

Home Canning



Literature Review
June 2014

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How to cite this document:

Ontario Agency for Health Protection and Promotion (Public Health Ontario). Home canning: literature review. Toronto, ON: Queen's Printer for Ontario; 2014.

ISBN 978-1-4606-4166-8 [PDF]

Public Health Ontario acknowledges the financial support of the Ontario Government.

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Background and

Objective

Canning is the method of food preservation where food is treated by the application of heat alone, or in combination with pH and water activity, then stored in hermetically sealed containers. Home canning is the process of preserving foods such as fruits, vegetables, and meats, by packing them into glass jars and heating the jars to eliminate organisms that would create spoilage.

Nicolas Appert, a French chef (1749-1841), known as the “father of canning”, developed the first commercial canning process. In 1810, he was awarded a prize by the French military for his method of preservation that included cooking foods in sealed jars at high temperatures.¹ Since then the canning industry has grown rapidly; it is now a multi-billion dollar business. Today’s canning industry uses high speed, high temperature and precise equipment that can produce a large volume of canned foods in a very short period of time.

Traditionally, home canning was a term used for canning at home; however, it is now also commonly used for small scale canning operations who sell to the public at food establishments and farmers’ markets. There are two different processing methods for home canning: boiling water bath canning and pressure canning. Boiling water bath canning is used for high-acid or acidified foods, while pressure canning is applied to low-acid foods.²⁻⁴

Low-acid foods are any foods with a finished equilibrium pH of greater than 4.6 and water activity of greater than 0.85. Acidic foods are foods that have a natural equilibrium pH of 4.6 or less. Acidified foods are low-acid foods to which acid or acid foods are added; they have an equilibrium pH of 4.6 or less and a water activity greater than 0.85.⁵ Water activity describes the amount of water available in food; pure water has water activity of 1 and water activity of zero refers to the total absence of free

Key Messages

Home canning has been regaining popularity in Canada.

In Canada and internationally, there are many reports of foodborne illness and outbreaks associated with improperly home-canned food. Shelf-stable home-canned products containing low acid foods such as vegetables and meat dishes are often implicated as contributing factors in *Clostridium botulinum* illnesses and outbreaks.

Spore-forming bacteria, including *Bacillus* and *Clostridium botulinum*, are a concern in the canning process. These spores are common in the environment.

Failure to meet the posted or correct thermal process or acidity requirements, are the primary causes of botulism illnesses and outbreaks.

Home-canned food is now available for sale in some retail food establishments. Food service establishments are potential high risk settings where widespread public exposure to contaminated food (including home-canned items) can occur.

Use of a validated recipe and design of a satisfactory HACCP-based process that includes achieving the required temperature, water activity and acidity to control or eliminate the growth of microorganisms of concern, and adequate delivery of this process, are necessary for the production of a safe canned product.

water molecules. U.S. Food and Drug administration defines water activity of a food as the ratio between vapor pressure of food, when in a completely undisturbed balance with the surrounding air media, and the vapor pressure of distilled water under identical condition.⁶

In Canada, home canning has been regaining popularity as part of the local food movement and the desire to be more environmentally friendly.⁷ Some restaurants across Ontario are also responding to this movement and including home-canned food as part of their menu. However, if home-canned foods are not prepared properly, they can cause foodborne illness. This review will address the incidences and hazards of foodborne illness with improperly home-canned food, and the effect of acidity and temperature in controlling these hazards.

Method

Five databases were searched (MEDLINE, Embase, CINAHL, Environment Complete, and Scopus); results were limited to English language and duplicate records were removed. Appendix I outlines the search strategy used for this review.

Additional information was found by checking references of obtained articles. All records were reviewed and 41 records were included in this report.

Discussion

While canning can be a safe way of preserving and storing food for a prolonged period of time, if not done properly, it can be associated with illnesses and health hazards. The following is a summary of the results obtained from a recent literature review on the reported illnesses, outbreaks and health hazards associated with the canning process, and the effect of temperature and acidity of food on the safety of home-canned products.

REPORTED ILLNESSES AND OUTBREAKS ASSOCIATED WITH THE CANNING PROCESS

In Canada and internationally, there are many reports of foodborne illnesses and outbreaks associated with improperly canned food.^{8-10, 14-32} Shelf-stable home-canned products containing low acid foods such as vegetables and meat dishes are often implicated in these illnesses and outbreaks. There are also reports of foodborne illness associated with large scale commercial canned food. For example, in the United States (US) in 1989, four outbreaks of staphylococcal food poisoning were linked to improperly canned mushrooms. Ninety-nine people were reported ill, eighteen of whom were hospitalized. *Staphylococcal enterotoxin A* was identified in the canned mushrooms.⁸ Another example included three cases of foodborne botulism in 2003 reported in South Korea; commercially canned sausage was identified as the most likely source of infection for this outbreak.⁹ However, due to advances in food

science, at the beginning of the 20th century the number of epidemics associated with commercial canned foods has reduced considerably. Nevertheless, home-canned food still represents one of the main causes of reported botulism cases around the world.¹⁰

Improperly prepared shelf-stable home-canned food is associated with incidents of foodborne botulism in Canada, the US and other countries. Foodborne botulism is a rare but serious paralytic illness in humans. It is caused by consuming food contaminated with the pre-formed botulinum toxin.¹¹ Shelf-stable food refers to processed food that can be safely stored at room temperature for specified long period of time without significant deterioration of quality. These products are free of microorganisms capable of growing in or on the product at non-refrigerated conditions.^{12,13}

The low acid, shelf stable, home-canned foods with anaerobic environments provide an optimal growth condition for *C. botulinum* spores, allowing for the growth and production of toxins in the finished product if the spores have not been effectively inactivated during the canning process. Following are examples of botulism illnesses and outbreaks associated with home-canned food where low-acid food (vegetables and meat) are most frequently implicated. Table 1 provides a summary of the published reports of botulism illnesses associated with home-canned food for the period of 2003 to 2013.

Table 1: Summary of reported illnesses and outbreaks of foodborne botulism associated with home-canned food published from 2003 to 2013.

Reference	Year of Event	Location	Number of cases*	Most Likely Source(s)	Contributing Risk Factor(s)
Loutfy MR. et al., 2003 ¹⁴	1999	Canada-Ontario	3	Home-canned tomatoes	Inadequate pH of the final product
Abgueguen P., 2003 ¹⁵	2000	France	9	Home-canned asparagus	Not recorded
Armada M. et al. 2003. ¹⁶	2003	United States	1	Home-canned baby food	Inadequate temperature treatment
Sobel J. et al. 2004** ¹⁷	1990-2000	United States	70	Home-canned vegetables, home-canned soup, stew, chili, tuna, egg and garlic in oil***	Not recorded
Varma KJ.,2004 ** ¹⁸	1980-2002	Georgia	565	Home preserved vegetables (implicated food for 80% of botulism cases)	Inadequate sterilization equipment and temperature treatment, canned food stored for too long and preserved vegetables eaten uncooked.

Reference	Year of Event	Location	Number of cases*	Most Likely Source(s)	Contributing Risk Factor(s)
Cengiz N., et al. 2004 ¹⁹	2004*** *	Turkey	1	Home-canned green beans	Not recorded
Cawthorne A. et al. 2005 ²⁰	2004	Italy	28	Restaurant-preserved green olives in saline	Inadequate pH of the final product
Peck MW., 2006 ⁹	2004	Kyrgyzstan	5	Home-canned aubergine	Not recorded
Peck MW., 2006 ⁹	2005	Russia	16	Home-canned cucumbers	Not recorded
Peck MW., 2006 ⁹	2005	Kyrgyzstan	6	Home-canned salad	Not recorded
Peck MW., 2006 ⁹	2005	Russia	5	Unspecified home-canned food	Not recorded
Peck MW., 2006 ⁹	2005	Russia	15	Unspecified home-canned food	Not recorded
Mclauchlin J. et al. 2006** ²¹	1998 2005	United Kingdom	3: 2 1	Imported home-canned mushrooms in oil (Italy) Imported home-preserved pork (Poland)	Not recorded Inadequate temperature treatment
Cengiz M., 2006 ²²	2005	Turkey	5	Roasted home-canned mushrooms	Not recorded
Pavlova V. et al. 2007 ²³	2005	Bulgaria	3	Home-canned pork	Not reported
CDC, 2006 ²⁴ & Ungchusak K. et al. 2007 ²⁵	2006	Thailand	163	Home-canned bamboo shoots	Inadequate temperature treatment

Reference	Year of Event	Location	Number of cases*	Most Likely Source(s)	Contributing Risk Factor(s)
Rebagliati V. et al. 2009** ¹⁰	1992-2004	Argentina	41	Improperly processed meats and vegetables and home-canned food: onions, pickled octopus, asparagus, fish and sweet corn.	Storing food under conditions that benefits the toxin's growth
Swaan CM., 2010 ²⁶	2008	Netherlands /Turkey	8	Home-packed black olives	Inadequate pH of the final product
Date K, et al., 2011** ²⁷	2008-2009	United States: Ohio and Washington	12	Home-canned vegetables (blend of carrots, beans, green beans, asparagus) Home-canned vegetables accounted for 56% of botulism outbreaks in the United States between 2008 and 2009.	Inadequate temperature treatment
Oriot C., et al. 2011 ²⁸	2010	Corsica	5	Home-canned green beans and/or salted roast pork	Inadequate temperature treatment
Lonati D. et al. 2011 ²⁹	2011***	Italy	1	Home-canned homogenized turkey meal	Inadequate temperature treatment
Ağaçayak A. 2011 ³⁰	2011***	Turkey	4	Home-canned red peppers	Not reported
Leclair D., et al. 2013** ³¹	1985-2005	Canada	18	Restaurant home-canned mushrooms; home-canned vegetables (mushrooms and asparagus); beef and vegetable soup; and sausage	Not reported
Hill SE., et al. 2013 ³²	2013***	United States	1	Home-canned corn	Not reported

Note:

* Studies where number of cases were divided into confirm and suspect; sum of cases were reported in this table.

**Meta analysis studies, the number of case reported are sum of reported cases.

*** Home-canned vegetables reported included: Asparagus, squash, peppers, corn, beans, pumpkin, greens, tomato juice, olives, beets, potatoes, eggplant, turnip, carrot, pickles and garlic.

**** Year of publication was used when there was no information on the year the cases were reported.

EFFECT OF ACIDITY AND PROCESSING TEMPERATURE OF FOOD ON THE SAFETY OF CANNED PRODUCTS

Spore-forming bacteria, including *Bacillus* species and *Clostridium botulinum*, are the key organisms of public health significance in the canning process. These spores are common in the environment and have been found in various food ingredients. Spores are the dormant stage of the microorganism; they have the ability to survive a wide range of adverse conditions and will germinate and grow when conditions are favourable. Types of microorganisms deemed to be critical in designing a safe canning process are: *Clostridium botulinum* ; resistant mesophilic , spore-forming bacteria; and thermophilic, spore-forming microorganisms.³³

Thermal process, or the combination of temperature and time required for safe canning of a food product, is based on the most heat-resistant organism associated with the food. The pH, or acidity of the food product, is the main factor in identifying the type of microorganism that should be controlled in canning process.⁵ Table 2 provides information on the reference temperature associated with effective treatment of microorganisms, based on the pH of food that is being canned. The D-value refers to decimal reduction time which is the time required to kill 90% of the organisms being studied at a reference temperature. The Z-value of an organism refers to the temperature required for one log reduction in the D-value.³⁴

Table 2: Microorganisms Associated with Thermally Processed Canned Foods⁵

Class of Food	Type of Microorganism	Microorganism(s)	Reference Temperature (°F/C)	D-Value (minutes)	Z-Value (°F)
Low-acid food (pH > 4.6)	Thermophiles (spores)	Flat-sour group (<i>G. stearothermophilus</i>)	250/121	4.0 – 5.0	14-22
	Mesophiles (spores)	Putrefactive anaerobes (<i>C.botulinum</i> types A and B)	250/121	0.10 – 1.20	14-18
		<i>C. sporogenes</i> group (including P.A. 3679)	250/121	0.10 - 1.5	14-18
Acid food and acidified food (pH	Thermophiles (spores)	<i>B. coagulans</i> (facultatively mesophilic)	250/121	0.01 – 0.07	14-18
	Mesophiles	<i>B. polymyxa</i> and	212/100	0.10 – 0.50	12-16

Class of Food	Type of Microorganism	Microorganism(s)	Reference Temperature (°F/C)	D-Value (minutes)	Z-Value (°F)
4.0 – 4.6)	(spores)	<i>B.macerans</i>			
		Butyric anaerobes (<i>C.pasteurianum</i>)	212/100	0.10 – 0.50	12-16
		<i>B.licheniformis</i>	200/94	4.5	27
Acid food and acidified food (pH < 4.0)	Yeasts, molds, and mesophilic non-spore-bearing bacteria	<i>Lactobacillus</i> species, <i>Leuconostoc</i> species	150/66	0.50 – 1.00	8-10

Note:

Thermophilic microorganism refers to an organism that thrives at a relatively high temperature, such as 50°C/122°F or above

Mesophilic microorganism refers to an organism that thrives at a moderate temperature, such as 37 °C/99°F

Facultative microorganism refers to an organism that can live under more than one set of environmental conditions

An application of high temperatures and/or an acidic environment are required to effectively control and eliminate the growth and germination of bacterial spores during the canning process.³⁵ *Clostridium botulinum* spores and toxins are resistant to freezing temperatures. The spores can germinate and produce toxins in low acid food with an equilibrium pH of more than 4.6, in an anaerobic environment of less than 2% oxygen, at temperatures of 4° – 50°C and water activity of greater than 0.85.³⁶ The nonprotelytic *Clostridium botulinum* strains (B,E,F) strains can grow at refrigerated temperatures.³⁷

Botulinum toxins can be inactivated at 85°C/185°F for a minimum of five minutes, but the spores are resistant to heat and require high temperatures to eliminate.²² Botulinum spores can be effectively treated at temperatures of 121°C /250°F or higher. The production of botulism toxin can be eliminated by preventing the growth and germination of the spores. Botulinum spores will also not germinate in an acidic environment with an equilibrium pH value of 4.6 or lower. An acidic canned food that has gone through sufficient heat treatment to eliminate vegetative microorganisms (bacteria, yeasts and molds) will not support the germination and growth of botulinum spores and production of the toxin.

Design of a satisfactory Hazard Analysis Critical Control Points (HACCP)-based process that includes achieving required temperature and acidity to control and eliminate the growth of these microorganisms, and an adequate delivery of this process are necessary for the production of a safe canned product.^{3,33}

ACIDITY

The US Food and Drug Administration (FDA) has identified improper acidification of home-canned foods as the cause of several botulism cases.³⁸ Acidity, or pH value of the home-canned product, and processing time are two of the key factors that control the growth of microorganisms in canned food. Reducing the pH in food can prevent the outgrowth of spores, reduce the heat resistance of microorganisms, and inhibit or decrease their growth rate.³⁸ A neutral pH or a pH of near 7.0 provides an ideal growth condition for *C. botulinum* spores and the production of toxins. The goal of acidification process is to reduce the finished product equilibrium pH to below 4.6. This takes into account the possibility of inter-or-intra-batch variability in the formulation of the home-canned food.

The techniques for reducing pH are:

1. Blanching food ingredients in acidified aqueous solution.
2. Immersion of blanched food in acid solution: the food product is blanched in a steam or water blancher followed by dipping into an acidic solution before being placed in containers.
3. Direct batch acidification: ingredients are mixed and acid is directly added to the batch. The product is heated and the high temperature improves the rate of penetration into solid particles; pH of the final product is checked prior to filling the containers with product.
4. Direct addition of acid to individual containers.
5. Adding acidic food to low-acid food, in controlled proportion, following a specific validated recipe.³⁸

Of the five techniques for acidifying vegetables mentioned above, the first three are generally used by the industry. Some of the concerns associated with last two methods include overlooking individual containers, inadequate mixing, and insufficient acid penetration into food particles.³⁸

Regardless of acidification technique used, the acid concentration, blanch time, and temperature of the product must be carefully controlled and checked to ensure the safety of the canned food. Acidity of the final product can be verified by accredited laboratories. Accredited laboratories in Ontario may be located through the Standards Council of Canada website, <http://palcan.scc.ca>. In addition, Public Health Ontario Laboratories (PHOL) provides laboratory services to local health units across the province such as microbiological and physiochemical testing of food samples for food safety investigations. If a public health inspector has concerns regarding the safety of a specific product, pH analysis or measure of the acidity of home-canned foods and analysis of water activity can be performed upon request. Routine testing of home-canned foods is not a program supported by the PHOL. Results are available within 48 hours of receiving the food sample at the testing laboratory.

TEMPERATURE

Application of temperature is required to control and eliminate the germination and growth of microorganisms. The temperature, the length of time for temperature treatment and the applied pressure required to guarantee the safety of canned food depends on the pH of the food. Canned food can be divided into two groups: acidic or acidified, and low-acid food.

To guarantee the safety of acidic and acidified home-canned food, it is recommended that the product undergo heat treatment at 100°C for a period of time indicated in the tested preserving recipe/validated recipe.^{3,38} Boiling of water is not a good indicator of heat treatment to 100°C. The boiling temperature of water varies with altitude.³ For example, Ontario's highest point is the Ishpatina Ridge at 693 m, and the lowest point is Hudson Bay at sea level. This translates to a water boiling temperature of 97.7°C at Ishpatina Ridge and 100°C at Hudson Bay.³⁹ It is recommended that a thermometer be used to ensure the required time-temperature combination is attained.

Low-acid foods can be sterilized at a temperature of 116° to 121°C /240° to 250°F. Pressure canning must be used for low-acid foods. The processing time needed to eliminate microorganisms in low-acid food ranges from 20-100 minutes.^{3,38}

The length of time required for temperature treatment of canned food depends on thermal conductivity and thermal diffusivity of the food items. It varies by the initial pH value of the food, initial temperature of food as it is filled into jars, shape and size of the container, the packing method and type/amount of food to be canned, i.e. types and amounts of particulate and liquid, size of particulates, product viscosity and presence of ingredients such as fat, starches and hydrocolloids.^{2,40}

Following the correct temperature, processing time and pH requirements for canning food is critical to producing a safe product. Between 1910 and 1989, between 4 and 13 botulism outbreaks per year in the US were likely caused by human error in delivering the required thermal process for a specific system and this is the primary cause of botulisms.³³

Use of validated canning recipes, from reputable sources, assists in production of a safe product. Validated canning recipes are recipes upon which verification tests for *C. botulinum* have been performed to identify the temperature, processing time, and acidification requirements to effectively inactivate the *C. botulinum* spores. The recipe will include such information as container type and size, ingredients, acidity/pH and time and temperature requirements for the food item that is being canned. The National Centre for Home Food Preservation⁴ and Ball Corporation⁴¹ are examples of sources of validated home canning recipes.

While botulinum spores can survive in boiling water, the botulinum toxin is heat-labile. When possible, heating canned food to a temperature of 85°C (185°F) for a minimum of five minutes before immediate consumption can reduce the risk of illness.

OTHER FACTORS

Other factors contributing to the production of safe canned products include:

- reducing the bacterial load of fresh food to be canned by washing, trimming and peeling
- forming an anaerobic environment using air tight seals that prevent post-processing contamination³
- detailed record-keeping of the canning process with identification and verification of critical control points, and
- adequate labelling of home-canned food — some of the information included on the label are: the producer information (producer name, address and date of production), ingredients and safety

messages (storage requirements, best-before dates and pre-consumption messages). This would provide assistance with safe usage of the canned product, identification of potential allergens and effective trace-back, if a problem is identified later on.²

FOOD SERVICE ESTABLISHMENTS AND CANNING

Food service establishments are potential high risk settings where widespread public exposure to contaminated food can occur. Affecting 37 people in 1985, the botulism outbreak from garlic in oil was the first reported and largest Canadian botulism outbreak associated with a food service establishment. In 1987, 11 people became ill after consuming home-canned mushrooms, locally canned at a hotel restaurant in Vancouver.³¹ In 2004, an outbreak associated with restaurant preserved home-canned olives resulted in 28 cases of botulism in Italy.²⁰

Safe home-canning in restaurants relies on the operator starting with a validated recipe, following the recipe correctly, and implementing a satisfactory HACCP process that identifies, verifies and records the critical control points in the processing. This reduces the probability of an error during the canning process.

Some of the recorded errors during the canning process are:

- inadequate validation process
- a change in the formulation and viscosity of the product
- equipment errors – e.g. temperature, processing time, pressure, failure to calibrate, wrong container size, change in headspace (the unfilled space from the top of the jar to the food or liquid in the jar), etc.
- failure to follow written instructions/HACCP
- failure to review records
- failure to act on adverse records.³³

Conclusion

This review found several reports of foodborne botulism outbreaks and illnesses associated with improperly home-canned food. Shelf-stable, home-canned products containing low acid or acidified foods, including vegetables and meat dishes, are often implicated as the most likely source.

An application of high temperatures and/or an acidic environment is required to effectively control the growth and germination of pathogenic microorganism and bacterial spores during the canning process.^{3,33} Applying adequate temperature and acidity to control and eliminate the germination of *Clostridium botulinum* spores is also sufficient to effectively control the growth of other pathogenic microorganisms of concern in the home canning process, such as *Bacillus* and *Staphylococcus aureus*.⁵

Insufficient temperature treatment and inadequate pH in the final canned product have been identified as the most likely contributing factors in botulism illnesses and outbreaks. The US Food and Drug

Administration (FDA) has identified improper acidification of home-canned foods as the cause of several botulism cases.³⁸ In addition, foodborne botulism has also been associated with inadequate thermal processing of home-canned foods.³³

In Canada, some food service establishments are producing home-canned food for public consumption. Food establishments, including restaurants, can provide widespread public exposure should a canned food become contaminated. The outbreaks associated with garlic in oil in Canada in 1985, restaurant prepared home-canned mushrooms in Vancouver in 1987, and home-canned olives in Italy in 2004 are all examples of restaurant-associated botulism outbreaks.^{20,31} A recent baseline study by the Ontario Ministry of Agriculture and Food (OMAF) has highlighted that a number of producers lack sufficient knowledge regarding the food safety principles of home-canned products, which has led to some of these products being recalled by the Canadian Food Inspection Agency. It has also identified concerns regarding insufficient labelling and lack of record-keeping by these operators.² If a food service establishment is considering home canning, it is important to use validated recipes and to ensure that the required temperature and acidity is achieved. It is also imperative to implement a satisfactory HACCP system to ensure adequate delivery of this process.^{3,33}

Canning can be a safe way of preserving and storing food for a prolonged period of time. However, if not done properly, it can result in serious illness and can have fatal consequences. It is important to understand the science of canning and implement proper control measures to ensure the safety of home-canned products.

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Appendix I

Search strategies:

Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1946 to Present

#	Searches	Results
1	Food Preservation/	9441
2	Food Handling/	16223
3	Food, Preserved/	233
4	exp Food Safety/	53089
5	Food Contamination/	28509
6	Food Microbiology/	25312
7	Food Storage/	413
8	Food Packaging/	2430
9	*Food/	11809
10	Foodborne Diseases/	7351
11	Botulism/	2629
12	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11	87022
13	(acidic or acidity or outbreak\$ or disease\$ or illness\$ or botuli\$ or toxic\$ or toxin\$ or health hazard\$ or safety or risk\$ or bacteria or foodborne\$ or (food adj2 poison\$)).mp.	6253746
14	(canning or canned or home-cann\$).mp.	1920
15	12 and 13 and 14	329
16	13 and 14	640
17	limit 16 to ("in data review" or in process or "pubmed not medline")	41
18	15 or 17	370

Embase 1974 to 2013 Week 22

#	Searches	Results
1	canned food/	689
2	food preservation/	8678
3	food handling/	14986
4	food safety/	8648
5	food contamination/	34117
6	food storage/	3706
7	food poisoning/	11548
8	food packaging/	5423
9	*food/	18914
10	botulism/	3675
11	2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10	93393
12	(canning or canned or home-cann\$).mp.	2515
13	11 and 12	990
14	1 or 13	1403
15	(acidic or acidity or outbreak\$ or disease\$ or illness\$ or botuli\$ or toxic\$ or toxin\$ or health hazard\$ or safety or risk\$ or bacteria or foodborne\$ or (food adj2 poison\$)).mp.	8054149

16	14 and 15	531
17	limit 16 to exclude medline journals	50

CINAHL with Full Text

#	Query	Results
S1	(MH "Food Safety") OR (MH "Food Preservation") OR (MH "Food Handling") OR (MH "Food Packaging") OR (MH "Food Contamination") OR (MH "Food Microbiology") OR (MM "Food") OR (MH "Food Poisoning") OR (MH "Botulism")	7,907
S2	acidic or acidity or outbreak* or disease* or illness* or botuli* or toxic* or toxin* or health hazard* or safety or risk* or bacteria or foodborne* or (food N2 poison*)	721,562
S3	canning or canned or home-cann*	133
S4	S1 AND S2 AND S3	24

Environment Complete

#	Query	Results
S1	SU canning or canned or home-cann*	2,251
S2	acidic or acidity or outbreak* or disease* or illness* or botuli* or toxic* or toxin* or health hazard* or safety or risk* or bacteria or foodborne* or (food N2 poison*)	696,222
S3	SU food* or botulism	55,751
S4	S1 AND S2 AND S3	400

Scopus

#	Query	Results
S1	(TITLE(canned OR canning OR home-cann*) OR KEY(canned OR canning OR home-cann*)) AND (TITLE(food* OR botulism) OR KEY(food* OR botulism)) AND (TITLE(acidic or acidity or outbreak* or disease* or illness* or botuli* or toxic* or toxin* or health hazard* or safety or risk* or bacteria or foodborne* or (food W/2 poison*)) or KEY(acidic or acidity or outbreak* or disease* or illness* or botuli* or toxic* or toxin* or health hazard* or safety or risk* or bacteria or foodborne* or (food W/2 poison*)))	260

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