to ensure that they are meeting the BC LCRB regulatory requirement of (less than or equal to) ≤1% ABV and ensure that this level is met during the shelf-life of the product and in the event of mishandling.

5. BCCDC recommends that processors include alcohol as a chemical hazard in their food safety plan and include how the hazard will be managed, monitored, and documented. Specifically, processors should review the information required at the Ministry of Health site, https://www2.gov.bc.ca/gov/content/health/keeping-bc-healthy-safe/food-safety/food-safety-sanitation-plans. This includes Hazard Analysis at Critical Control Point (HACCP) food safety plan information on hazard identification, critical control points, critical limits, monitoring, corrective action, verification and record keeping with alcohol as a chemical hazard.

6. BCCDC recommends that processors monitor pH in kombucha to ensure it does not go below a pH of 2.5, as recommended by best practices for kombucha manufacture.[10] If kombucha pH falls below 2.5, mitigation should include diluting the tea or choosing to not sell that particular batch to consumers. Records of pH should be kept.

7. BCCDC recommends that labelling of raw kombucha products should also include the statement "keep refrigerated". This would inform retailers as well as consumers that this product must be kept refrigerated. Retailers should be advised of potential alcohol issues associated with temperature abuse and ensure that products are properly stored and refrigerated.

8. BCCDC recommends that processors of kombucha ensure that best before dates on bottles and cans are present, readable, and durable.

APPENDIX 1. KOMBUCHA ALCOHOL CONTENT EXPOSURE, DOSE, AND RISK ESTIMATES FOR CHILDREN AND PEOPLE WHO ARE PREGNANT

Note: this document was prepared by Dr. David McVea during a rotation through Environmental Health Services, March 18, 2019.

BACKGROUND

Kombucha is a sweetened tea, mixed with bacteria and yeast, and fermented. Though kombucha is not marketed as an alcoholic beverage, alcohol is a by-product of the fermentation process, and may pose a risk to children or people who are pregnant.

ALCOHOL CONTENT

Analysis of commercially available kombucha has shown alcohol by volume (ABV) levels over 2%.[2] Analysis of kombucha for sale in Canada has shown ABV levels as high as 2.5%, and that ABV can continue to rise after manufacturing.[2] Reports of alcohol levels above 2.5% and nearing 5% ABV, although rare, have been reported.[1]

	% ABV			
Weight(kg)	0.5	1	2	2.5
10	6.7 mg/dL	13.3 mg/dL	26.7 mg/dL	33.3 mg/dL
20	3.3 mg/dL	6.7 mg/dL	13.3 mg/dL	16.7 mg/dL
30	2.2 mg/dL	4.4 mg/dL	8.9 mg/dL	11.1 mg/dL

1.CHILDREN

EXPOSURE ESTIMATE

The risk of alcohol intoxication depends on peak blood alcohol level. Table above shows peak blood alcohol level following the ingestion of 100 ml of liquid at 4 levels of ABV.[26]

DOSE RESPONSE

Alcohol intoxication in infants and young children causes hypoglycemia, lethargy, seizures and, at sufficiently high levels, death. Most cases of serious harm occur when blood alcohol levels over 100 mg/dL are detected during the initial physician evaluation (and a blood alcohol ABV test).[27] Initial blood alcohol values may be suggestive of peak ABV levels that were two or three fold higher as children metabolize alcohol at a faster rate than adults.[27] However, cases of lethargy, hypoglycemic seizures and fatal hypoglycemia have been documented at blood ethanol levels between 50 and 100 mg/dL.[27, 28] Although these effects are likely due to peak ethanol levels that occurred prior to ethanol testing, the potential for harm had led to recommendations that any child with blood ethanol level over 50 mg/dl should be observed in hospital for signs of hypoglycemia, such as lethargy, behaviour changes or shakiness. Consumption of 150 mL of kombucha tea with 2.5% ABV could produce this level of blood alcohol in a 10 kg or lighter weight child, with half this amount (75 mL) a concern in a kombucha tea product with 5% ABV.[26]

RISK ESTIMATE

Young children consuming small amounts of kombucha with ABV within the previously detected range could be at risk of hypoglycemia due to blood ethanol levels.

2. PEOPLE WHO ARE PREGNANT

EXPOSURE ESTIMATE

The risk of fetal harm depends on the cumulative intake of alcohol. Assuming a maximum ABV of 2.5% and a daily intake of 250 ml, the intake of alcohol would be: 2.5% * 250 ml/day * 0.8 g/ml *7 days/week = 35 g/week

DOSE RESPONSE

There is no known safe level of alcohol consumption during pregnancy.[23] While there is evidence of cognitive impacts of moderate alcohol consumption during pregnancy, features of fetal alcohol spectrum disorder or adverse events during pregnancy have not been conclusively shown following exposure to low levels (<32 g/week) of alcohol.[36] Nevertheless, many jurisdictions recommend abstinence from alcohol during pregnancy as there is insufficient research to demonstrate absence of harms at low levels.[24,25]

RISK ESTIMATE

Daily consumption of kombucha at the highest levels of detected ABV may expose people who are pregnant to levels of alcohol that have been shown to cause fetal harm. Consumption of kombucha at lower volumes or a lower ABV has not been conclusively shown to cause fetal harm. However, alcohol intake given these assumptions is non-trivial and the potential for fetal harm cannot be excluded.

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