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Safety of Fermented Foods

Assessing risks in fermented food processing practices and advice on how to mitigate them

BC Centre for Disease Control
Provincial Health Services Authority
Alberta Health Services
Saskatchewan
Manitoba
Public Health Ontario | Santé publique Ontario
New Brunswick | Nouveau Brunswick
NOVA SCOTIA
Prince Edward Island CANADA
Newfoundland & Labrador
Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

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Additional fermented food guidance can be accessed at:
http://www.bccdc.ca/health-professionals/professional-resources/fermented-foods

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Section 3 | Food safety reviews of fermented foods

A national working group of health inspectors, food safety specialists, and industry fermentation experts reviewed this food safety guidance.

Each fermented food review includes:

- background on the food,
- a description of the food preparation,
- a food flow chart,
- a review of the potential issues with the food preparation, and
- food safety control points.

Foods covered in this guidance are sorted in order of increasing complexity and fermenting agent.

Figure 1 | Fermented foods described by fermentation agent and complexity

Complexity	Foods	Fermenting Agent	Section
high ↑	Sausage	Added LAB[1], spontaneous moulds & yeasts	3.13
	Kefir, Kombucha	SCOBY[2] based: *Acetobacter*, yeast & mould	3.11-3.12
	Koji, Miso	*Aspergillus*, spontaneous or added yeast & LAB	3.10
	Tempeh	*Rhizopus*	3.9
	Natto	*Bacillus*	3.8
	Yogurt, Plant-based cheese	Added LAB	3.6-3.7
	Dosa, Idli, Fesikh	Spontaneous LAB and Yeast	3.4-3.5
↓ low	Vegetables, Sauerkraut, Kimchi	Spontaneous or added LAB	3.1-3.3

[1] – LAB-lactic acid bacteria; [2] – SCOBY-symbiotic culture of bacteria and yeast

A non-fermented, high alkalinity processed food is also included in this guidance: pidan century egg (Section 3.14).

Box 1 | How to use the information in this food safety review

The information presented here lays out best practices for a variety of fermented foods, however, it does not replace or supersede federal and provincial guidance or regulatory requirements for fermented foods. Health inspectors, food safety staff, owner and operators of food processing facilities should follow federal and provincial food safety requirements. This work intends to assist food safety staff (health inspectors) to evaluate the safety of fermented foods and fermentation processes encountered during inspections. Owners and operators of food processing facilities may also find this guidance helpful as it reviews critical control points and measures recommended to produce safe fermented foods. The best available evidence guided this work at the time of publication. The application and use of this document is the responsibility of the user.

Guidance does not include information about good manufacturing practices, labelling practices, or management control programs for cleaning and sanitation, pest control, employee training etc. It is expected that operators will follow approved guidance and seek this information elsewhere.

3.6 | Yogurt

Authors: Leslie Hudson, Brooke Coopland, Yuchen Nan | Manitoba Agriculture

Overview

Description	  Yogurt is made with pasteurized milk that is inoculated with bacterial culture and fermented.
Starter culture	Commercial starter culture, including but not limited to *Streptococcus thermophilus* and *Lactobacillus bulgaricus*.
Key features	• Yogurt is a semisolid fermented milk product that may also include ingredients such as thickening agents, stabilizers, sweeteners, flavours, nuts and fruit. • The shelf life of commercially prepared yogurt products is commonly 4-7 weeks under refrigeration (these products have added stabilizers). • The shelf life of yogurt made in smaller facilities, without added stabilizing ingredients, is between 1 to 3 weeks.
Hazards of concern	• *Salmonella* spp., *Listeria monocytogenes*, *E. coli* O157:H7, moulds, physical fragments and others. • Microbial risks associated with raw milk or ineffective pasteurization: ○ Companies must start with commercially sourced, pasteurized milk unless they are a licenced dairy plant following a validated pasteurization process. • Microbial risks linked to post-fermentation processes, from added contaminated ingredients, cross-contamination and unsatisfactory food handler hygiene. • Poor quality of starter culture leading to ineffective fermentation and growth of spoilage agents and pathogens.
Important control points	• Use commercial starter culture (backslopping not recommended). • Use of pasteurized milk is a CCP. Small-scale producers must purchase commercially pasteurized milk. Commercial producers may pasteurize raw milk under a licenced dairy plant. • Implement strict sanitation controls. • Cooling milk to the inoculation temperature within 1 hour (best practice for commercial and small-scale), and up to a maximum of 2 hours (this is a CCP). Inoculation temperature is recommended by the starter culture manufacturer, and should be approximately 35°C-45°C. • Achieving an acidic pH of 4.6 or lower within a specified timeframe according to starter culture manufacturers' specification. This is usually between 2.5 to 5 hours. This is a CCP. The critical limit is to achieve the endpoint pH of 4.6 or lower within 2 hours of the manufacturers' expected incubation time. Example: manufacturers' specification states pH of 4.6 is achieved in 5 hrs. The fermentation is failed when a pH of 4.6 or lower is not achieved within 7 hours (5 + 2 hrs). *(continued on page 6)*

Important control points cont'd	• Cooling to 4°C or colder to stop fermentation, from the incubation temperature to 20°C within 2 hours, and from 20°C to 4°C within 4 hours. • Refrigerating yogurt to 4°C or colder. • Added ingredients must be free of contaminants. • Allergens are declared on labels or menus.

Background

Yogurt (or yoghurt) is a popular fermented product worldwide.[1] Most commercial yogurt is made from cow's milk, but it may be made from other milk sources such as buffalo, goat or sheep[2], or non-dairy plant-based milk like almonds, soy, coconuts, peas, oats, or cashews. In some jurisdictions, non-dairy-plant-based products cannot be called yogurt. This is linked to legislated specific compositional requirements associated with dairy yogurts, and other concerns. There are no federal regulations that describe the standards of identity for yogurt in Canada. There may be provincial regulations or industry guidance (e.g., Canadian Dairy Commission) that provinces follow. Box 2 describes naming concerns when using the word yogurt for plant-based products.

Yogurt is a semisolid fermented milk product that may also include ingredients such as thickening agents, stabilizers, sweeteners, flavours and fruit.[3] Canada's National Dairy Code describes yogurt as:

> "food obtained by lactic acid fermentation through the protosymbiotic mixture action of *Streptococcus thermophilus* and *Lactobacillus delbruckii* subsp. *bulgaricus* from milk ingredients and modified milk ingredients to which may have been added optional permitted ingredients".[4]

The Canadian Dairy Commission specifies yogurt compositional requirements as follows:[5]

> "The composition standards stipulate that yogurt must contain not less than 0.8% lactic acid, not less than 9.5% non-fat milk solids and not less than 3.0% protein. It may also contain some ingredients that come from milk (either whole or skim milk powder, or concentrated evaporated milk), fruits, fruit juices or extracts, jams, cereals or any other flavouring, sweeteners, a quantity not exceeding 2.0% of texturizing agents (stabilizers, gelling, thickening or emulsifying agents), citric acid, food colouring and, in the case of yogurt with added fruit, fruit juices or extracts or jams, a preservative not exceeding 50 ppm."

Detailed, internationally recognized compositional definitions for yogurt may be found in the Codex Alimentarius international standard for fermented milk products, published by the Food and Agriculture Organization and World Health Organization.[6]

Box 2 | Use of the word yogurt when describing plant-based products

The Codex Alimentarius is an international body that defines food standards. Yogurt is categorized as dairy product and is defined as milk fermented with a combination of *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus*. Products labelled with 'alternative culture yogurt' can also contain other *Lactobacillus* spp.[6] As adopted in 1999, milk is defined as a "normal mammary secretion of milking animals…".[7] How this ruling is interpreted is further explained in the General Standard for the Use of Dairy Terms (GSUDT) guidance.[8] In this context, non-dairy products such as yogurts made from plant-based sources, may not fit this specific definition and consequently, may not be described using the term "yogurt" as this term may mislead the consumer. The International Dairy Federation would strongly oppose any attempt to define or label any finished products that do not contain dairy as milk or milk products.[9] The objective of these standards is also to allow fair practices in food trade among countries.

The distinction is important because proteins of vegetable origin or made via genetic engineering culture methods are commonplace in many countries, and may represent misuse of the term "milk" and "yogurt". Consumers expect milk and dairy products to be made from the "normal mammary secretions of milking animals", not from nuts or in a laboratory.

(continued on page 7)

In Canada, the following response was also communicated on the issue of labelling of plant-based foods: "the common name selected to describe an unstandardized food product is subject to the requirements of subsection 5 (1) of the Food and Drugs Act and subsection 6 (1) of the Safe Foods for Canadians Act which prohibit the use of a common name that is false, misleading, deceptive or that creates an erroneous impression regarding the product."[10,11] The common name chosen to describe an unstandardized food must be suitable for the product. It should adequately describe the true nature of the product and it should not be misleading to the consumer. Any words or descriptors used in the common name of an unstandardized food product should be appropriate and they should accurately describe the product as it is sold to the consumer.

CFIA considers the yogurt as a derivate of milk.[12] However, there are no federal regulations that describe the standards of identity for yogurt or fermented milk in Canada. Only, some provincial regulations (i.e., province of Quebec)[13] or industry guidance (e.g., Canadian Dairy Commission)[5] regulate the composition associated with dairy yogurts. Thus, for yogurt made with soy, almond, coconuts or other non-dairy products, the use of the term "yogurt" on labels is inappropriate.

The GSUDT explains that commonly used marketplace terms in each country may be allowable if there is long and established use of the term in the country.[8] Operators making fermented plant-based products will also need to comply with provincial labelling practices that may be tied closely to compositional requirements. In the context of dairy products made with animal milk, this may mean use of words like "yogurt" and "milk" are not allowed in that province unless they contain animal milk. Operators in Quebec are instead advised to review requirements with authorities to ensure compliance with the Food products act.

In this guidance, we have decided to refer to all fermented plant-based products using the consumer recognized name for the product with the added description of what type of plant was used in the manufacture like Soy yogurt or Coconut yogurt. Nut milks, such as coconut milk, are additionally differentiated from true milk by using the term plant-based milk.

Milk from mammals (including cow, goat, sheep and buffalo) naturally contains lactose as a primary carbohydrate. Milk used to produce yogurt should be pasteurized to ensure that this is free of pathogenic bacteria such as *E. coli*, *Salmonella* and *Campylobacter* spp. The addition of starter culture to pasteurized milk initiates the fermentation process. The fermentation is normally completed in approximately 2.5 to 5 hours, during which the starter bacteria ferment lactose to lactic acid decreasing the pH. The acidification of milk by starter cultures provides the tart taste of yogurt and facilitates the formation of a semisolid yogurt texture as proteins coagulate in the increasingly acidic environment.[14] The growth of the organisms also results in the breakdown of peptides and amino acids.[14] The resulting metabolites including acetaldehyde and diacetyl, contribute to yogurt's aroma and flavour properties.[14]

Common yogurt types include skyr, Greek, French, Australian, drinkable and traditional varieties, which vary in thickness, texture, and sweetness. Set-style, stirred yogurt, and drinkable yogurt are three manufacturing procedures typically used, other types of yogurt, such as frozen, flavoured, and concentrated are variations.[15,16] For set-style yogurt, the milk mixture can be packaged immediately after the starter inoculation and incubated in the package.[15] Once the fermentation has reached the target acidity and pH, the containers are cooled rapidly to 4°C or colder to stop the fermentation. For stirred-style yogurt, the milk mixture is incubated in the fermentation tank until the titratable acidity is between 0.85 to 0.90% (pH 4.6 or lower), then it is cooled, stirred and combined with flavouring or fruit preparations prior to being packaged.[15]

Recalls and Outbreaks

Table 1 outlines the Canadian and international recalls associated with yogurt. Allergen recalls were issued to undeclared egg ingredients, and milk ingredients in plant-based soy and coconut yogurts. Biological (*Salmonella*, *Listeria monocytogenes*, moulds, insects), chemical (ethylene oxide) and physical (fragments of glass, plastic and metal) contaminants have been associated with these recalls.

Table 1 | Recalls related to yogurt products in Canada and elsewhere

Country	Year(s)	Hazard Category	Hazard Detail	Number Recalls	Product Description
Canada[17], U.S.[18,19]	2011, 2022	Allergen	Egg	3	Frozen yogurt mix, Mango Greek yogurt, French vanilla yogurt
New Zealand[20], U.S.[21,22]	2021, 2019, 2017	Allergen	Milk	3	Fruit puree drink with Greek yogurt pouch, Soy yogurt, Coconut yogurt
Canada[23-25], U.S.[26]	2011, 2013, 2014, 2021, 2022	Biological	Mould and Spoilage	5	Various chain and speciality brand yogurt products, Blueberry plant-based yogurt
Canada[27]	2015	Biological	Insect infestation (extraneous material)	1	Mango and cranberry yogurt topping
Canada[28,29]	2011	Biological	*Listeria monocytogenes*	2	Yogurt and yogurt drinks
Canada[30]	2012	Biological	*Salmonella* Braenderup	1	Made in store yogurt with added mango
Canada[31]	2012	Chemical	Chemical residues	1	Goat milk yogurt
Europe[32-34]	2021	Chemical	Ethylene oxide (pesticide and sterilizing agent)	40+	Yogurt and multiple other food products (40+ in total)
Canada[35,36]	2017	Physical	Plastic pieces	5	Yogurt and yogurt drinks
U.S.[37,38]	2018, 2022	Physical	Glass pieces	2	Plant-based yogurt, Greek and low-fat yogurts

Yogurt has been implicated in several outbreaks in the U.S., from a variety of foodborne pathogens, such as hepatitis A, *L. monocytogenes*, norovirus and *Clostridium perfringens*. Many outbreak clusters involve frozen yogurt and it is likely that addition of contaminated ingredients (e.g., frozen berries) and food handler issues contributed to these foodborne illness (e.g., norovirus, hepatitis A).[39]

Table 2 | Outbreaks related to yogurt products in Canada and elsewhere

Country	Date	Pathogen causing illness[1]	No. Ill (no. hospitalized)	Premises where outbreak occurred	Reason
United Kingdom[40,41]	1989	*Clostridium botulinum*	27 (26) and one death	Consumer purchases of manufactured yogurt	Hazelnut yogurt, inadequately processed hazelnut preserves
Turkey[41]	2005	*Clostridium botulinum*	10	Not applicable	Yogurt buried under soil in warm summer months
U.S.[39,41]	2015	*Clostridium perfringens*	12	Not identified	Not identified
U.S.[42]	2021	*E. coli* O157:H7	17 (10) and 4 HUS*	Consumer purchases of manufactured yogurt	Pasteurized yogurt – unknown
U.S.[39]	2007	Hepatitis A	16 (5)	Restaurant	Not identified
U.S.[39]	2014	*Listeria monocytogenes*	2 and 1 death	Homemade	Raw milk-based yogurt
U.S.[43,44]	2013	*Mucor circinelloides*	200	Consumer purchases of manufactured yogurt	Greek yogurt – virulent toxin producing mould species

* HUS = hemolytic uremic syndrome

Description of food preparation for yogurt

Box 3 | Pasteurized milk must be used to make yogurt

Small-scale producers, such as restaurants, must purchase commercial pasteurized milk for yogurt production. There is one exception: licensed dairy plants. Dairy plants pasteurizing raw milk are required to meet additional regulatory requirements and be licenced specifically for this activity. Unless the operator has a dairy plant licence issued in their province, they cannot pasteurize raw milk in the premises.

Commercial producers will add pasteurized liquid dairy ingredients such as milk, cream, whole milk, and skim milk into the processing vat.[15] Various dry ingredients, including stabilizers and sweeteners, are blended into the liquid dairy ingredients, examples of added ingredients are shown in Table 3.[16,45] The temperature of the milk should be controlled during the addition of ingredients in order to maintain temperature at 4-5°C.[15] The raw milk mixture is homogenized to thoroughly mix the ingredients.[15] Homogenization improves yogurt consistency by reducing the size of fats so that milk fat is evenly distributed in the yogurt.[46,47] In commercial dairy plants, the homogenization step occurs before pasteurization. Following pasteurization, the milk is cooled to the yogurt inoculation temperature, or chilled to 4°C or below for storage. Commercial processors will have equipment that rapidly cools milk within one hour to the desired temperature. Cooling is a CCP.

Small-scale producers using pasteurized milk may blend in or add additional ingredients, such as skim milk powder.[48] A recommended optional step is to heat the milk to 85°C for 30 min (or equivalent) to denature whey proteins and improve yogurt gelling consistency.[49] The milk should then be cooled to the starter culture inoculation temperature as quickly as possible, within 1 to 2 hours (cooling is a CCP). The recommended best practice is to cool milk within 1 hour, milk must be cooled within 2 hours.

Pasteurized milk mixture should be at the designated temperature according to the culture supplier's recommendation (e.g., 42°C) before the yogurt starter culture is inoculated.[15] The optimal temperature for starter cultures may range from 35°C to 45°C for *S. thermophilus* and *L. bulgaricus* cultures.[50,51] The starter culture is inoculated into the milk mixture at the designated ratio following the culture supplier's recommendations.[15,46]

Dry starter culture may be mixed with a small volume of milk before adding to the processing container. Based on the desired yogurt type and texture, the bacteria composition and ratio may vary to achieve the optimum flavour, acidity, and texture.[46] It is recommended to use commercialized concentrated cultures as a yogurt starter culture; since the culture manufacturer controls the bacteria ratio, it can provide more consistent yogurt quality.[46] Additional ingredients such as ready-to-eat fruit, nuts and flavours can be added.

Table 3 | Description of added ingredients to yogurt products

Sweeteners	Milk composition and Stabilizers	Flavourings and Additives
sucrose molasses honey high fructose corn syrup	gelatin locust bean gum modified starch pectin skim or whole milk powder xantham gum whey protein concentrates	fruit juice fruit puree nuts vitamins A and D colouring

For **stirred-style yogurt**, the inoculated milk mixture is transferred into the fermentation tank to produce the plain yogurt. The yogurt is then transferred or mixed with other ingredients prior to filling into containers. For the **set-type yogurt**, the inoculated milk mixture is immediately transferred into individual cups, with a fruit layer on the bottom (optional), and then the cup is sealed.[46] It is recommended to use commercially processed fruit products (e.g., pasteurized or equivalent process) for yogurt production to reduce food safety risks. The inoculated milk mixture, in either individual packages (set-type yogurt) or the fermentation tank (stirred-style yogurt), is incubated at the designated temperature (ranging from 35°C to 45°C)[49] according to the culture supplier's recommendation.[15] The product is refrigerated once the fermentation is complete, when the pH is 4.6 or lower (or the titratable acidity (TA) of the yogurt is between 0.85 to 0.90%), depending on culture supplier's recommendation.[15,52] For **stirred-style yogurt**, the coagulated yogurt mix is cooled to 4°C, then blended/ stirred with flavour, fruit (optional) and packaged.[46]

For small-scale and commercial producers, the time to achieve an adequate pH drop must be monitored, measured and recorded (this is a CCP). The time typically required for pH drop from pH 6.6 (milk) to pH 4.6 or lower (yogurt) varies, according to the starter cultures types and fermentation temperature, from 2.5 hours to 5 hours or longer.[15] Check initial pH and test pH according to expected timelines from starter culture manufacturer. Manufacturers provide expected pH curves based on incubation temperature. If the pH of the batch does not reach the end-point pH of 4.6 or lower within two hours of the expected timeframe (this is the critical limit for this CCP), the batch has failed, and must be discarded.[49] Operators should check the pH at the end-point to ensure the correct pH is achieved, and continue monitoring to ensure the batch pH decreases as expected.

Example: the manufacturers' specifications for the starter culture state that a pH of 4.6 should be achieved within 4 hr at a fermentation temperature of 39°C. Fermentation should be completed within 4 hr. Two additional hours (the critical limit) is permitted to achieve a pH of 4.6 or lower. At 4+2=6 hr, if a pH of 4.6 or lower is not achieved, the fermentation is considered failed and the batch must be destroyed. pH checks should be recorded by the operator for every batch in a log. In the example given in Table 4, the yogurt batch in Scenario A and Scenario B does not reach a pH of 4.6 in the expected 4 hr timeframe. The operator keeps checking the pH every 30 minutes. Scenario A yogurt does achieve pH of 4.6 within the next 2 hr (at 5.5 hr) but Scenario B yogurt does not and the batch is considered failed (at 6 hr).

Table 4 | Critical limit scenarios

	Scenario A	Scenario B
Operator checks pH at 0 hr	pH=6.6 Operator begins incubation	pH=6.6 Operator begins incubation
Operator checks pH at 4 hr	pH=4.8 Operator continues incubation	pH=4.8 Operator continues incubation

(continued on page 11)

Operator checks after 30 min (at 4.5 hr)	pH=4.7 Operator continues incubation	pH=4.7 Operator continues incubation
Operator checks after 60 mins (at 5 hr)	pH=4.7 Operator continues incubation	pH=4.8 Operator continues incubation
Operator checks after 90 min (at 5.5 hr)	pH=4.6 Fermentation successful. Yogurt is refrigerated.	pH=4.8 Operator continues incubation
Operator checks after 120 min (at 6 hr)		pH=4.7 Fermentation fails. Batch of yogurt is discarded.

The shelf life of commercially prepared, packaged yogurt products is commonly 4-7 weeks under refrigeration (2-4°C).[46] The shelf life of yogurt prepared by restaurants or small-scale producers will be much shorter, depending on the ingredients added to the yogurt, packaging and refrigeration temperatures. Without added ingredients, the shelf life of plain yogurt under refrigeration is between 10 days to 3 weeks.[16,48] Note: the acidity of yogurt will continue to increase slowly during storage.

To prevent post-fermentation contamination, the safety and microbial quality of all additional ingredients such as fruit purees, or nuts must be carefully controlled.[16] Raw, fresh fruits are likely to contain bacteria and moulds that may affect product safety and shelf life. Washing raw fruits with potable water will remove surface contaminants but will not remove all bacteria, moulds or pathogens. Using pasteurized or thermally processed fruit mixtures when adding to the yogurt (for example) is one method of controlling risk of added ingredients. In commercial yogurt production, fruit mixtures (or fruit preparations) are thermally processed, hot-packed and cooled. In one review of commercial yogurt preparation, the fruits are heated with sugar, water, stabilizers and other ingredients to temperatures >85°C, held for 3 minutes at this temperature to ensure all parts of the fruit are heated through, then cooled to 71°C before packaging, and cooling.[53] Other methods to control ingredient risk (for example) are to: control the time by serving yogurt with added raw fruits on the day made, then discarding at the end of the day; or control the process by adding raw fruits just before service.

Raw nuts may contain harmful bacteria and all nuts in general are subject to mould and mycotoxin contaminants. Nuts and yogurts made with plant-based milks made with nuts (for example, almond milk) contain allergens and must be declared on the label or in the menu to advise consumers of allergen risk. Operators can demonstrate controls of ingredients for fruits, nuts and other inclusions that may pose a human health risk for pathogens, chemicals and allergens by:

- Obtaining a letter of guarantee from the supplier confirming the product has been tested for indicators and pathogens (e.g., *E. coli* or *Salmonella*) or chemical contaminants (e.g., mycotoxins such as aflatoxin),
- Apply a treatment to the added ingredients to reduce the likelihood of microbial contamination (e.g., heat treating nuts or fruit, to boiling or temperatures of 90°C or higher for at least 2 min or to 85°C or higher for at least 3 min; the minimum temperature of 74°C for at least 15 sec must be achieved),
- Using acidified fruit ingredients with a pH of 4.6 or lower,
- Using dried ingredients with an a_w of 0.85 or lower,
- Controlling time, when fresh ingredients are added (e.g. added fruit berries). For example, use yogurt same day, up to a maximum of 3 days, then discard.
- Evaluate the product shelf life and quality (e.g., check for yeasts and mould growth, separation in the yogurt as signals the safety and quality of the product is affected)
- Provide allergen labelling on packaged products or on menus for products served in restaurants on-site.

Shelf life should be assessed by the operator. In general, yogurt made in-house by small scale producers and stored under refrigeration, will have an optimal shelf life of 10 days to 3 weeks, however this shelf life may be reduced depending on other factors, for e.g., added ingredients, packaging and temperature controls.[16,48]

Additional considerations for small-scale producers:

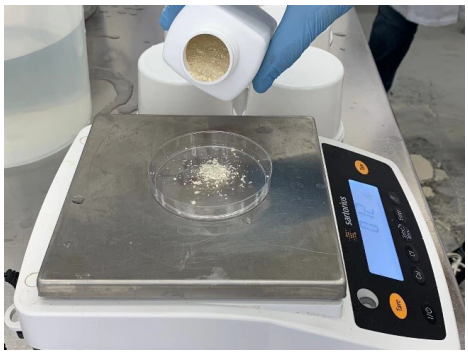
- Backslopping is not an acceptable practice for small-scale producers of yogurt.
- Small-scale producers should check applicable legislation in their province if they wish to sell and distribute yogurt. For example, restaurant operators may be restricted from sale and distribution of products without additional over-sight (inspection, licensing) from agriculture and health authorities.

An excellent resource aimed at small scale producers of yogurt and other cultured dairy products is available from this website: https://foodsafetyplans.foodsafe.ca/dairy-guidelines.html[49] The guidance provides step-by-step process instructions for making small batches of yogurt and other cultured dairy products.

Figure 2 | Processing steps for yogurt manufacture

Step 1: Warm the pasteurized milk blend

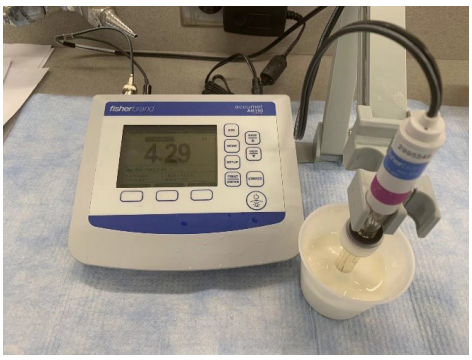
Step 2: Inoculate with starter culture



Step 3: Package (optional depending on yogurt type)

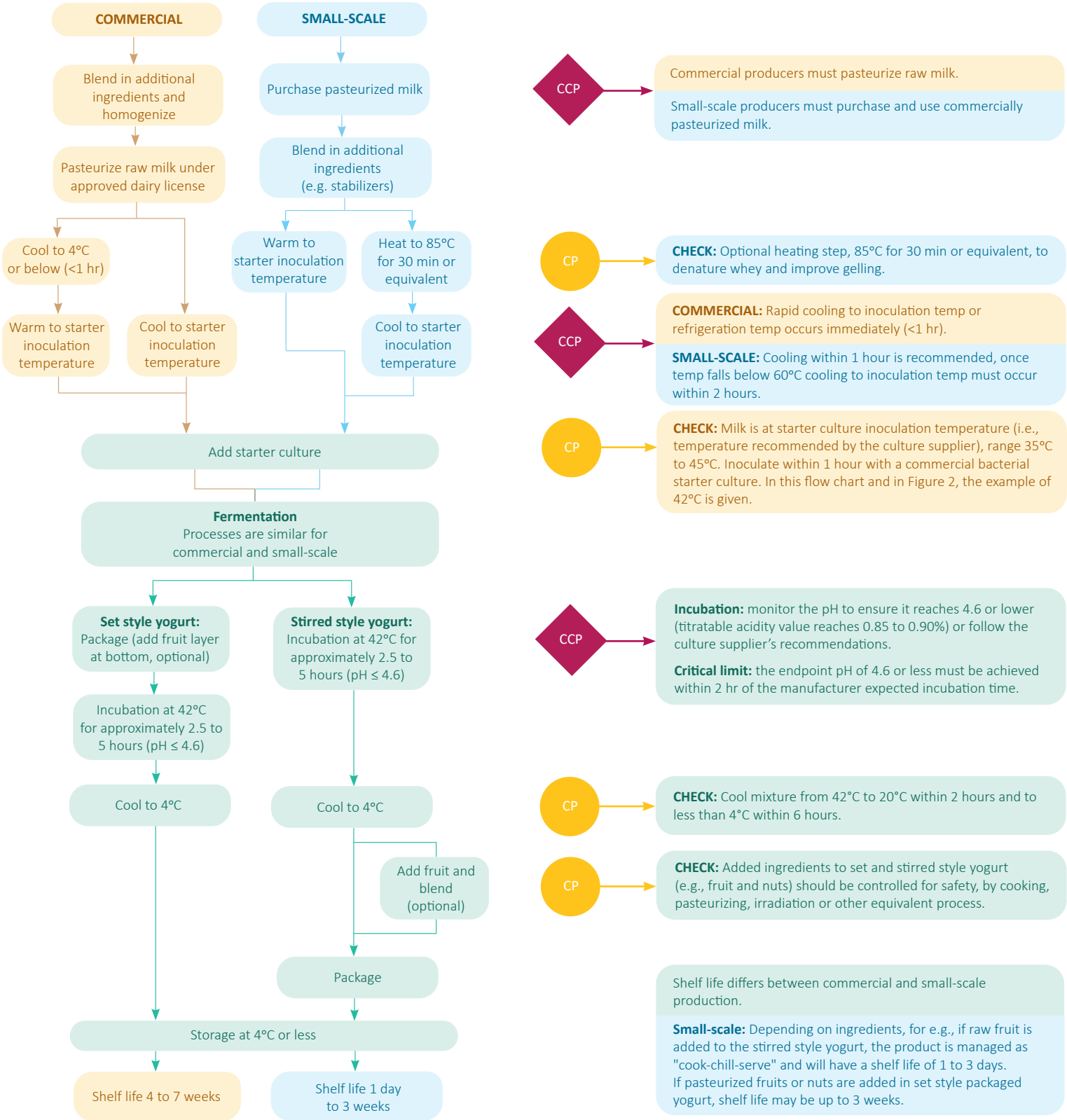
Step 4: Incubate at appropriate temperature

Step 5: CCP - Measure pH value



Step 6: Cool to 4°C

Yogurt food flow chart | Process flow and controls



Potential issues with yogurt food preparation

Issue	Description
Milk source	Use pasteurized milk to make yogurt. Pasteurization of raw milk can only be performed by a licensed dairy plant.
Starter culture source	Use a commercially sourced starter culture, and follow manufacturer's recommendations for inoculation temperature. Backslopping is not recommended.
Improper temperature of milk when inoculated	When cold, pasteurized milk is used, the mixture must be warmed to the incubation temperature (37°C to 45°C, per manufacturer) and be inoculated with the starter culture within one hour.[54] Quickly establishing the fermentation will decrease the milk mixture's pH and prevent pathogenic and spoilage microorganisms growth.[54]
Incorrect use of starter culture	When the starter culture is added to milk that is too hot or too cold, it can lead to slow acid production or death of the culture leading to potential growth of pathogenic organisms in the milk mixture.[46] This may also compromise the yogurt products' final flavour and texture. Discard the yogurt product when the fermentation process is slow or ineffective to prevent growth of pathogenic and spoilage microorganisms.[46]
Hygienic procedures not used	Always use a sanitized thermometer to measure the milk temperature to prevent contamination. When measuring pH before, during, and at the end of fermentation, remove a portion of the mixture to test the pH. After the pH check, discard the test batch, do not pour it back into the fermentation vessel.
Yogurt spoilage	Dispose of any yogurt product with signs of spoilage or unpleasant odours.[55] Discard batches associated with potentially contaminated ingredients or starter cultures.[55] To prevent spoilage, thoroughly clean and sanitize all equipment and utensils to ensure the quality of yogurt products.[55] Use new starter cultures and ensure the ingredients such as fruits and nuts are pasteurized or ready-to-eat.[55]
Approved ingredient source	Obtain all ingredients from reliable suppliers, where possible obtain certificates of assurance that ingredients are free of microbial and chemical (e.g., allergens, antibiotics) hazards.
Added ingredients	Contaminated ingredients have resulted in yogurt outbreaks and recalls. It is recommended to use canned, cooked fruits in yogurt. Added fruits should, at a minimum, be cooked to an internal temperature of 74°C for 15 seconds prior to adding to yogurt. Added nuts should also be pasteurized, and allergens declared on label or menu. Limit food safety risks of ingredients by asking for certificates of assurance from ingredient suppliers. Other controls may be considered for added ingredients (for e.g., raw fruits) such as serving the product on the same day, then discarding at the end of day.
Foreign material (Glass, Plastics)	Implement good manufacturing practices in the processing facility to reduce possible sources of physical hazards such as brittle plastics (e.g., fragments of packages or utensils) and glass (e.g., light bulbs, glass containers).
Shelf life of yogurt	The shelf life of yogurt should be established by the operator. Shelf life is dependant on the added ingredients, such as whether stabilizing agents were added, flavourings, storage temperature and packaging.

Yogurt food safety control points

- Small scale producers (e.g., restaurants) without a provincial or federal dairy processing licence must use commercially pasteurized milk to make yogurt.
- Use a starter culture from a commercial supplier to ensure consistent yogurt quality and safety. Follow the manufacturer instructions for amounts of starter culture to add, and inoculation temperatures to use.
- Sanitation: implement strict sanitation controls to prevent contamination during fermentation, and during packaging and storage to prevent post-pasteurization contamination. For example, always clean and sanitize thermometers before measuring milk temperature; during pH checks, remove a small portion of milk or yogurt from the batch, check the pH, then discard.
- Acidification: use pH or TA values as an indicator for fermentation process evaluation. Recommended pH and TA values may vary according to a culture supplier's specifications. Yogurt must be fermented to an endpoint pH of 4.6 or lower (≤4.6) within the expected time-frame. Yogurt that does not reach endpoint pH within 2 hours of the expected time (this is the critical limit) is considered failed. Batches that do not reach the desired pH are to be discarded.
- Cooling steps prior to adding starter culture and after fermentation to refrigerated temperature are CCPs and must be monitored and recorded.
- Added ingredients (e.g., fruits or nuts) should have a minimum heat-treatment of 74°C or higher for 15 seconds before they are added to final product. Higher temperatures, e.g., to 90°C for 2 min or to 85°C for 3 min are recommended. All allergen risks should be declared on the label or menu.

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Photo attributions

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Overview photo (right, yogurt in bowl): Getty Images

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