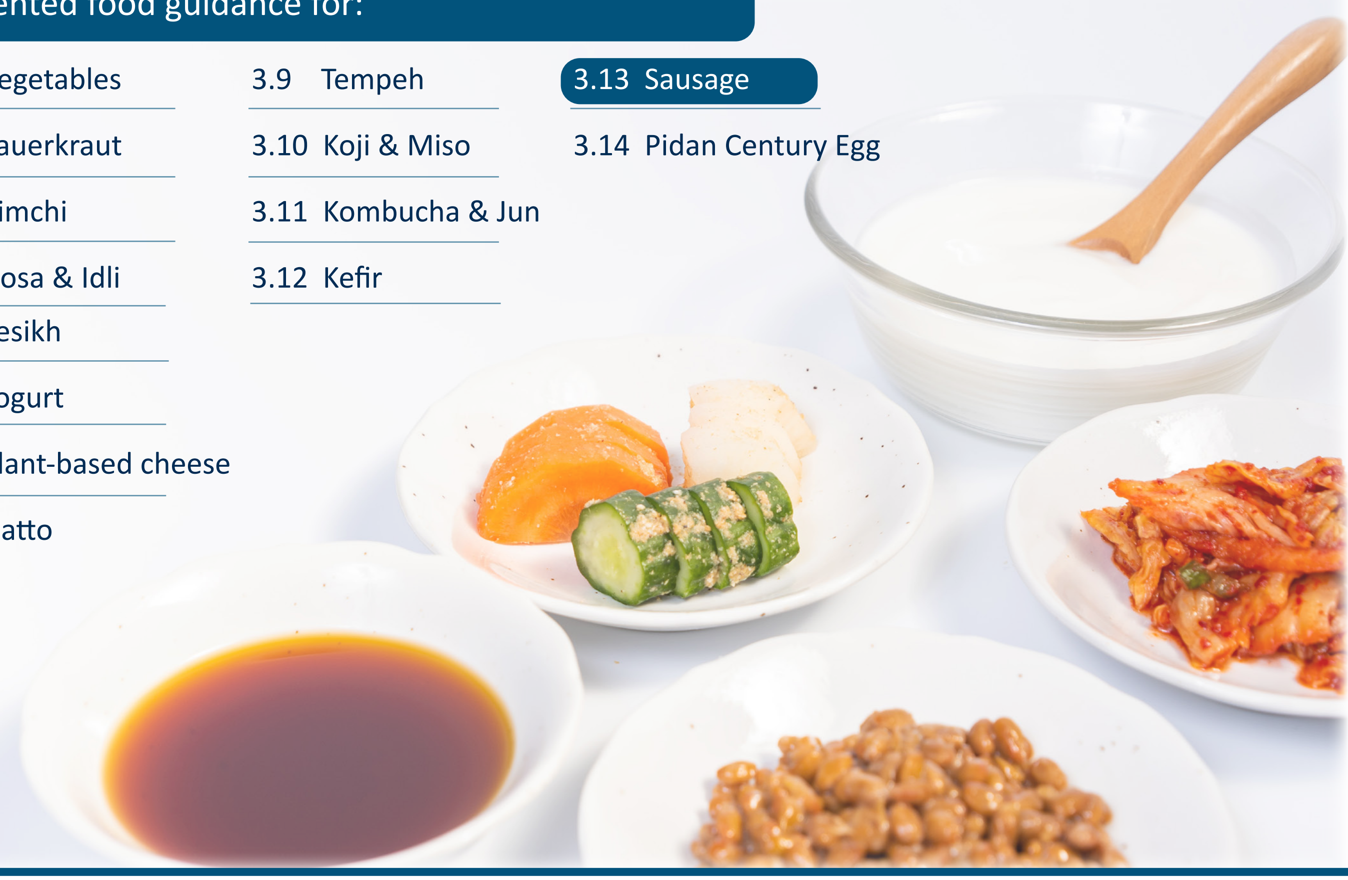
June 2026

Safety of Fermented Foods

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



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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.

3.13 | Fermented Sausage

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Overview

Description	 Ground or comminuted beef and/or pork is encased and fermented with or without heat to make charcuterie style meat products, such as dried salami and pepperoni, or semi-dry summer sausage (see Table 2 for additional examples of fermented sausages). The scope of this document does not include other meats such as poultry.
Starter culture	Lactic acid bacteria (LAB): commercial source recommended. Other starter cultures may include *Micrococci* and *Pediococci*. The most common name for this starter is Bactoferm. Chemical acidifiers may also be added to speed up fermentation.
Key features	Depending on process chosen • May be ready-to-eat (RTE) or require further cooking • May be shelf stable or require refrigeration
Hazards of concern	• *C. botulinum* • *E. coli* O157:H7 and other pathogenic shiga-toxigenic *E. coli* (STEC) • *Salmonella* • *Listeria* • *Trichinella* in pork meat • *Staphylococcus* aureus • *Yersinia* (predominately pork) • Biogenic amine
Important control points	• Time and temperature as a control calculated as degree-hours to control *Staphylococcus aureus* if fermentation is performed above 15.6°C. • Nitrite/nitrate is added to control for *C. botulinum* and calculated in recipe to a minimum limit of 100ppm and a maximum limit of 200 ppm for each salt. Common names for nitrites include Prague powder, pink salt, and cure. • If using beef as an ingredient implement one of the 5 control measures in Health Canada Guideline No. 12 to control for *E. coli* O157:H7 and *Salmonella*.[1]

(Continued on page 7)

Important control points cont'd	• If making pork sausages in a facility that processes beef, operators must follow Health Canada Guideline No. 12, unless they ensure 'forward flow' of pork sausage products. Forward flow means pork sausage may only be processed using materials and equipment in processing areas where beef is not being processed, after applying adequate cleaning and sanitizing procedures. Beef containing products may be processed behind the pork, but not in front. • If using pork as an ingredient implement control measures for *Trichinella* by following one of Health Canada's control recommendations for the inactivation of *Trichinella spiralis* in pork products.[2] It is important to note that *Trichinella* found in wildlife (i.e. *T. nativa*) may be resistant to freezing, and, therefore are not eliminated using the freezing controls developed for pork; instead meat from wild pigs and other animals needs to be well cooked.[2] • Ensure pH and water activity (a_W) growth limiting requirements are met as described in Government of Canada guidance (i.e., Canadian Food Inspection Agency guidance for shelf stable, fermented and dried meats[3] and Health Canada control measures for *L. monocytogenes* in RTE foods)[4]. • Growth limiting factors such as pH decrease, presence of lactic acid, decreases in a_W, and presence of starter culture are important for controlling *Yersinia*. • Incorporate good manufacturing and hygiene practice (GMP/GHP) controls throughout fermentation, smoking and drying processes. Limit opportunities for post-processing contamination (e.g., during slicing, packaging) because *Listeria* spp. contamination is most likely to occur AFTER processing when controls are limited, primarily as *Listeria* spp. can multiply under refrigeration temperatures.

Background

Fermentation and drying of fresh meat can extend the shelf life of this highly perishable protein, with these processes primarily used to produce sausages.[5,6] The production of sausage-shaped fermented meats is thought to have originated back to the Romans as early as 2,000 B.C.[5,7] Many sausages derive their names from the city where they originated, such as Salami, Genoa, Mettwurst and others.[8]

In the production of fermented products bacterial growth is desirable and required to reduce pH to produce a safer product.[6] Fermentation requires lactic acid bacteria (LAB) commercial starter culture. Chemical acidifiers may also be used to reduce pH as an optional aid in addition to use of LAB starter culture.[9] Chemical acidifiers include Glucono Delta-Lactone (*GDL* - a *fermented* rice sugar); and encapsulated citric or lactic acid.[10] Regardless of which method is used, the pH drop within degree-hour requirements must be achieved to control *Staphylococcus aureus* if fermentation is performed above 15.6°C.[3]

There are several critical control points (CCPs) in the production of fermented sausages, described further in this guidance, including CCPs that require calculations. Important controls include:

- using an appropriate starter culture and/or chemical acidifiers (backslopping is not recommended, see Box 11),
- ensuring incoming materials come from an approved licensed and inspected source,[11]
- ensuring sufficient pH drop, time as a control during fermentation to limit growth of *S. aureus* requiring degree-hour calculations,
- implementing control measures for *Trichinella*,
- ensuring minimum and maximum amounts of salt are added,
- ensuring minimum and maximum amounts of nitrite/nitrate salt are added (operators must be able to calculate the exact amounts),
- implementing control measures to avoid excess nitric oxide (NO) production, methemoglobin production, and potentially cyanosis and hypoxia,
- ensuring acceptable water activity (a_W) and pH of end product for shelf stable products.

As the level of lactic acid rises, the pH of the product decreases. The tangy, sour taste that we associate with fermented RTE meat products comes from the lactic acid that is produced because of LAB growth.

All fermented sausage products[3]:

- must be cured, having at least 100 ppm and no more than 200 ppm of nitrite/nitrate (sodium nitrite, potassium nitrite, sodium nitrate, or potassium nitrate),
- must have a minimum of 2.5% salt, generally in the range of 2.5% to 3.5% salt (note: additions of 4% or higher salt may inhibit the bacterial culture), and
- require an appropriate starter culture or chemical acidifier (natural fermentation and backslopping are not recommended).

Fermented sausages are required to contain nitrites and nitrates. In addition to acting as microbial hurdles for *S. aureus*, *C. perfringens*, *L. monocytogenes*, *B. cereus* and *C. botulinum* these chemicals will develop curing flavours, red colour, and inhibit lipid (fat) oxidation and rancidity.[12,13]

Nitrates (sodium nitrate or potassium nitrate) should only be used for long-term cured/fermented products (when 3 weeks or longer is required for fermentation/drying) and should be used with a *micrococcus* starter culture. *Micrococcus* bacteria convert nitrate to nitrite and have been used for a long time as a starter culture in salami because of their contribution to development of curing colour and flavour.[14] If using a combination of nitrites and nitrates for fermented products where the fermentation/drying time is 3 weeks or more, the maximum would be 200 ppm nitrite and 200 ppm nitrate, a total combined concentration of 400 ppm.[15]

The addition of nitrates is to ensure the product stays protected from *C. botulinum* for the duration of the ripening and drying period. The nitrates act as a reservoir by slowly converting nitrate to nitrite and thus continuing to protect products from *C. botulinum* after the 100-200 ppm nitrite reservoir becomes depleted. In products fermenting within a few days to a few weeks the 100-200 ppm nitrite should not deplete enough to require any nitrate addition. If one were to add nitrates in conjunction with nitrites to a product fermenting/drying for only a couple weeks, then one risks excess nitric oxide (NO) production, methemoglobin production, and potentially cyanosis and hypoxia in the end consumer.

If using beef as an ingredient, which would include beef casings, implement one of the 5 control measures in Health Canada guideline No. 12 to control for *E. coli* O157:H7 and *Salmonella*.[1,10] For sausage types that do not contain beef but where the facility processes beef for other products, operators must ensure the "forward flow" of products and prevent the risk of cross contamination, in particular by applying adequate cleaning and sanitizing procedures for equipment and materials.

An alternative to Health Canada guideline No. 12 would be to follow a process approved by provincial regulatory oversight, as summarized in Table 1 below. For example, in Quebec, uncooked fermented sausage may be acceptable if additional measures (such as but not limited to) trimming or surface searing of meat before grinding, not using beef casings, evaluation of control measures and microbiological lot testing are implemented by the manufacturer. Spontaneous (natural, wild) fermentation of meats is not recommended, as the time required for pH drop may allow growth of unacceptable bacteria. Use of previous culture, or backslopping, is also not recommended, although allowable in some cases (see Box 11). In provinces where backslopping is an option, it is only permissible under very strict conditions that include microbiological testing for *Salmonella* and *E. coli* O157:H7 in finished lots.

Table 1 | Options for Control of *E. coli* O157:H7 and *Salmonella* per Guideline No. 12 for Fermented Beef Sausage in Canada

Option	Method	Detail
1	Heat treatment	Heat process to control *E. coli* O157, e.g., to an internal temperature of 54.4°C (130°F) for 121 minutes or equivalent Lot testing for *E. coli* O157 not required.
2	Process for 5D reduction of *E. coli* O157	Use a manufacturing process (combination of fermentation, heating, holding and/or drying) which has already been scientifically validated to achieve a 5D reduction of *E. coli* O157:H7
3	Micro end-product testing	Lot testing for *E. coli* O157:H7 and *Salmonella* required. Minimum 30 samples per lot (a maximum of 3 samples may be pooled for composite testing, e.g., 10 composites of 3 samples each). Records kept for 2 years. Refer to CFIA if this option is chosen.[a]
4	HACCP system and 2D reduction of *E. coli* O157	Lot testing for *E. coli* O157 and *Salmonella* required. Raw product batter taken at beginning of process, and final product are compared to ensure 2D to 5D reduction of *E. coli* O157:H7[a]
5	Alternative process – federal oversight	Evaluation by Health Canada and CFIA of process that will achieve a 5D reduction of *E. coli* O157:H7[a]
6	Alternative process – provincial oversight	Evaluation by provincial regulator. Example requirements (may vary by jurisdiction): incoming ingredients from validated supplier; *E. coli* O157:H7 and *Salmonella* controls in place; meat is trimmed or outer surface cooked before grinding; measures to prevent cross-contamination; and periodic microbiological lot testing for Shiga toxin-producing *E. coli* (STEC) and *Salmonella* required.

[a]Unless mandated by CFIA, options 3-5, in highlighted rows, would not be sustainable or realistic for small-scale operations and restaurants. Microbiological testing options are provided from guideline No. 12 but would require laboratory testing and approval by CFIA or the provincial authority that reductions meet acceptable standards.

If using pork as an ingredient, control measures must be implemented to address *Trichinella*. Control measures must include one of Health Canada's control recommendations for the inactivation of *Trichinella spiralis* in pork products, from defined parameters of curing, freezing, or cooking.[2] It is important to note that most species of *Trichinella* found in wildlife are resistant to freezing, and, therefore are not eliminated using the freezing controls developed for pork; instead meat from wild pigs needs to be well cooked.[2] Box 2 below describes concerns in more detail.

Box 2 | *Trichinella* concerns in fermented meats

Domestic pork concerns. Domestic sources of pork have been tested and found free of *Trichinella spiralis* for decades, control measures in commercially raised pork keeps this risk low.[16] The last case of domestic trichinellosis occurred in a small family run farm in 2013, although none of this meat went into commercial supply.[16] Free range farms, and farms with exposure and interaction with forest-dwelling (sylvatic) omnivores are at higher risk for acquiring this disease because it is well-established in wild-life and pests (e.g., rats) can pass on this zoonotic disease to farmed pigs.[17] In the U.S. some companies have developed a system to certify pork as *Trichinella*-free pork,[18] however, we could not find evidence these pork products are available in Canada (in 2024). As a precautionary measure in Canada, all pork products must undergo a curing, freezing or cook step to ensure *Trichinella* is absent in domestic pork.[2] Operators are required to document the methods used to inactivate *Trichinella* in their products.

Concerns with wild boar, beer, walrus and other hunted meats. *Trichinella* is common in many hunted animals, including wild boars, walruses, grizzly, polar, and black bears.[17] Many other sylvatic animals are documented to carry *Trichinella* in Canada too, for example, foxes, wolves, coyotes, racoons, bob cats, lynx, etc.[17]

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Outbreaks of trichinosis are not uncommon in hunters consuming previously frozen black bear meat[19–21], and one trichinosis outbreak was documented in fermented sausages and jerky made with bear meat (British Columbia (BC), 1997, unpublished). *Trichinella nativa* is of special concern in Canada because it is cold-tolerant and resistant to freezing. Reports of meats with viable parasites surviving freezing conditions of-10°C for 18 months and at-20°C for up to one year mean freezing as a control is not reliable to inactivate *T. nativa*.[17] Instead, meats are recommended to undergo a cook step to ensure minimum internal temperatures of 71°C are achieved for one minute or longer.[22]

Standards of identity for fermented sausage are shown in Table 2, other meat product standards can be found on the CFIA website.[23] By definition, sausage products must be cured as described earlier with the addition of nitrite/nitrate and salt. Salami and pepperoni, examples of fermented dried sausage, are raw sliceable sausages. They do not undergo a heat treatment that provides significant log reduction of bacteria. The combination of fermentation with an appropriate starter culture to promote rapid LAB growth, added curing agents of nitrite/nitrate, and drying, results in acidic pH and low water activity that provides process control for product safety.

Table 2 | Standards of identity for fermented sausage

Names of RTE sausage meat products	**Semi-dry** examples include summer sausage, German salami, cervelat, teawurst, liverwurst, chorizo, landjäger, pepperoni **Dry** examples include salami-hard, pepperoni-hard, dried beef sticks, genoa salami, chorizo, salminette, landjäger	
Mandatory ingredients	a. minimum 2.5% salt, generally in the range of 2.5% to 3.5% salt (for example, 3.3% salt is common with fresh pork sausage). b. 100-200ppm nitrite/nitrate c. bacterial culture/lactose or acidifier (GDL, encapsulated citric/lactic acid) d. water/ice	
Optional ingredients	a. Spices/seasoning b. Flavour enhancers c. Wine d. Cure accelerators/reductants e. Phosphates	f. Binders g. Extenders h. Starch i. Gums
Mandatory treatments and processes	Comminuted and cured, and fermented and one or more of the following: smoked, cooked, dried	
Minimum amounts	Min. 9.5% meat product protein Min. 11% total protein Min. 25% of the meat product ingredients to be liver, calculated as fresh liver, if common name is liver sausage or liverwurst	

Outbreaks and Recalls

Listeria monocytogenes detections in fermented salamis and ready-to-eat (RTE) meats account for most recalls shown in Table 3 (n=8), followed by *Salmonella* (n=5), *E. coli* O157:H7 (n=2) and *Staphylococcus aureus* (n=1).[24] Fermented sausage and RTE charcuterie products are high risk products that have been recalled in several countries. Allergen recalls and physical recalls (from metal fragments, blades or bones) are also noted. Other recalls occurred due to suspicion of processing failures and misbranding.

Table 3 | Recalls related to fermented sausage and meat products in Canada and elsewhere

Year(s)	Hazard Category	Hazard Detail	Number Recalls	Country (s)	Product Descriptions
2021, 2018, 2014, 2011[25–29], 2020[27], 2018[28]	Biological	*L. monocytogenes*	8	Australia, Canada, France, United States	Cheese, sausage/salami consumer size portions Salami, several varieties (Genoa, mustard seed, Calabrese, garlic) Horse salami and RTE meats
2021, 2019, 2017[27–29]	Biological	*Salmonella*	5	Italy, Germany, United States, Canada	Salami and assorted antipasto meats (prosciutto, soppressata, Milano salami, and coppa)
2018[29]	Biological	*E. coli* O157:H7	2	Canada	Pork salami
2013[29], 2024[65]	Biological	Staphylococcal enterotoxin (*S. aureus*)	3	Canada	Polish salami, cocoa salami, cacciatore salami
2012, 2013, 2017[28,29]	Allergen	Milk	3	United States, Canada	Pork salami, salami
2021, 2014, 2013[29]	Allergen	Mustard	3	Canada	German salami, Black forest salami
2021[29]	Allergen	Wheat	1	Canada	Salami
2021[29]	Other	Spoilage	1	Canada	Salami (soppraseta)
2018, 2015, 2019[25,29]	Other	Failure to process properly	3	New Zealand, Canada	Salami, and other cured products
2019, 2017[28]	Physical	Metal	3	United States	Andoille sausage Pork salami, Genoa salami, capacollo
2013, 2016[29]	Physical	Bone fragments	1	Canada	German salami, other varieties varieties
2015[28]	Temperature abuse	Concern *C. perfringens*	1	United States	Smoked salami
2015 to 2021[28]	Uninspected	Misbranding (unauthorized use of USDA inspection mark)	9	United States	Various RTE, smoked beef and pork salami products

Outbreaks linked to fermented sausages and meats have occurred and continue to occur throughout the world. Shigatoxigenic *E. coli* (STEC) strains in fermented beef sausages and meats were linked to significant outbreaks in the United States (1994), Australia (1996), and Canada (1999).[30–32] In 1999, a STEC outbreak occurred in BC in a federally registered processing facility that was linked to dry fermented meat products.[30] Understanding of STEC was developing, and these outbreaks spurred development of new standards in Canada, and other countries, specifically guideline No. 12 that is described in Table 1. Canadian guidance requires process control to reduce *E. coli* in meat products containing beef. This salami outbreak marked the first occurrence where epidemiological evidence, without laboratory confirmation in the food, resulted in food product recalls and the first instance that pulsed field gel electrophoresis (PFGE) was used to match clinical and food specimens to the STEC strain. Of interest, an additional 47 cases of *Yersinia enterolitica* were also epi-linked to sausages (unreported).

Botulism, trichinosis and salmonellosis have also caused illnesses in fermented meat products, summarized in Table 4.

Table 4 | Outbreaks related to fermented sausage and meat products in Canada and elsewhere

Date[1]	Country	Pathogen causing illness*	No. Ill (no. hospitalized)	Premises where outbreak occurred	Reasons
2006	Taiwan	*Clostridium botulinum*	5 (0)	Home	Home fermented raw goat meat, type B botulinum
1999[30]	Canada	*E. coli* O157:H7	143 (42) 6 HUS	Processing Plant	Hungarian and Cervelat Salami. Processing methods did not reduce *E. coli* to acceptable levels.
1995[31]	Australia	*E. coli* O111:NM	139 (24) 1 death 16 HUS[2]	Processing Plant	Uncooked semi-dry fermented
2004	Australia	*E. coli* O111 -	23 (21) 1 death	Home	Fermented meat – mettwurst
2007	Sweden	*E. coli* O157:H7	30	Community	Contaminated beef was suspected. Delayed start of fermentation, lack of heat-treatment & a short curing period in cold temperature were identified as the main factors enabling Enterohemorrhagic *E. coli* (EHEC)
1994[32]	United States	*E. coli* O157:H7	23 (6) 2 HUS	Retail	Commercially purchased dry cured salami
2007	United States	*E. coli* O157:H7	27[3] (11)	Home	Pepperoni
2011	United States	*E. coli* O157:H7	14 (3)	Community	Lebanon bologna is a fermented, semi-dry sausage
2007	Sweden	VTEC	1	Home	
2008	Canada	*Listeria monocytogenes*	57 (23)	Retail and Institutions	Cooked deli meats, including salami, pepperoni and sausage contaminated on slicer processing lines
2020	France	*Salmonella*	42	Imported	Fuet, a type of sausage from Spain, dry-cured sausage
2007	Sweden	*Salmonella* Typhimurium	5[3]	Home	
2010	Argentina	*Trichinella*	7	Community	Unapproved source of pork

[1]Unless indicated, all other references from the Publicly Available International Foodborne Outbreak Database PAIFOD summary[33]; [2]HUS – hemolytic uremic syndrome; [3]reported as presumptive cases.

In addition to the outbreaks listed above, a review of the United States CDC national outbreak reporting database also found pork and beef sausages linked to several outbreaks due to several contaminating pathogens, including *Clostridium perfringens*, *Staphylococcus aureus*, *Bacillus cereus*, multiple *Salmonella* serotypes, and norovirus. It is not clear if the outbreaks all involved fermented sausage, however, deli meat and pepperoni are recorded in more than 10 outbreaks with identified pathogens, and many others where no etiologic agent was found. This database also captured the published outbreaks from fermented sausages and *E. coli* O157:H7 in Australia, Canada and the US.[34]

Box 3 | Overview of semi-dry and dry fermented sausage process

There are generally two types of fermented sausages, semi-dry and dry.

Semi-dry sausages are usually fermented at higher temperatures, greater than 15.6°C, between approximately 25°C to 45°C. This shortens the fermentation time to less than 24 hours or up to 2 days to reach pH 5.3 or less. Operators should refer to starter culture manufacturer instructions for optimal fermentation temperatures. They are often smoked or partially cooked. Smoking is usually started and completed during the fermentation cycle. Most semi-dry sausages are not subsequently dried, are packaged soon after completion of fermentation (or fermentation and smoking) with a water activity (a_W) higher than 0.9, therefore these sausages require refrigeration. To control *L. monocytogenes* sausages should have a_W <0.92 for refrigerated storage.

Dry sausages are usually fermented at lower temperatures, 20°C to 24°C, so fermentation times are extended (usually 48 hours but up to 6 days to reach pH 5.3 or less). Dry sausages can be smoked but are not fully cooked. If smoking is desired, cold smoke is applied and it must mirror the fermentation or drying room temperature. Dry sausages are usually dried in a drying chamber/room after fermentation to reduce a_W to 0.9 or below. These sausages are shelf stable and do not require refrigeration.

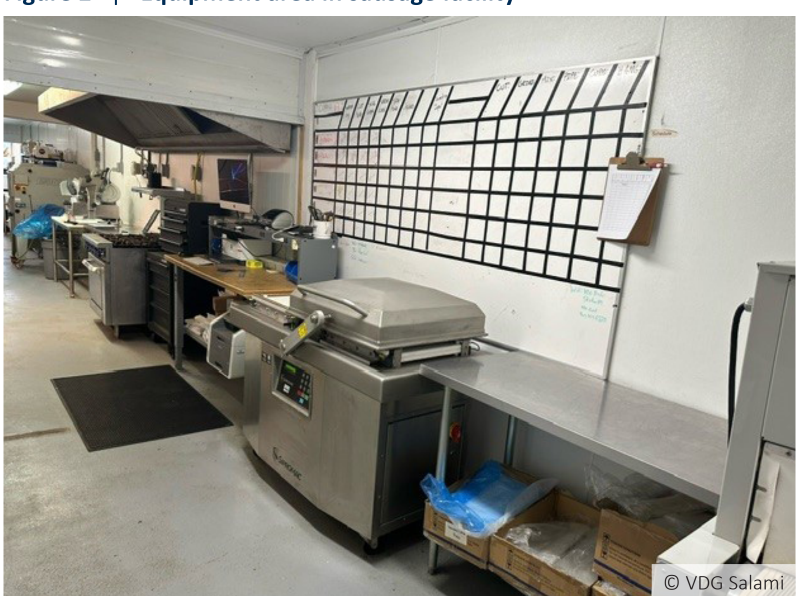
Humidity and air flow are important to control for both types of sausages. Generally, airflow should be maintained to prevent case hardening (if air flow is too great) and wild mould growth (if air flow is too low). Rooms should contain relative humidity controllers (metres), and rooms should be equipped with a fan for air flow. Relative humidity is generally set in the range of 60-90% (at 65% there is a risk of case hardening). Ideally relative humidity should be initially set at 95% and then kept 5% less than the product, dropping with the product as it dries. Operators are expected to monitor relative humidity, the products, and adjust relative humidity accordingly.

Fermentation and drying are two important, but different steps in the fermentation sausage process. Both will be discussed in more detail in this document.

Description of food preparation for fermented sausage

Validated recipes and a food safety control plan are recommended for fermented sausages. There are many critical control and control points through-out the processing steps for fermented sausages, and operators are required to keep records in log-sheets (see Appendix 1) and take pH readings, relative humidity readings and check other parameters, if required. Operators may be requested and are recommended to consult with food consultants (non-government 3rd party entities) who specialize in fermented meats to assess their food plan and that all critical control and control points are achieved.

Figure 2 | Equipment area in sausage facility



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The cleaning and sanitizing of the facility and the food contact equipment is critical. Food premises are required to have a cleaning and sanitizing schedule for the facility, equipment used in the process, and all food contact surfaces.[6,35]

Managing ingredients: receipt, supplier, and quality

Raw materials (raw beef or pork) from suppliers should be of good quality and control measures should be in place to ensure the quality and safety of the product are maintained. These raw materials must be from an approved source, and processors should have good communication with their suppliers. Best practice would be to request a certificate of analysis from suppliers to ensure generic *E. coli* is at acceptable levels. Generic *E. coli* counts in meat, according to Health Canada (Annex T-1), should be limited to 1000 CFU/ml or less.[36] All meats must be received under temperature control as frozen product or under refrigeration (4°C or lower) and be stored at 4°C or lower to limit microbial growth.

If requiring a certificate of analysis or supplier quality assurance (SQA) certificate for ingredients e.g., raw meat, lactic acid bacteria starter culture, these certificates must be available upon request and in compliance with local licensing authority. Ingredients must be stored according to the manufacturer's instructions and used by the best before date (BBD).

Steps to make fermented sausage:

Step 1. Manage all ingredients as described above. The control of suppliers and raw materials are essential to ensure the quality, hygiene, and safety of raw, ready-to-eat meat products. Prepare casings as described in Box 4 below. (Note: if using beef or pork casings refer to "*Important control points*" in the "*Overview*" section in the beginning of this document).

The operator must ensure lactic acid bacteria starter used for the ferment is not outdated and that it has been stored according to the manufacturer's instructions. As discussed earlier, if using nitrates, a micrococcus starter should be used.

Box 4 | Preparation and control of sausage casings

All casings should be from an approved source. Casings made of natural animal-based product, or natural casings should be preserved in a saturated brine to prevent microbial growth. Dehydrated natural casings must be desalinated and rehydrated by soaking them in cold water before transferring them to the stuffing area. This will soften the casings and reduce the risk of crusting on the outside of the product that may interfere with dehydration during the drying process. When there is a manufacturing delay, the desalted casings must be stored in a refrigerated room.

Natural casings stored in brine should be desalted and rehydrated according to the supplier's recommendations for the number of rinses required, amount of water used, water temperature, soaking time, and draining. Rehydrated casings that are ready for use must be stored at temperatures of 4°C or lower before use. All surplus rehydrated and handled casings must be discarded.

Other types of casings include cellulose (plant-based) that may be stored at room-temperature, then rehydrated prior to use. Plastic casings, which are not permeable, are not recommended for fermented sausages. Use and store all casings based on manufacturers' recommendations.

Step 2. Prior to beginning the fermentation process, meat products must be held under refrigeration, at 4°C (40°F) or lower (closer to 0°C and lower to -4°C is ideal) for no more than 2 days to prevent the growth of pathogens that may be present in the raw meat product.[37,38] If thawing meat from frozen when making sausage, store refrigerated and use within 3 days. Refrigerated units must be equipped with accurate thermometers and temperatures of each unit must be logged as required by the licensing authority.

If making pork sausages, refer to the CFIA guidance document to control for *Trichinella spiralis*.[2] For meat from wild pigs or other hunted animals, freezing is not an option for pathogen control and the meat needs to be well cooked (see Box 2).

Step 3. The meat product that will be used in the fermentation process must first be cut into consistent portions. By doing this, the fat content can be monitored, and pieces can be trimmed to ensure consistency. The usual practice is for processors to purchase whole muscle and back fat separately, then combine these for the desired fat content.

Step 4. Remove the meat product from the refrigerator and feed the meat into a chopper, then into the meat grinder. Thawed, semi-thawed and partially frozen pieces of meat may be added to keep temperatures low enough, between 0 to -4°C, to prevent fat smearing (see below).[38] Once the meat is ground, transfer the product into a meat mixer. Another option is to grind the meat product directly into the meat mixer.

Note: fat smearing refers to the fat pieces that are added to a meat mixture and stuffed into sausages. In fermented, dry-cured sausages, smearing may prevent moisture loss when sausages are being dried. Smearing also refers to fat texture and meats getting pasty during grinding. Meat and added fat must be kept cold enough, otherwise fats will smear, and not stay as individual pieces. This compromises the texture and flavour of the sausage.

Step 5. Once the meat product is ground and put into the mixer, add the ingredients e.g., wine, other flavourings, spices, and sugar (sugars are often added to promote fermentation). Box 5 below provides controls for sugars in fermented sausage. The final mix is then put into a container and weighed. The weight of the container must be subtracted from the total weight. The weight of the mixture is required to determine the amount of nitrite/nitrate (sodium nitrite, potassium nitrite, sodium nitrate, potassium nitrate) to be used. Once weighed, place meat mixture product back in the refrigerator.

Box 5 | Control of sugars in fermented sausage

Sugar provides a source of energy for the microorganisms responsible for fermentation and lowering the pH.[39] Considering that these microorganisms constitute the the naturally occurring microbial flora of the raw meat, it is necessary to add sugar in the preparation of the mixture to promote their growth. The main sugars used in making fermented sausage are listed in order of their importance on producing lactic acid by lactic acid bacteria:

a) dextrose (the sugar of choice)
b) sucrose
c) maltose
d) lactose

The type of sugar and the dose to be used varies according to the starter culture used, the type of product and the manufacturer. In general, the supplier of the starter culture is the best advisor for the processor regarding the conditions of its use. About 1 g (0.1%) of dextrose per 1 kg of meat lowers the pH of meat by 0.1 (e.g., 10 g of dextrose will lower the pH by 1.0).[40] Sugar levels of 0.5% to 0.7% are usually added for reducing pH levels to just under 5.0.[40] The amount of sugar added can help indicate the final pH of the product.[39] When more sugar is used, lactic acid levels increase and therefore lower the pH.[39]

Step 6. Determine the required amount of nitrite/nitrate for the recipe. Whether using nitrite/nitrate, the amounts for each should not exceed 200 ppm and should be calculated separately (see formula below in Box 6, and example calculations in Appendix 2). Note: short-term fermentations and drying periods (less than 3 weeks) must use nitrites because nitrite immediately provides antimicrobial activity in the formulation.[41] Also, for short term fermentations, nitrates cannot be used by themselves or in combination with nitrites.[41] Nitrates must only be used for long term cured/fermented products (3 weeks or more for fermentation/drying) and should be used with a micrococcus starter culture. For long term fermentations nitrites may be used in combination with nitrates. However, each must not exceed 200 ppm. Weigh out and set aside. **The weight of the emulsion is the combined weight of the meat, flavourings, spices, sugars, and any other ingredient that is used such as ice.**

Box 6 | Formula for calculation of nitrite/nitrate required in meat recipe

Calculation for nitrite/nitrate required in the recipe:

$$\text{ppm } NaNO_2 = \frac{\text{Weight of } NaNO_2 \text{ (kg) X } 10^6}{\text{Weight of emulsion (kg)}}$$

Examples of calculations can be found at the following links:
https://www.inspection.gc.ca/preventive-controls/meat/nitrites/eng/1522949763138/1522949763434
https://www.inspection.gc.ca/preventive-controls/meat/fermented-and-dried/eng/1522951036924/1522951037158

Step 7. Once each amount of nitrite/nitrate has been confirmed, measure the required amount of nitrite/nitrate and set aside. The amount of nitrite/nitrate must be greater than 100 ppm and not exceed 200 ppm. The use of Cure #1 Prague powder/pink salt (6.25% sodium nitrite, 93.75% table salt) or Cure #2 Prague powder/pink salt (6.25% sodium nitrite, 4% sodium nitrate, 89.75% table salt) is recommended over using pure nitrite/nitrate powder as it lowers the risk of accidental nitrite/nitrate poisoning.

Step 8. Prepare the starter culture. Cultures will come pre-packaged as frozen or freeze-dried. Manufacturer's directions are to be followed and usually involve hydrating with a specific small amount of water. The directions will also dictate the batch size. Once prepared set aside the starter culture. Starter culture MUST be safe and suited for the intended purpose. **It is highly recommended that a commercially purchased culture is used.**[6]

Step 9. Add the nitrite/nitrate to the mixture. **This is the curing step.**

Step 10. Add the starter culture.

Step 11. Mix thoroughly.

Step 12. Feed the product into the sausage casing machine and fill the casings. Plastic casings should NOT be used for fermented sausage. Box 3 provides information on the correct preparation and control of sausage casings.

Figure 3 | Preparation area

Step 13. FERMENTATION Once the casings are filled, transport them into a dry rack unit. It is in the dry rack unit where the fermentation will take place, meaning this is the step where lactic acid is formed from microbial activity. The recommended time between receipt of fresh meat and the start of the fermentation step is between 24 to 48 hours.[37] If thawing meat from frozen when making sausage, store refrigerated and use within 72 hours. Considerations for how operators use their fermentation chamber or 'green room' are shown below in Box 7.

Box 7 | Control considerations for the fermentation chamber (green room)

There needs to be a dedicated area for fermentation. Options include a separate 'green room' dedicated to fermented products such as a smoke, with a controlled separate environment, or some other suitable location.

During fermentation, the temperature of the 'green room' should be in the range of 25-45°C for semi-dry sausages, and 20-24°C for dry sausages, and the relative humidity should start at 95% and decrease over time, kept at 5% less than the moisture of the product.

The time, temperature, humidity, and airflow should be controlled, monitored and recorded. Records should be maintained for the duration specified by applicable local legislation/guidance. This is important for several reasons:

1. Different starter cultures require different optimal temperatures and humidity for optimal curing to be achieved and for accurate calculation of degree-hours.
2. Fermentation must take place in a cooler when GDL or a chemical acidifier is used.
3. Humidity that is too low or when there is too much air movement will cause case hardening and potential pathogen growth.

Control of temperature and humidity and **calculation of degree hours to control for *Staphylococcus aureus*** occur at this stage of the fermentation.[11]

This calculation will require the operator to:

1. record the pH of the sausage during fermentation when temperatures exceed 15.6°C. Note: the pH of fresh meat is approximately 5.6-5.8.[39]
2. Record the temperature of the fermentation room (this temperature must be constant). If the temperature increases measure and record temperature and time when changes occur to >33°C or >37°C (see Box 8). This is described as a variable temperature process by CFIA.[3]

Figure 4 | Humidifier and temperature controllers

The operator must monitor the length of time the sausages stay above 15.6°C until a pH of 5.3 or lower is achieved.

Tables for calculating degree-hours can be found in the link in Box 8 below. If smoking the sausages, and the smoking occurs during fermentation, the time during smoking should be included in the degree-hour calculation, e.g., before the pH drops to 5.3 or below.

The fermentation stage could be accomplished in less than a day or up to 6 days, depending on temperature used and starter culture employed, following the degree-hours chart provided in the link listed at the bottom of Box 8. Fermentation to pH 5.3 will be complete on average within 48 hours, regardless, if semi-dry or dry. If done properly, the decrease in pH to 5.3 or less will result in a safer product.

During the fermentation stage the sausages may be exposed to a smoking room, described in the next step.

Box 8 | Calculation of Degree-hours and *Staphylococcus aureus* control

It is critical that the pH is lowered at a rate that will sufficiently inhibit the growth of *S. aureus* to low levels to prevent toxin development and human illness. It is key for the pH of the product to be lowered to 5.3 quickly enough to limit the amount of enterotoxin produced. The rate of acid production in fermented products is measured using a calculation referred to as "degree-hours". If the degree-hours standard is met, then the product is considered to sufficiently inhibit the product of this pathogen. If the degree-hours standard is not met, then we cannot be assured that the product will be safe. The number of degree hours must not exceed 665 degree-hours when the highest fermentation temperature is <33°C, not exceed 555 degree-hours when the highest fermentation temperature is between 33° and 37°C, not exceed 500 degree-hours when the highest fermentation temperature is >37°C.[3]

***S. aureus* enterotoxinenterotoxintoxins can only be produced at temperatures above 15.6°C (60°F) AND if the pH of the product has not yet reached 5.3.**

Refer to the following link to calculate the degree-hours:
https://www.inspection.gc.ca/preventive-controls/meat/fermented-and-dried/eng/1522951036924/1522951037158

Figure 5 | Sausages fermenting

Fermentation stage complete: Provided that the sausage has reached a pH of 5.3 or below, with a calculated degree-hours that did not exceed the maximum permitted degree-hour limit, then the fermentation stage is complete. Smoking can be introduced in the fermentation stage or after the fermentation stage (See Step 14). If not further processed at this point, the sausages must be refrigerated within 6 hrs or frozen.[42]

Step 14. SMOKING. Smoking sausages in smokehouses is a common practice to impart flavour to sausages. They may be smoked from several hours to several days, depending on the diameter of casings used and whether the sausage is semi-dry or dry. The time during smoking should be included in the degree-hour calculation if it occurs during fermentation, e.g., before the pH drops to 5.3 or below.

Generally semi-dry sausages are smoked at temperatures 25°C to 45°C.[43] Dry sausages are usually smoked at lower temperatures, between 4 to 15°C. Smoking can be considered as the cooking step if the temperatures used are cooking temperatures. Smoking at cooking temperatures is referred to as hot smoking (see below).[6] Cold smoking occurs when smoke is introduced at lower, non-cooking temperatures. Cold smoking, from a food safety perspective, by itself, it is not considered a pathogen kill or pathogen control step.[6] It is for flavour only, a control point in the smoking step is ensuring that the wood used is specifically dedicated for smoking, for example, wood preservatives that create inhalation hazards for workers and may contaminate the meat products.[6] Liquid smoke is another option, however, like cold smoking, it is not considered a pathogen kill or pathogen control step, and is for flavour only.

HOT SMOKING (COOKING). Note: Most operators do not hot smoke because fat starts to render and melt. They will cold smoke or add liquid smoke.

Health Canada provides guidance for minimum cooking temperatures for different types of meat products.[37] In addition to the minimum cooking temperatures recommended by Health Canada, lower temperatures are also permitted provided longer holding times are used. Refer to the Health Canada preventive control recommendations for manufacturing cooked ready-to-eat meat products.[44] Heating and cooling times must be chosen based on the diameter of the product being produced for pathogen control of *Salmonella*, *E.coli* and *Trichinella*.[2,3]

Following the cooking process the sausage must be cooled. Once cooled the product can be packaged and labelled and then refrigerated. Ideally, product cooling rates should be similar to those required in food service establishments:

1. From an internal temperature of 60°C to 20°C (21°C in Quebec) within 2 hours, and then
2. From an internal temperature of 20°C (21°C in Quebec) to 4°C within 4 hours.

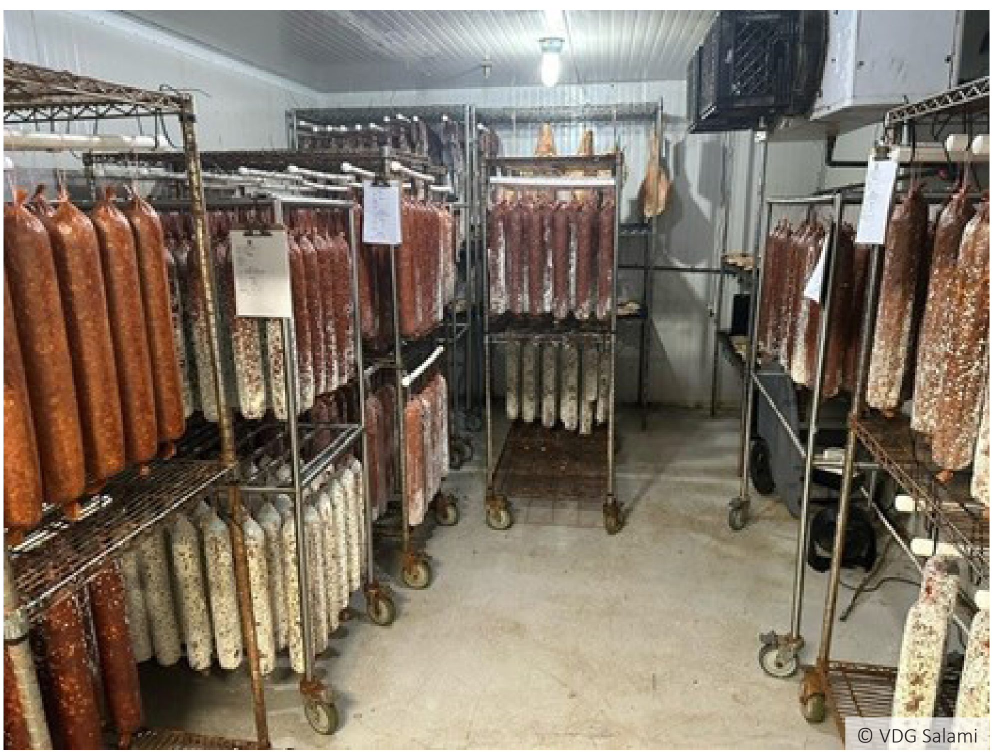
Alternative methods of cooling can only be used when suitable to the diameter of the product being made.[3] Approved cooling methods for meat products with specific sodium nitrate and brine levels as listed by CFIA may also be used.[45]

There is not one single way of making sausage. Sausages may be smoked before drying or after drying or not smoked at all. In Appendix 2, example 2, sausages are fermented then smoked and then dried. During fermentation the pH and degree hours are met. Once these criteria are met it is not necessary to perform any additional degree hours calculation.

Step 15 DRYING. Drying can take anywhere from a few days to a few weeks and is separate from meeting degree-hours. Drying time is dependent on the size of sausages/casings and the final aw is what defines if a sausage is semi-dry (a_w >0.90) or dry (a_w ≤0.90).

Providing the product has successfully met the degree-hours requirement during the fermentation stage, a temperature range of between 4°C and 15°C is used for drying. In some provincial jurisdictions, optimal drying temperatures of 12°C are recommended, in other jurisdictions, lower drying temperature (down to 4°C) are recommended for greater safety margins.

Figure 6 | Drying cooler



The drying period varies depending on the recipe, the product type, the temperature, level of humidity and amount of air flow in the drying room, and the targeted level of moisture in the finished product.[3,6] A review of drying conditions for different types of sausages is described in Box 9 below.

Some fermented products will have exterior mould that is a desirable characteristic of the product. An approved culture should be added if mould is desired. If not, then mould will only be acceptable if it is present in a quantity that can be easily removed by rubbing (with vinegar) regularly throughout the drying process.

There should be a separate room dedicated for drying, however, in certain situations the 'green room' may also be used as the drying area when making semi-dry sausages, as described below.

For semi-dry sausages, where the fermentation and drying are completed at the same time, the 'green room' can be used for both processes.

- For quick semi-dry sausages, the product is both fermented and dried in 2 days
- For slow semi-dry sausages, fermentation is completed within 2 days, and the drying process is more than 2 days and up to 40 days, the 'green room' can be used for both.

For quick semi-dry, slow semi-dry and dry sausages, during the fermentation process the temperature of the 'green room' would be set between 25-45°C with a relative humidity ideally starting at 95% and decreased over time (kept at 5% less than the moisture of the product), until the product reaches a pH of 5.3. When drying in the fermentation chamber, or drying in a separate cooler or area, the temperature would be dropped between 4-15°C and the relative humidity adjusted to 60-90%. Note that the difference between semi-dry and dry sausages is the final resting a_w, or stable a_w, rather than length of time to dry.

Drying rates should be as low as possible to avoid the surface becoming hardened.[43] At the beginning of the drying process, casings should be soft and wet, and relative humidity should be high.[43] A too low humidity could cause crusting on the surface and thus harm the internal drying of the sausage meat. Too much humidity could cause excess moisture on the surface.
A humidity of 60-90% for drying all cured meats should be used with an ideal range of 75-80% at the beginning of the process. This humidity may be lowered later for removing moisture but not drop below 60%. Dry and semi-dry sausages have approximately 30% of their moisture removed.[46]

Once the above requirements are met the product can be packaged, labelled, and stored. Only products (e.g., dry sausages) that meet shelf stability requirements can be stored at room temperature. All other sausages (e.g., semi-dry sausages) must be refrigerated. Consult Table 5 below for acceptable pH, a_w parameters for room temperature or refrigerated storage.[3,4] It is the responsibility of the processor to determine the shelf life for their products, including the maximum time the products may be stored under refrigeration. This may require having their product tested in a commercial laboratory for food quality and safety indicators, consult Section 2 for guidance on shelf life testing options. Operators are advised to inquire if they should obtain approval for shelf life declarations from their local licensing authority.

Figure 7 | Finished product storage

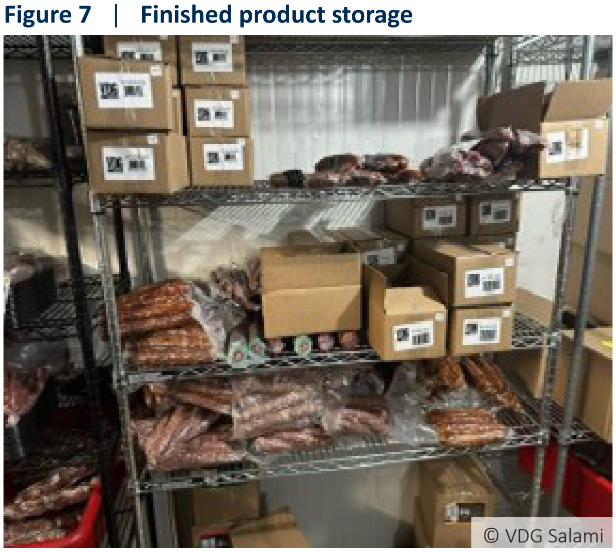


Table 5 | Shelf stability parameters for fermented and dried meat products

Room temperature (shelf stable) requirements
At time of formulation product must contain[3] • minimum of 100 ppm nitrites/nitrates AND • minimum of 2.5% salt AND
• the a_W of the finished product is 0.85 or less, regardless of pH, *OR* • the pH of the finished product is of 4.6 or less, regardless of a_W *OR* • the pH is 5.3 at the end of the fermentation period and the end product has an a_W of 0.90 or lower.

Box 9 | Drying conditions for different types of sausages

For both semi-dry and dry sausages, water activity of the sausage will be reduced, regardless of whether smoke or heat are being applied or not. This is because fermentation occurs at temperatures above 15.6°C and requires 24 hours or more to complete. For semi-dry sausages, fermenting and drying occur in tandem, this is usually the only drying stage, therefore most semi-dry sausages do not require a separate drying step. Semi-dry sausages are generally packaged soon after fermentation, so the a_W will remain above 0.90 and the sausage will require refrigeration. Drying rooms are employed for some dry fermented sausages and are usually set in the range of 4°C to 18°C. Sausages may be moved to drying rooms after the fermentation process is complete. Provided degree-hours have been met, you can consider *S. aureus* to be controlled. The drying room could be set to any desired temperature; however, food safety best practices recommend temperatures below 15°C, closer to 4°C or lower is preferred.

Step 16. LABELLING AND PACKAGING. Labelling is beyond the scope of this document. Operators should follow approved guidance and local legislated requirements on labelling practices (as applicable) and to seek this information elsewhere.[47]

Figure 8 | Labelled finished product

© VDG Salami

With fermented sausages that are ready-to-eat with no cooking step there can be no guarantee that all pathogens have been destroyed. As a food safety best practice, it is recommended that these sausages, in addition to following approved guidance on labelling practices,[47] be labelled with a disclosure advising customers of the increased health risk of consuming raw meat products, that includes a warning clearly stated on the packaging. “This product contains uncooked meat. Vulnerable populations such as the elderly (over 65 years), children (<5 years), pregnant women, and individuals who are immunocompromised are advised to reheat these products prior to consumption or to avoid consumption of these products.”[48] In restaurants, this may take the form of a menu warning; alternatively in other food premises (e.g., butchers, delis) verbal or written, posted declarations are advisable.

One hazard of particular concern in fermented meats and other charcuterie style deli meats is *Listeria monocytogenes*. All fermented sausages and meats are required to comply with Health Canada's guidance [Policy on *Listeria monocytogenes* in ready-to-eat foods (2023)].[4] Introduction of *L. monocytogenes* into RTE meats can occur during slicing and packaging steps. The final pH and a_W of the fermented meat product and intended storage conditions, i.e., if the product will be refrigerated, are used to determine if additional controls for *L. monocytogenes* are required. This is explained further in Box 10 below.

Box 10 | *Listeria monocytogenes* Health Canada requirements for RTE foods

Listeria monocytogenes is a cold-tolerant pathogen that persists in refrigerated environments, growing at temperatures below 4°C and at temperatures down to -4°C.[4] This pathogen is the leading cause of deaths related to foodborne illnesses annually in Canada, responsible for 178 illnesses, 150 hospitalizations, and 35 deaths (Public Health Agency of Canada data from 2016).[49] People most at risk include the elderly, those with weakened immune systems and women during pregnancy.[50] *L. monocytogenes* infections cause blood poisoning and can be fatal. During pregnancy, *L. monocytogenes* can cause mother to fetus infections in utero, causing miscarriages, stillbirths, premature births and serious illnesses in infants after birth (e.g., meningitis and septicemia).[50] Canada's largest outbreak involving deli meats occurred in 2008 in Maple Leaf products.[51] This outbreak caused 57 illnesses and 24 deaths, and illnesses occurred within vulnerable populations because the products were served in institutions.[51,52]

Listeria spp. are naturally occurring bacteria in soils and the environment, however, in processing plants *Listeria* spp. have a unique ability to form biofilms on surfaces, persisting in harbourage sites, such as equipment requiring disassembly (for e.g., slicers).[4] Cleaning and sanitation programs and regular swabbing and testing of food contact surfaces are required to ensure *Listeria* does not become a resident pathogen in the plant.[4] The concern for RTE foods is post-processing contamination. For fermented sausages, this may occur following fermentation and smoking steps, during packaging or contact with any contaminated food-contact surface. The Maple Leaf outbreak was eventually traced to inadequately cleaned and sanitized slicers on processing lines that contaminated cooked deli-meats, including salami, pepperoni and sausages.[52]

Refrigerated RTE fermented meats could fall under the Health guidance as a Category 1 or Category 2 product. Operators should measure a_W, or a_W in combination with pH at the end of processing and through the product shelf life to determine if their fermented sausage falls under this (*Listeria*) policy, in particular, consult Figure 1.[4]

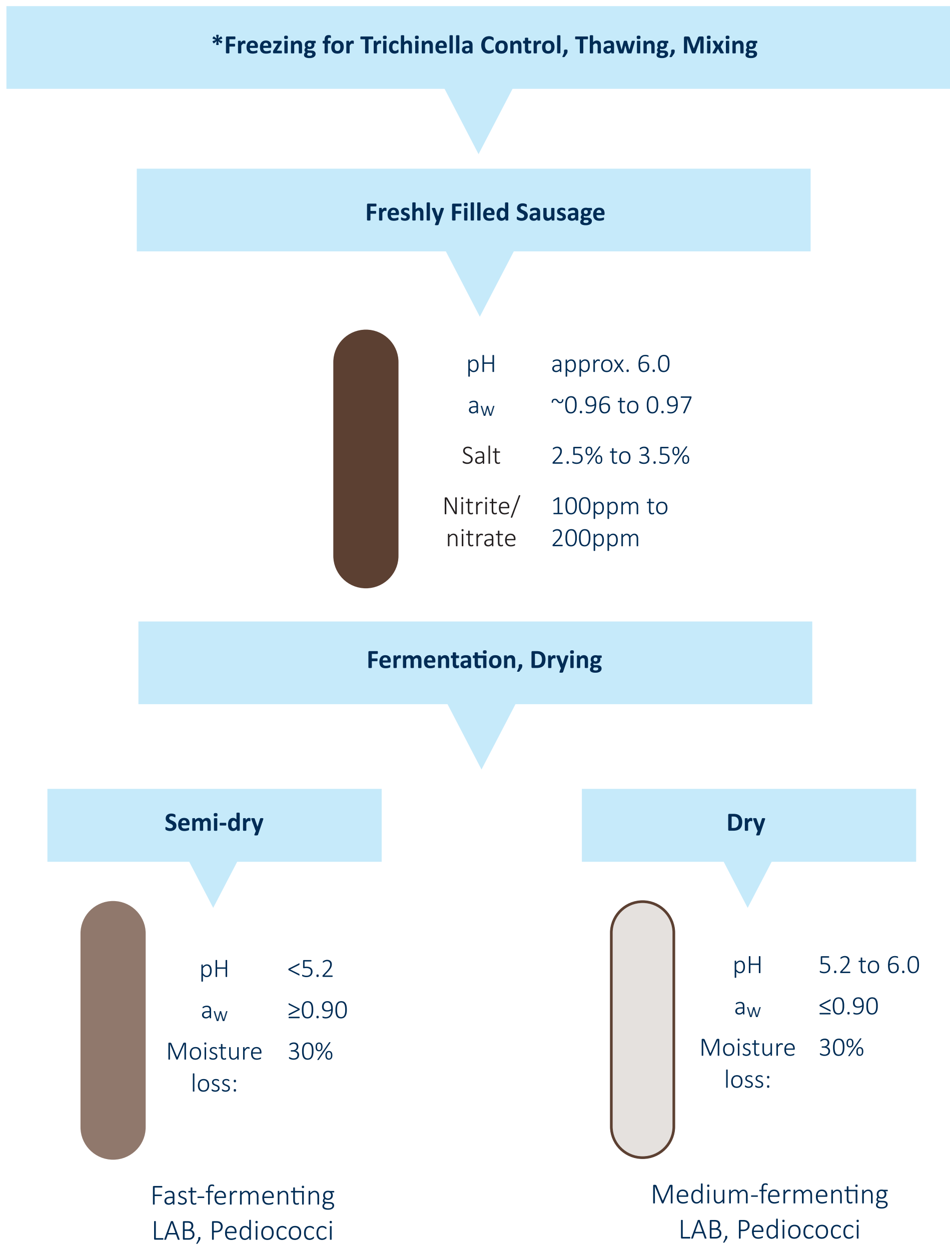
Fermented sausages sold refrigerated are in Category 2B (do not support growth and low likelihood of *Listeria monocytogenes*) with longer refrigerated shelf life if they meet these criteria:[4]

- a_W lower than 0.94 AND pH lower than 5.0, OR
- a_W lower than 0.92, regardless of pH

Operators will still be required to determine the shelf life of their product. Other useful requirements for operators are also found in the guidance. For example, if the pH of the fermented meat is 5.3 at the end of the fermentation period and the end product has an a_W of 0.90 or lower, it may meet the definition of a low-moisture food and be excluded as long as pH and a_W are stable through the product shelf life. If pH and a_W increase during product shelf life then the food would be covered by the *Listeria* policy. Even if a food is excluded from the *Listeria* policy, if it is found to contain *L. monocytogenes* it will need to be assessed on a case by case basis.[4]

Characteristics of fermented, dried sausages are shown below in Figure 9 on page 23, adapted from Australian Meat & Livestock guidance.[46]

Figure 9 | General characteristics of finished fermented sausages



*** Freezing for *Trichinella* control.** Freezing is a long established control point for *Trichinella* in pork and is effective to inactivate *T. spiralis*. However, wild boar, wild bear and other hunted omnivore, sylvatic species in Canada are frequently contaminated with *T. nativa* which is a cold-tolerant parasite resistant to freezing. As a precaution, a cook step (hot-smoking or equivalent) should be added to sausages made with wild and hunted meats to fully inactivate this parasite if present in meat. See Box 2 for further information about *T. nativa* concerns.

Fermented meat process flow and controls

Diagram 1. Preparation of ingredients, curing (nitrite/nitrate), adding fermenting agent (starter) and stuffing sausage into casings

Process Flow | CCP or CP | Critical Limits and Control Measures

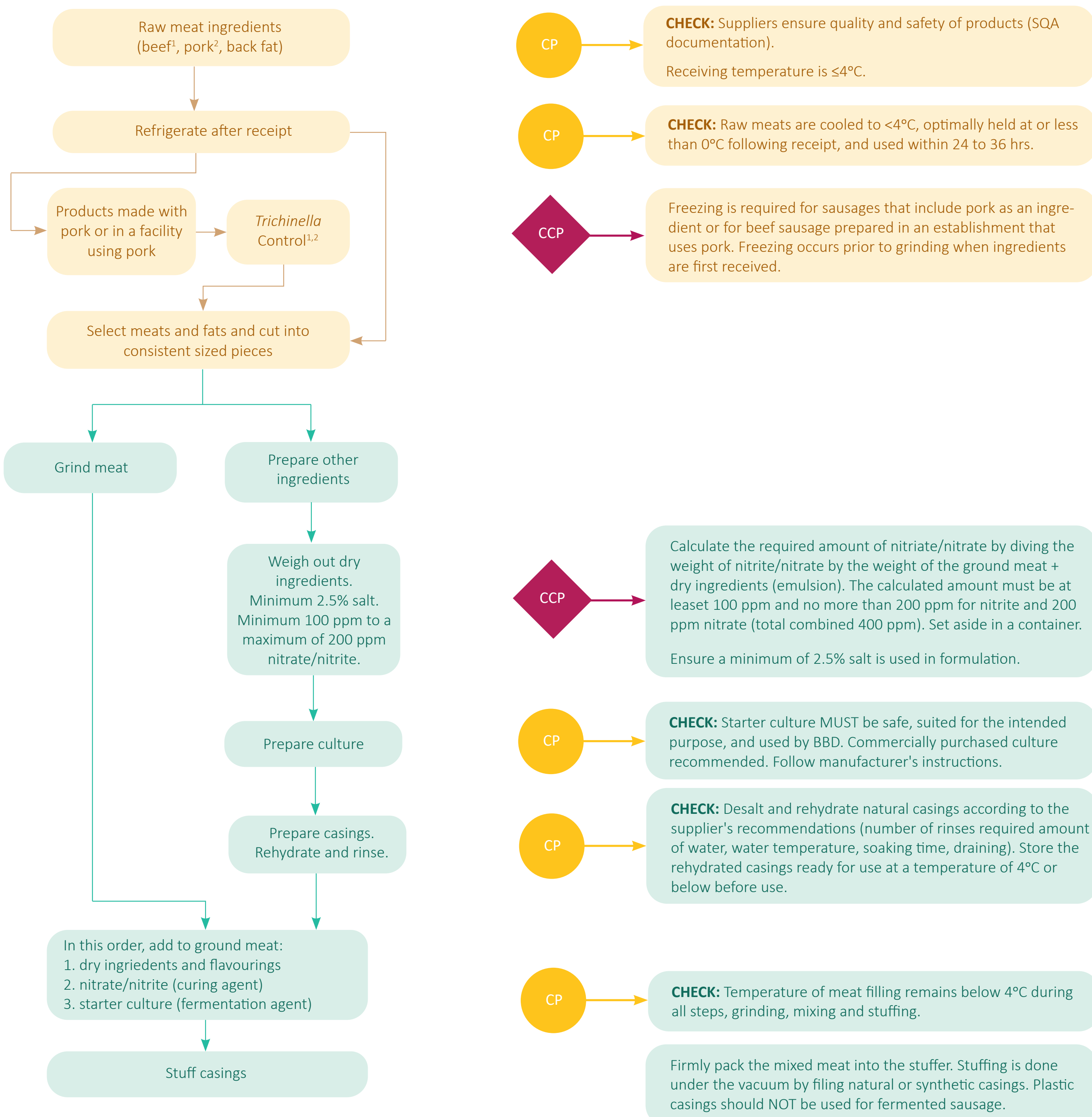
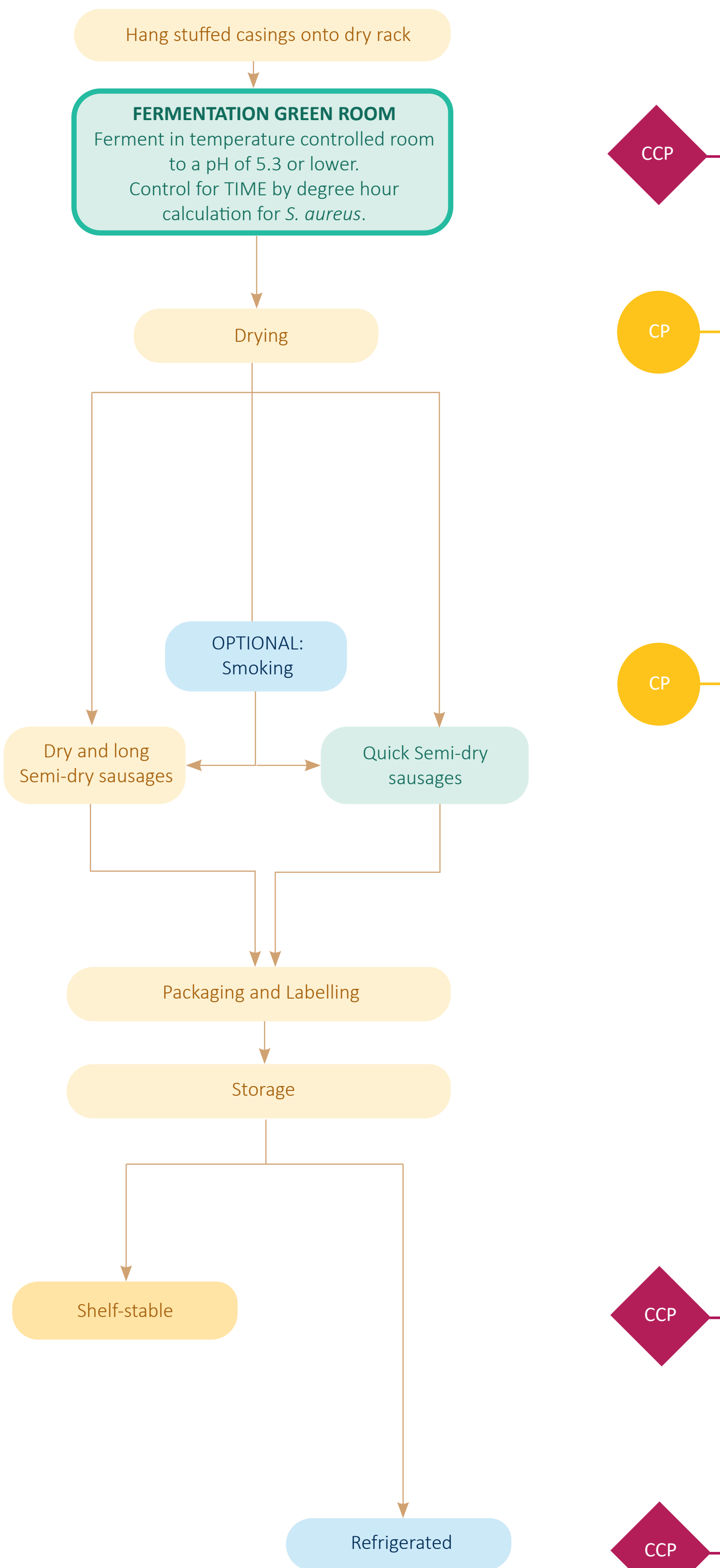


Diagram 2. Fermentation and drying options

Process Flow | CCP or CP | Critical Limits and Control Measures



Once cased, the sausages must be transported into a dry rack unit in a clean and controlled environment, called a **Green Room**.

Time, temperature, humidity and airflow is controlled, monitored and recorded.

During fermentation, the pH of meat product must be lowered to 5.3 quickly enough to limit the amount of enterotoxin produced. This can be achieved using the degree-hour calculation.

If the drying occurs in the fermentation room, any temperature can be used for drying providing the requirements for the successful completion of fermentation are met. The drying period varies depending on the recipe, the product type, the temperature, level of humidity (Ideal relative humidity range is 75-80%,) and amount of air flow in the drying room, and the targeted level of moisture in the finished product. Dry sausages have a slow drying rate in the range of 4°C-15°C for 4-12 weeks; semi-dry sausages have a fast-drying rate in the range of 4°C-15°C for 2-40 days.

Note: above 80% moulds may grow; below 65% case-hardening may occur.

CHECK: Location for drying. Quick semi-dry sausages are usually dried in the green room. Longer semi-dry sausages and dry-fermented sausages are usually dried in a separate, dedicated drying room, e.g., a dedicated cooler; otherwise the parameters for the green room are changed to optimize drying conditions.

Smoking can occur during or after fermentation, and sausages can be hot or cold-smoked. For hot-smoking refer to Health Canada preventive control recommendations for manufacturing cooked ready-to-eat meat products.

Cold smoking occurs when smoke is introduced at lower, non-cooking temperatures during the drying process at the drying temperature. Cold smoking has no public health benefit, and by itself, it is not considered a pathogen kill or control step.

CHECK: Ensure wood is specifically dedicated for smoking. Using improper wood could expose the meat to chemicals such as hydrocarbons, wood preservatives, and others.

Following the fermentation or drying process, the finished product can be packaged and labelled. Products may be packaged under vacuum or modified atmospheres to help prevent quality deterioration during handling, transportation and storage. Labelling must follow CFIA requirements for ready-to-eat (RTE) meats.

To inform at risk vulnerable populations of their risk when consuming RTE fermented meat products that have not undergone a cook step, recommended, voluntary labelling should state “This product contains uncooked meat. The elderly, children, pregnant women, and individuals who are immunocompromised are advised not to consume this product.”

Fermented products are considered shelf-stable when the following criteria are met:

A minimum 100 ppm of nitrite/nitrate AND a minimum 2.5% salt at time of formulation AND one of the following parameters:

- the pH is 5.3 at the end of the fermentation period and the end product has an a_w of 0.90 or lower. **OR**
- a_w of 0.85 or less, regardless of pH, **OR**
- pH of 4.6 or less, regardless of a_w

If shelf-stable conditions aren't met, fermented products must be refrigerated and meet requirements for *L. monocytogenes* control:

A minimum 100 ppm of nitrite/nitrate AND a minimum 2.5% salt at time of formulation AND one of the following parameters:

- a_w of 0.94 or less **AND** a pH of 5.0 or less, **OR**
- a_w of 0.92 or less, regardless of pH

Potential issues with fermented sausage food preparation

Issue	Description
<2.5% salt	Salt is a microbial hurdle that inhibits Gram-negative bacteria, such as *Salmonella* and *E. coli*. It lowers a_W, solubilizing meat proteins that bind water, and acts as a fat emulsifier.[53] A minimum of 2.5% salt is a CFIA requirement in fermented sausages.[3] Salt also promotes growth of LAB starter culture to rapidly lower pH in the meat.
pH >5.3 & temperatures above 15.6°C (60°F)	*S. aureus* can grow and produce enterotoxin at temperatures above 15.6°C (60°F) when the pH of the product is greater than 5.3 during fermentation process.[6] Degree-hours must be met for safety.
Too little nitrite <100 ppm nitrite/nitrate	Nitrites are required to develop curing flavours, red colour, inhibit lipid (fat) oxidation and rancidity, and are microbial hurdles for *S. aureus*, *C. perfringens*, *L. monocytogenes*, *B. cereus* and *C. botulinum*.[12,13] At concentrations below 80 ppm, it is ineffective. Concentrations below 200 ppm do not, however, impact growth of starter cultures, *Micrococcus*, *Lactobacillus* or *Enterococcus* spp.[13]
Too much nitrite is poisonous! >200 ppm nitrite/nitrate	Too much nitrite is poisonous. Notable that nitrite is 10X more toxic than nitrate. The lethal dose for humans is approximately 33 to 250 mg nitrite per kg body weight.[12] Methemoglobinemia occurs when blood nitrite levels are too high, bind hemoglobin and oxidize it to methemoglobin, basically reducing tissue oxygen blood supply. This can be life-threatening.[12] Nitrites in meats may also lead to development of carcinogenic nitrosamines.[12] Excess nitrite discolouration may cause meats to be green-brown in colour (above 600 ppm).[13] The use of Cure #1 Prague powder/pink salt (6.25% sodium nitrite, 93.75% table salt) or Cure #2 Prague powder/pink salt (6.25% sodium nitrite, 4% sodium nitrate, 89.75% table salt) is recommended overusing pure nitrite/nitrate powder as it lowers the risk of accidental nitrite/nitrate poisoning.
Nitrate use	Nitrates are only used for long-ferments, use 100-200 ppm, in combination with nitrites, 100-200ppm. Nitrates are not used in short-term ferments due to risk of methemoglobinemia as nitrates break-down over time into nitrites.
No cooking step	If no other measures are used to control *E. coli* O157:H7, without cooking beef product there is a risk of potential pathogens surviving and creating a food safety hazard. *E. coli* O157:H7 is a pathogen of concern in raw RTE fermented products made with beef.
Exposure to air contaminants	If the fermentation process is not conducted in a sanitary and controlled environment then the product can be exposed to air contaminants and mould.[6]
Inconsistent fat content	Could impact the cooking process when referring to minimum holding time/temperature tables.[6]
Contaminated or expired starter culture	Contaminants will grow during the fermentation step (see risk of using backslopped culture in Box 11). Starter culture that is expired or past its Best Before Date may negatively impact the fermentation process.
Smoking using improper wood	Sausage could be exposed to chemicals such as hydrocarbons, wood preservatives, and others.[6]
Improper cooking process	If applicable, should the minimum temperature or temperature/time not be achieved, pathogens that may be present in the product will not be destroyed.
Improper cooling process	If applicable, could allow pathogens to multiply to dangerous levels if present in the product.
Improper drying process	Premature case-hardening is an issue when it prevents proper drying. Mould growth on the outside of drying sausages may or may not be of concern. Mould could affect the quality of the product; could impact the ability for the product to be shelf-stable; could introduce contaminants to the product if the environment is not sanitary. Humidity control above 60% will prevent premature case hardening and humidity control under 80% will prevent mould growth. When fermentation first begins humidity may be higher than 80% but levels must be reduced to prevent excessive mould growth.

Box 11 | Risk of using backslopped culture

Backslopping is NOT RECOMMENDED for small operators who cannot conduct routine pH and microbiological tests. Operators considering this are advised to consult with CFIA.

Backslopped culture is only allowable if the starter culture can be handled to prevent contamination and regularly tested for pathogens. It must have a product pH of 5.3 or lower and be held refrigerated as described by the CFIA below. pH tests must be performed with equipment to an accuracy of ±0.01, pH indicator paper is not allowed. However, the practice is not recommended because backslopping may amplify pathogen loads if the culture becomes contaminated. For this reason, backslopping is not allowed in some jurisdictions, for example, it is illegal in Australia and starter culture is required by regulation.[55]

CFIA Conditions when using Backslopped Starter Culture:

4.16.1.3 Starter Culture

The operator must have a control program in place to prevent the transmission of pathogens when using the inoculum from a previous batch (backslopping) to initiate the fermentation process of a new batch. These must include:

- The storage temperature must be maintained at 4°C or less and a pH of 5.3 or less.
- Samples for microbiological analysis must be taken to ensure that the process is in line with the specifications. Consult with CFIA for testing requirements.
- The frequency of sampling is to be adjusted according to compliance to specifications.
- Any batch of inoculum which has a pH greater than 5.3 must be analysed to detect at least *Staphylococcus aureus*. Only upon satisfactory results will this inoculum be permitted for use in back slopping.

Note: although this advice is archived correspondence with CFIA confirms this is consistent with current best practice.[56]

Summary of critical control points for making fermented sausages

- Salt concentration is a a minimum of 2.5% salt, generally in the range of 2.5% to 3.5% salt in formulation. This weight is calculated. Note: the salt concentration used most of the time for pork sausages is 3.3%.
- Nitrite concentration is a minimum of 100 ppm and up to a maximum of 200 ppm. This weight is calculated.
- Nitrates are only added to slow-fermented sausages up to a maximum of 200 ppm. This weight is calculated.
- Commercial cultures are used, backslopping is not recommended.
- The fermentation room or green room has controlled time, temperature, humidity, and airflow supported by documentation/log records.
- Weight loss and pH of sausage is measured and recorded in a log.
- Time and temperature of sausage above 15.6°C before the sausage reaches a pH of 5.3 or lower is calculated to meet degree-hours for *S. aureus* control.
- Sausages made with beef, or with beef as an ingredient use a control option for *E. coli* O157:H7 per Health Canada Guideline No. 12.
- Sausages made with wild meat at risk of *T. nativa* contamination, must include a cook step that allows sausage to reach an internal temperature of 71ºC or higher as freezing is not effective.
- Sausages are evaluated for pH and a_W to determine shelf-stable or refrigerated storage.
    - Shelf-stable requirements: pH of the finished product is of 4.6 or less, regardless of a_W; or a_W of the finished product is 0.85 or less, regardless of pH.
    - A fermented sausage is also considered shelf stable if the pH is 5.3 at the end of the fermentation period AND the end product has an a_W of 0.90 or lower.
    - Refrigerated requirements: a_W <0.92; or pH <5.0 AND a_W <0.94.

Other control points for making fermented sausages

- Food contact equipment used throughout the process must be cleaned and sanitized to reduce the risk of introducing pathogens, and physical and chemical hazards into the food process.[6]
- Food ingredients (e.g., meats, casings) must be stored properly to minimize the risk of contamination and spoilage.
- Prior to beginning the fermentation process, meat product must be held under refrigeration at or below 4°C. Holding at temperatures below 0°C, between-1°C to-2°C is ideal to avoid fat smearing and to make it easier to stuff into casings. When salt is added, temperatures may decrease up to 2°C and lower the meat mass temperature.[38]
- Meat product and ingredients must be weighed to determine the amount of nitrite/nitrate (sodium nitrite, potassium nitrite, sodium nitrate, potassium nitrate, or any combination of each) to be used.[6]
- For slow cured at least 100 ppm and no more than 200 ppm nitrates are recommended. When adding nitrates to slow cured, up to 200 ppm of nitrites may also be used in addition to the 200 ppm nitrates.[6,10]
- Once cased, the sausages must be transported into a dry rack unit in a clean and controlled environment.[6]
- The casing diameter will impact processing time.
- The use of a controller, a device for measuring temperature and humidity, helps monitor and control temperature and humidity during the fermentation and drying processes.
- If fermenting pork and the product will not be cooked then freezing the product to specific time, temperature and thickness of product combinations is needed for *Trichinella* control. Freezing for *Trichinella* control occurs before processing into fermented product. The raw cuts of pork would be frozen prior to grinding, addition of ingredients, stuffing, etc. Heating and curing (in combination with drying) are other forms of *Trichinella* control.[2]
- Cooked sausage must meet minimum cooking temperatures (temperature/time combinations) to destroy pathogens. Once cooked, the sausage must be cooled using validated cooling processes.[6]
- Some meat moulds can produce mycotoxins/aflatoxins. With adequate air flow, temperature, and humidity mould growth should not be a concern. If mould cannot be wiped away with vinegar, then send finished meat sausage for testing and/or discard. All drying rooms must be equipped and monitor air flow, temperature, and humidity. Keeping humidity under 80% should eliminate the concern.

Table 6 | Examples of semi-dry and dry fermented sausage production methods

Type of Fermented Sausage	Semi-dry (Summer Sausage, German Salami, cervelat, teawurst)	Dry (Salami-hard, pepperoni, dried beef sticks, genoa salami, chorizo)
Total Production Time (Fermentation plus dry time)	Usually within 3 weeks (up to 40 days)	3 weeks or more (usually 12 to 14 weeks)
Fermentation time to drop pH	Within 2 days to pH 5.3 or less	2 days to 6 days to pH 5.3 or less
Nitrite Added	Yes	Nitrate recommended. Nitrite can be added in addition to nitrate
Nitrate Added	No (not enough time to convert)	Yes
Other Ingredients	Dextrose and GDL to rapidly lower pH	Sugar
Salt Content	Minimum 2.5% salt, generally in the range of 2.5% to 3.5% salt	Minimum 2.5% salt, generally in the range of 2.5% to 3.5% salt
Sugar Content	More sugar for faster fermentation acidification (see Box 4)	Less sugar for fermentation when compared to semi-dry
Starter Culture	Fast culture, e.g. Bactoferm HLP or F-LC	Slow culture, e.g. Bactoferm T-SPX
Fermentation Bacteria	*Pediococci, Lactobacilli*	*Pediococci, Lactobacilli, Micrococcus*
Fermentation Temperature (°C)	25-45	20-24

(Continued on page 29)

Type of Fermented Sausage	Semi-dry (Summer Sausage, German Salami, cervelat, teawurst)	Dry (Salami-hard, pepperoni, dried beef sticks, genoa salami, chorizo)
Green Room Humidity	Ideally starts at 95% and is decreased over time, keep at 5% less than the moisture of the product	Ideally starts at 95% and is decreased over time, keep at 5% less than the moisture of the product
Drying Room Humidity	Ideal 75 to 80% (range 60-90%; at 65% or less there is a risk of case hardening)	Ideal 75 to 80% (range 60-90%; at 65% or less there is a risk of case hardening and at 80% and higher there is a risk of mould growth)
Drying	2 to 40 days at 4-15°C	4 to 12 weeks at 4-15°C
Moisture Loss	30%	30%
Sausage Shrinkage	12-20%	30-40%
Final pH	Usually 4.5 to 4.7 (<5.2)	Usually 5.0 to 5.3 (5.2 to 5.6)*
Final a_w	Greater than 0.9 (kept refrigerated)	0.9 or less (usually 0.82 to 0.86)
When Packaged	Following fermentation or heating	Following drying
How Packaged	Vacuum packed intact	Deli sliced or vacuum packed
Smoking	Usually done during fermentation - cold smoking (25-45°C). Important to account for that temperature in degree-hours. Hot smoking is also an option.	Usually done during drying- cold smoking (4-15°C)
Market	30-35% of sausage market (larger more diverse manufacturers)	65-70% of sausage market (large establishments-few companies)

*note: pH may increase from 5.3, achieved during fermentation, to higher pH of up to 5.6 during drying, but there is no added *S. aureus* risk as a_w is low.

Potential health issues with fermented sausage

Biogenic amines (BA) can be produced during sausage fermentation and are harmful if ingested in high concentrations. BA occur primarily from metabolic activity by microorganisms during fermentation (see Box 12 below). The highest levels of histidine reported for meats in the category of fermented sausages were 515 mg/kg, and in salami at 500 mg/kg, well above the threshold of 80 mg/kg for causing illness.[57] For tyramine, the highest levels reported were 510 mg/kg (fermented sausage) and 347 mg/kg (salami), and within reported levels that cause illness between 100 and 800 mg/kg.[57] The highest level for phenylethylamine was 376 mg/kg, found in salami, well level above the threshold of 30 mg/kg for causing illness.[57]

Box 12 | Biogenic amines in fermented foods

Biogenic amines (BAs) can be produced by microbes in fermented foods, such as fermented soybean products, vegetables, cheeses, sausage, and fish. Normal BA intake does not cause illness as intestinal amine oxidases break down and detoxify the BAs.[58,59] If large amounts of BA are ingested, or if amine oxidase activity is inhibited, then acute toxic symptoms can occur such as nausea, respiratory distress, hot flushing, sweating, heart palpitations, headache, bright red rash, burning sensations in the mouth, alterations in blood pressure, diarrhea and hypertensive crises.[58,60,61] The toxic effects of BA may vary between individuals depending on individual sensitivity and on the consumption of alcohol or drugs that are monoaminooxidase inhibitory.[62,63]

The main BAs are histamine, tyramine, β-phenylethylamine, putrescine, cadaverine and spermidine. Health Canada has set action levels for histamines in anchovies, and fermented fish sauces and pastes at 200 mg/kg and for other fish and fish products at 100mg/kg.[64] However, there are no guidelines set for other fermented food products and BAs other than histamines in Canada, or elsewhere in the world.

(Continued on page 30)

At present, the toxic doses in food are suggested only for three biogenic amines: 100-200 mg/kg for histamines, 100-800 mg/kg for tyramine and 30 mg/kg for phenylethylamine.[59]

Operators manufacturing fermented foods are not required to test for BAs in their products. Operators are recommended to list BAs as a potential chemical hazard in their food safety plan. Operators can address risks of BAs by

(1) ensuring preventative measures are in place, the facility is clean and sanitary, handling practices are hygienic to limit bacteriophages and bacteria that interfere with the culture process;

(2) optimizing the fermentation: regulating time, temperature, moisture content, salt concentrations, and storage conditions; using good quality ingredients;

(3) purchasing commercial starter culture and/or verifying quality of the starter culture;

(4) monitoring that thethe expected culture activity occurs within correct timeframe; and

(5) monitoring for expected pH.

If a fermented food is linked to foodborne illness in consumers, inspectors are recommended to consider testing for BAs if symptoms and onset of illness in cases fit suspected BA illness. Further information about BAs and testing is found in Section 2 of this guidance.

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References

1. Health Canada. Interim guidelines for the control of verotoxinogenic Escherichia coli including *E. coli* O157:H7 in ready to eat fermented sausages containing beef or a beef product as an ingredient [Internet]. 2000 [cited 2021 Oct 18]. Available from: https://www.canada.ca/en/health-canada/services/food-nutrition/legislation-guidelines/guidance-documents/interim-guidelines-control-verotoxinogenic-escherichia-coli-including-colio157-fermented-sausages-beef-product-ingredient.html
2. Canadian Food Inspection Agency. Control recommendations for the inactivation of *Trichinella spiralis* in pork products [Internet]. 2018 [cited 2021 Oct 18]. Available from: https://inspection.canada.ca/preventive-controls/meat/trichinella-spiralis/eng/1522956607996/1522956608262
3. Canadian Food Inspection Agency. Preventive control recommendations for manufacturing fermented and dried meat products [Internet]. 2018 [cited 2021 Dec 1]. Available from: https://inspection.canada.ca/preventive-controls/meat/fermented-and-dried/eng/1522951036924/1522951037158
4. Health Canada. Policy on *Listeria monocytogenes* in ready-to-eat foods (2023) [Internet]. 2023 [cited 2023 Oct 30]. Available from: https://www.canada.ca/en/health-canada/services/food-nutrition/legislation-guidelines/policies/listeria-monocytogenes-ready-eat-foods.html
5. Di Gioia D. Chapter 7. Safety of fermented meat. In: Prakash V, Martín-Belloso O, Keener L, Astley S, Braun S, McMahon H, et al., editors. Regulating Safety of Traditional and Ethnic Foods [Internet]. 1st ed. Waltham, MA, USA and Kidlington, Oxford, UK: Academic Press, Elsevier; 2016. p. 125–48. Available from: https://www.sciencedirect.com/science/article/pii/B9780128006054000074
6. National Collaborating Centre for Environmental Health. Ready-to-eat meats online course: assessing the food safety risks [Internet]. [cited 2021 Oct 18]. Available from: https://ncceh.ca/courses/ready-eat-meats-online-course-assessing-food-safety-risks
7. Leroy F, Geyzen A, Janssens M, De Vuyst L, Scholliers P. Meat fermentation at the crossroads of innovation and tradition: a historical outlook. Trends Food Sci Technol [Internet]. 2013 Jun 1 [cited 2021 Oct 18];31(2):130–7. Available from: https://www.sciencedirect.com/science/article/pii/S092422441300071X
8. Mohan A. Basics of sausage making. Formulation, processing & safety. UGA Extension Bulletin 1437. [Internet]. University of Georgia Extension Publications; 2014. Available from: https://secure.caes.uga.edu/extension/publications/files/pdf/B%201437_1.PDF
9. Leroy F, Vuyst LD. Fermentation and Acidification Ingredients. In: Tarté R, editor. Ingredients in Meat Products: Properties, Functionality and Applications [Internet]. New York, NY: Springer; 2009 [cited 2023 Oct 30]. p. 227–52. Available from: https://doi.org/10.1007/978-0-387-71327-4_11
10. Yim DG, Jang KH, Chung KY. Effect of gdL addition on physico-chemical properties of fermented sausages during ripening. Korean J Food Sci Anim Resour [Internet]. 2015;35(3):322–9. Available from: http://koreascience.or.kr/article/JAKO201525961777176.page
11. Otwell WS, Schneider KR, Garrido V, Mobley R. Guidance for processing fermented and dried sausage in retail operations [Internet]. Florida: University of Florida; 2022 [cited 2023 Jun 8] p. 23. (Food Science and Human Nutrition Department, UF/IFAS Extension). Report No.: FSHN-0501. Available from: https://edis.ifas.ufl.edu/publication/FS109
12. Shakil MH, Trisha AT, Rahman M, Talukdar S, Kobun R, Huda N, et al. Nitrites in cured meats, health risk issues, Alternatives to nitrites: a review. Foods [Internet]. 2022 Oct 25 [cited 2024 Mar 15];11(21). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9654915/
13. Feiner G. Chapter 7. Colour in fresh meat and in cured meat products. In: Feiner G, editor. Meat Products Handbook [Internet]. 1st ed. Woodhead Publishing; 2006. p. 142–57. Available from: https://www.sciencedirect.com/science/article/pii/B9781845690502500393
14. Feiner G. Chapter 39. The microbiology of specific bacteria. In: Feiner G, editor. Meat Products Handbook [Internet]. 1st ed. Woodhead Publishing; 2006. p. 595–615. Available from: https://www.sciencedirect.com/science/article/pii/B9781845690502500393
15. Canadian Food Inspection Agency. Annex C: use of phosphate salts and nitrites in the preparation of meat products [Internet]. 2013 [cited 2024 Mar 15]. Available from: https://epe.lac-bac.gc.ca/100/206/301/cfia-acia/2011-09-21/inspection.gc.ca/english/fssa/meavia/man/ch4/annexce.shtml

16. Canadian Food Inspection Agency, Goverment of Canada. Trichinellosis- Fact Sheet [Internet]. 2013 [cited 2024 Sep 20]. Available from: http://inspection.canada.ca/en/animal-health/terrestrial-animals/diseases/reportable/trichinellosis/fact-sheet
17. Appleyard GD, Gajadhar AA. A review of trichinellosis in people and wildlife in Canada. Can J Public Health Rev Can Santé Publique [Internet]. 2000 Jul [cited 2024 Sep 20];91(4):293–7. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6980012/
18. Food Safety Inspection Service, U.S. Department of Agriculture. FSIS compliance guideline for the prevention and control of *Trichinella* and other parasitic hazards in pork products [Internet]. 2018 [cited 2024 Sep 20] p. 41. Available from: https://www.fsis.usda.gov/sites/default/files/import/Trichinella-Compliance-Guide-03162016.pdf
19. McIntyre L, Pollock SL, Fyfe M, Gajadhar A, Isaac-Renton J, Fung J, et al. Trichinellosis from consumption of wild game meat. CMAJ [Internet]. 2007 Feb 13 [cited 2024 Sep 20];176(4):449–51. Available from: https://www.cmaj.ca/content/176/4/449
20. Schellenberg RS, Tan BJK, Irvine JD, Stockdale DR, Gajadhar AA, Serhir B, et al. An outbreak of trichinellosis due to consumption of bear meat Infected with *Trichinella nativa* in 2 northern Saskatchewan communities. J Infect Dis [Internet]. 2003 Sep 15 [cited 2024 Sep 20];188(6):835–43. Available from: https://doi.org/10.1086/378094
21. Cash-Goldwasser S. Outbreak of human trichinellosis — Arizona, Minnesota, and South Dakota, 2022. MMWR Morb Mortal Wkly Rep [Internet]. 2024 [cited 2024 Sep 20];73. Available from: https://www.cdc.gov/mmwr/volumes/73/wr/mm7320a2.htm
22. Public Health Agency of Canada. Pathogen safety data sheets: infectious substances – *Trichinella* spp. [Internet]. 2011 [cited 2024 Sep 20]. Available from: https://www.canada.ca/en/public-health/services/laboratory-biosafety-biosecurity/pathogen-safety-data-sheets-risk-assessment/trichinella.html
23. Canadian Food Inspection Agency. Canadian standards of identity: volume 7 – meat products [Internet]. 2018 [cited 2021 Dec 1]. Available from: https://inspection.canada.ca/about-cfia/acts-and-regulations/list-of-acts-and-regulations/documents-incorporated-by-reference/canadian-standards-of-identity-volume-7/eng/1521204102134/1521204102836
24. Dale K, McIntyre L. Canadian and international fermented food recalls extracted from food recall databases. Regina, SK: Saskatchewan Ministry of Health; 2022.
25. Ministry for Primary Industries (MPI), New Zealand Government. Magills Butchery ready-to-eat cured meat products [Internet]. Ministry for Primary Industries; 2020 [cited 2023 Mar 31]. Available from: https://www.mpi.govt.nz/food-safety-home/food-recalls-and-complaints/recalled-food-products/magills-butchery-ready-to-eat-cured-meat-products/
26. Food Standards Australia New Zealand. Good to go tasty cheese salami and cabanossi [Internet]. Current Food Recalls. [cited 2023 Mar 31]. Available from: https://www.foodstandards.gov.au/industry/foodrecalls/recalls/Pages/Good-To-Go-Tasty-Cheese-Salami-and-Cabanossi.aspx
27. European Commission. RASFF window- search [Internet]. RASFF Window. [cited 2023 Mar 31]. Available from: https://webgate.ec.europa.eu/rasff-window/screen/search
28. U.S. Department of Agriculture. Recalls & public health alerts [Internet]. [cited 2023 Mar 31]. Available from: http://www.fsis.usda.gov/recalls
29. Health Canada. Advanced search – recalls, advisories and safety alerts [Internet]. 2021 [cited 2023 Mar 31]. Available from: https://recalls-rappels.canada.ca/en/search/site
30. MacDonald DM, Fyfe M, Paccagnella A, Trinidad A, Louie K, Patrick D. *Escherichia coli* O157:H7 outbreak linked to salami, British Columbia, Canada, 1999. Epidemiol Infect [Internet]. 2004 Apr [cited 2023 Mar 31];132(2):283–9. Available from: https://www.cambridge.org/core/journals/epidemiology-and-infection/article/escherichia-coli-o157h7-outbreak-linked-to-salami-british-columbia-canada-1999/4A18AC2B1212F87EB1B65A111943BAB5
31. Paton AW, Ratcliff RM, Doyle RM, Seymour-Murray J, Davos D, Lanser JA, et al. Molecular microbiological investigation of an outbreak of hemolytic-uremic syndrome caused by dry fermented sausage contaminated with Shiga-like toxin-producing *Escherichia coli*. J Clin Microbiol [Internet]. 1996 Jul [cited 2023 Mar 31];34(7):1622–7. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC229082/
32. Alexander ER, Boase J, Davis M, Kirchner L, Osaki C, Tanino T, et al. *Escherichia coli* O157: H7 outbreak linked to commercially distributed dry-cured salami—Washington and California, 1994. MMWR Morb Mortal Wkly Rep [Internet]. 1995 Mar 10;44(4):157–60. Available from: https://www.cdc.gov/mmwr/PDF/wk/mm4409.pdf

33. Mascarenhas M. Foodborne outbreaks associated with fermented products from 1985 to Feb 7, 2022, recorded in Publically Available International Foodborne Outbreak Database (PAIFOD). Guelph, ON: Public Health Agency of Canada; 2022 p. 11.
34. McIntyre L. Foodborne outbreaks associated with fermented foods from 1998 to 2018 recorded in the National Outbreak Reporting System (NORS) Centers for Disease Control and Prevention Database. Vancouver, BC: Environmental Health Services, BC Centre for Disease Control; 2022 p. 6.
35. Canadian Food Inspection Agency. The food safety enhancement program approach to a preventive control plan [Internet]. 2018 [cited 2023 Mar 31]. Available from: https://inspection.canada.ca/preventive-controls/preventive-control-plans/the-food-safety-enhancement-program/eng/1525869691902/1525869759693
36. Canadian Food Inspection Agency. Annex T-1: compliance guideline – requirements for microbiological monitoring of process controls in livestock and ratites abattoirs [Internet]. 2020 [cited 2024 Mar 15]. Available from: https://inspection.canada.ca/exporting-food-plants-or-animals/food-exports/requirements/export-requirements-for-meat-and-poultry-products/annex-t-1/eng/1594664700798/1594664701605
37. Government of Canada, Health Canada. Safe food storage [Internet]. 2013 [cited 2024 Mar 14]. Available from: https://www.canada.ca/en/health-canada/services/general-food-safety-tips/safe-food-storage.html
38. Feiner G. Chapter 16. Raw fermented meat products. In: Feiner G, editor. Meat Products Handbook [Internet]. 1st ed. Woodhead Publishing; 2006. p. 314–75. Available from: https://www.sciencedirect.com/science/article/pii/B9781845690502500393
39. Alberta Agriculture and Rural Development Food Safety Division, Government of Canada. Fermented sausages- part 1. Food safety sentinel. [Internet]. Agricultural Policy Framework; 2008 [cited 2024 Mar 14]. Available from: https://www1.agric.gov.ab.ca/$department/newslett.nsf/pdf/fss13651/$file/fss_jun_2008.pdf?OpenElement
40. Fermented sausages are cured sausages [Internet]. [cited 2024 Mar 14]. Available from: https://www.meatsandsausages.com/sausage-types/fermented-sausage
41. Hammes WP. Metabolism of nitrate in fermented meats: The characteristic feature of a specific group of fermented foods. Food Microbiol [Internet]. 2012 Apr 1 [cited 2023 Mar 31];29(2):151–6. Available from: https://www.sciencedirect.com/science/article/pii/S0740002011001535
42. Federal/Provincial/Territorial Food Safety Committee. Food retail and food services code [Internet]. 2020 [cited 2021 Oct 18]. Available from: https://f.hubspotusercontent20.net/hubfs/7498226/foodservicescode.pdf
43. Savic IV. Small-scale sausage production [Internet]. Rome, Italy: Food and Agriculture Organization of the United Nations; 1985 [cited 2023 Mar 31]. Available from: https://www.fao.org/3/x6556e/X6556E05.htm
44. Canadian Food Inspection Agency. Preventive control recommendations for manufacturing cooked ready-to-eat meat products [Internet]. 2018 [cited 2023 Apr 3]. Available from: https://inspection.canada.ca/preventive-controls/meat/cooked-ready-to-eat/eng/1522942479864/1522942558310
45. Canadian Food Inspection Agency. Recommandations de contrôles préventifs pour le refroidissement des produits de viande traités à la chaleur [Internet]. 2018 [cited 2024 May 24]. Available from: http://inspection.canada.ca/fr/controles-preventifs/produits-viande/refroidissement-traites-chaleur
46. Meat & Livestock Australia. Guidelines for the safe manufacture of smallgoods, 2nd edition [Internet]. Meat & Livestock Australia; 2015 Apr [cited 2023 Nov 3] p. 140. Available from: https://www.mla.com.au/globalassets/mla-corporate/research-and-development/program-areas/food-safety/pdfs/guidelines-for-the-safe-manufacture-of-smallgoods_2nd-edition.pdf
47. Canadian Food Inspection Agency. Food labelling for industry [Internet]. 2019. Available from: https://inspection.canada.ca/food-labels/labelling/industry/eng/1383607266489/1383607344939
48. Joseph A, Cointe A, Mariani Kurkdjian P, Rafat C, Hertig A. Shiga toxin-associated hemolytic uremic syndrome: a narrative review. Toxins [Internet]. 2020 Feb [cited 2024 Mar 15];12(2):67. Available from: https://www.mdpi.com/2072-6651/12/2/67
49. Public Health Agency of Canada,. Infographic: Food-related illnesses, hospitalizations and deaths in Canada [Internet]. 2016 [cited 2024 Jul 16]. Available from: https://www.canada.ca/en/public-health/services/publications/food-nutrition/infographic-food-related-illnesses-hospitalizations-deaths-in-canada.html
50. Public Health Agency of Canada. Risks of listeriosis (Listeria) [Internet]. 2016 [cited 2024 Jul 16]. Available from: https://www.canada.ca/en/public-health/services/diseases/listeriosis/risk-listeriosis.html

51. Weatherill S, Government of Canada. Report of the independent investigator into the 2008 listeriosis outbreak [Internet]. 2009 [cited 2024 Jul 16]. Available from: https://publications.gc.ca/site/archivee-archived.html?url=https://publications.gc.ca/collections/collection_2009/agr/A22-508-2009E.pdf
52. Currie A, Farber JM, Nadon C, Sharma D, Whitfield Y, Gaulin C, et al. Multi-province listeriosis outbreak linked to contaminated deli meat consumed primarily in institutional settings, Canada, 2008. Foodborne Pathog Dis [Internet]. 2015 Jun 3 [cited 2024 Jul 16];12(8):645–52. Available from: https://www.liebertpub.com/doi/abs/10.1089/fpd.2015.1939
53. Feiner G. Chapter 5. Additives: phosphates, salts (sodium chloride and potassium chloride, citrate, lactate) and hydrocolloids. In: Feiner G, editor. Meat Products Handbook [Internet]. 1st ed. Woodhead Publishing; 2006. p. 72–88. Available from: https://www.sciencedirect.com/science/article/pii/B9781845690502500393
54. Canadian Food Inspection Agency. Fermentation- archived- chapter 4- meat processing controls and procedures [Internet]. 2013 [cited 2021 Oct 18]. Available from: https://inspection.canada.ca/food-safety-for-industry/archived-food-guidance/meat-and-poultry-products/manual-of-procedures/chapter-4/eng/1367622697439/1367622787568?chap=18
55. Ross T, Shadbolt C. Predicting *Escherichia coli* inactivation in uncooked comminuted fermented meat products. 2001 [cited 2021 Oct 18]; Available from: https://www.semanticscholar.org/paper/Predicting-Escherichia-coli-inactivation-in-meat-Ross-Shadbolt/b2efb717ea9684b4b3ee0ca96356d3b91df54281
56. Canadian Food Inspection Agency inquiry line. Wild fermentation meat response to Mr. Rick Kane (Enquiry ID: 29334). 2019.
57. Saha Turna N, Chung R, McIntyre L. A review of biogenic amines in fermented foods: occurrence and health effects. Heliyon [Internet]. 2024 Jan 30 [cited 2024 Jan 30];10(2):e24501. Available from: https://www.sciencedirect.com/science/article/pii/S2405844024005322
58. Doeun D, Davaatseren M, Chung MS. Biogenic amines in foods. Food Sci Biotechnol [Internet]. 2017 Dec 13 [cited 2021 Oct 14];26(6):1463–74. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6049710/
59. Ruiz-Capillas C, Herranz AH, editors. Biogenic amines on food safety [Internet]. MDPI- Multidisciplinary Digital Publishing Institute; 2019 [cited 2023 Jan 26]. Available from: https://directory.doabooks.org/handle/20.500.12854/42202
60. Tofalo R, Perpetuini G, Schirone M, Suzzi G. Biogenic amines: toxicology and health effect. In: Caballero B, Finglas PM, Toldrá F, editors. Encyclopedia of Food and Health [Internet]. Oxford: Academic Press; 2016 [cited 2023 Jan 26]. p. 424–9. Available from: https://www.sciencedirect.com/science/article/pii/B9780123849472000714
61. Gardini F, Özogul Y, Suzzi G, Tabanelli G, Özogul F. Technological factors affecting biogenic amine content in foods: a review. Front Microbiol [Internet]. 2016 Aug 12 [cited 2023 Jan 26];7. Available from: https://www.frontiersin.org/articles/10.3389/fmicb.2016.01218/full
62. Barbieri F, Montanari C, Gardini F, Tabanelli G. Biogenic amine production by lactic acid bacteria: a review. Foods [Internet]. 2019 Jan [cited 2023 Jan 26];8(1):17. Available from: https://www.mdpi.com/2304-8158/8/1/17
63. Santos MS. Biogenic amines: their importance in foods. Int J Food Microbiol. 1996;29(2–3):213–31.
64. Health Canada. Health Canada's maximum levels for chemical contaminants in foods [Internet]. 2005 [cited 2023 Jan 26]. Available from: https://www.canada.ca/en/health-canada/services/food-nutrition/food-safety/chemical-contaminants/maximum-levels-chemical-contaminants-foods.html
65. Le ministère de l'Agriculture, des Pêcheries et de l'Alimentation (MAPAQ, Gouvernement du Québec. Mise à jour- Avis de ne pas consommer de salami vendu par l'entreprise Aliment Stabile [Internet]. Nouvelle. Mise en garde à la population. 2024 [cited 2024 Nov 12]. Available from: https://www.quebec.ca/nouvelles/actualites/details/mise-a-jour-avis-de-ne-pas-consommer-de-salami-vendu-par-lentreprise-aliment-stabile-57527

Photo attribution

Overview photo: accessed from https://pixabay.com/photos/salami-sausage-cut-hearty-fat-2645403/

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Fermentation Monitoring

Batch Description			Ingredients (amount, calculate concentration as %)			pH start	Time & temp monitored during fermentation (± smoking)						Final pH	Degree Hours
							Phase 1		Phase 2 (if needed)		Phase 3 (if needed)			
Date	Product	Batch #	Salt	Nitrite	Culture		Time	Temp	Time	Temp	Time	Temp		

Smokehouse Temperature Monitoring

BATCH DESCRIPTION			PRODUCT LOADING TIME AND TEMPERATURES			TIME AND TEMPERATURE MONITORING DURING COOKING						UNLOADING TIME AND TEMPERATURE		
Date	PRODUCT	BATCH #	Internal temp	Time	Operator	Time	Temp	Time	Temp	Time	Temp	Final temp	Time	Operator

Drying Monitoring														
BATCH DESCRIPTION			**WATER ACTIVITY TO START**			**DRYING TIME, TEMP AND HUMIDITY**						**FINAL TIME AND WATER ACTIVITY**		
Date	Product	Batch #	A_w	Time	Operator	Time		Temperature		Humidity		Time finished	A_w	Operator

CALIBRATION LOG | YEAR:				
REFERENCE TEMP: 0ºC				
DATE	SCALE	THERMOMETER 1	THERMOMETER 2	THERMOMETER 5 - INFRARED
	DIFFERENCE FROM REFERENCE/COMMENTS	DIFFERENCE FROM REFERENCE/COMMENTS	DIFFERENCE FROM REFERENCE/COMMENTS	DIFFERENCE FROM REFERENCE/COMMENTS
1-Jan	0; ok	+1/Adjusted; rechecked; ok	0; ok	-4; replaced unit
1-Feb	/	0; ok	0; ok	0; new thermometer
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Appendix 2 | Examples of calculations for nitrite and degree-hours for fermented sausage

The following examples are provided to show a range of questions possible for fermented meat. The information provided here reflects what was actually received by an inspector. You will be asked to do the calculations for nitrite (for botulism control) and degree-hours (for *S. aureus* control). Because the information provided may not be comprehensive you will be asked to consider additional questions for the operator to gather the information required. Answers will be provided at the end.

Example 1. Chorizo sausage – a fermented dry sausage – recipe and process steps provided by the operator:

Recipe	**Processing steps**
Pork shoulder- 10 kg Salt Cure #2- sodium nitrate Spices Culture Dextrose	1. Trim pork shoulder 2. Weigh out Cure #2 powder to 0.25% of total weight 3. Weigh out salt to 2.8% 4. Allow to cure 48 hrs at 2°C 5. Inoculate with hydrated starter culture 6. Grind, mix and stuff into casings 7. Cold smoke (ferment) 48 hrs at 22°C until the pH drops below 5.3 8. Hang to dry (80% humidity) at 12°C until 35% weight loss from green weight. 9. A_W should be <0.9 in about 3 weeks

Other information: A test report for chorizo was done by a commercial lab. The results were: a_W = 0.89; Total plate count, coliforms, *E. coli*, *S. aureus*, *L. monocytogenes* and *Salmonella* were all Not Detected. Yeasts and moulds were 9600 MPN/g. This Operator is also making Basturma (beef) in the facility.

Nitrite calculation:
Degree-hour calculation:
Drying:
What other questions do you have for the Operator?

Answers

Nitrite calculation. Nitrite should be added at a minimum of 100 ppm and should not exceed 200 ppm. This recipe did not provide weights of ingredients. But is the amount of Cure 2 powder being added reasonable? The Operator adds 0.25% Cure 2 powder to the total weight. Assume 10 kg pork, calculate salt as 280 gram (2.8% of weight), and estimate 100 g for remaining ingredients (dextrose is usually added at 0.5% or 50 grams, and assume 50 grams for culture and spices). Total weight = 10.38 kg. Cure 2 added = 25.95 grams (0.25%). But, what is the % of sodium nitrite in Cure 2 powder? Cure 2 powder is pink, and typically contains 6.25% sodium nitrate and 4% sodium nitrate. Now do the calculation, using total weight as 10.40595 kg.

$$\text{ppm } NaNO_2 = \frac{\text{Weight of } NaNO_2 \text{ (kg) X } 10^6}{\text{Weight of emulsion (kg)}}$$

The amount of nitrite is 25.95g X 0.0625=1.621875 g or 0.001621875 kg. % nitrite added is 155.86 ppm.

The amount of nitrate is 25.95g X 0.0400=1.038g or 0.00138 kg. % nitrate added is 132.62 ppm

The % amounts are acceptable. Operator should provide actual measures (weights) for ingredients.

Degree-hours calculation. Degree-hours should not exceed 665 hrs. (22-15.6)*48=307.2 hrs. This is acceptable.

Drying. The final a_W is below 0.9. This is acceptable.

Other questions and recommendations you have for the Operator.

- What are the weights of the ingredients? Provide for each ingredient. Provide example calculations in a log sheet.
- What freezing controls do you have in place for pork?
- What is the name of the starter culture? Is it a commercial starter and is there any documentation for it?
- The pH and a_W measurements are mentioned, but no pH measure was provided. Provide pH measures in a log sheet and describe how this result is obtained during the process.

Example 2. Summer sausage – a semi-dry sausage (quick ferment)

The culture used for this recipe is Bactoferm F-RM-52 fast fermenting culture. The basic steps are shown below:

Ingredients	Steps
Lean Pork 1000 g Lean Beef 500g Back Fat 500g **Total: 2000g** *If using fattier cuts on meat, back fat is not required. Cure #1 (Prague Powder) 5g Sodium nitrite percent by weight in Cure #1 0.313 g Other ingredients: Dextrose 20 g Salt 60 g (3% of weight of meat and fat) Spices 20 g **Total: 100 g** Water 52 g Culture 0.53 g Total other ingredients plus water plus culture 100 g 52 g 0.53 g **Total: 152.53 g** **Total weight of sausage mix (emulsion)** 2000 g plus 152.53 g **Total: 2152.53 g or 2.1525 kg**	1. Use fresh chilled meat and fat. 2. Cut meat and fat into small chunks. 3. Grind meat and fat. Before grinding, ensure meat is partially frozen and equipment is cold to prevent fat from smearing which creates a better product. Once done put meat back in freezer. 4. Start the starter culture. Rehydrate with water to activate it. Follow manufacturer's recommendation for rehydration time and amount used per green weight of meat. 5. Prepare casings as per manufacturer's recommendation. 6. Set up a dedicated area for fermentation (green room). The temperature range is 25°C (77°F) to 45°C (113°F) and is based on the manufacturer's recommendation for the culture used. A high humidity for at least 24 to 48 hours is required. Humidity ideally starts at 95% and is decreased over time, keep at 5% less than the moisture of the product (e.g., 5% below the water activity of the product). Need two controllers, one for temperature and one for humidity. Make sure there is enough airflow (e.g., cooling fans can be used to maintain good air flow). 7. Mix meat. Make sure it's below 4°C (40°F). 8. Add seasonings, sugar, and cure and mix thoroughly. 9. Add starter culture and mix thoroughly 10. Stuff casings with mixture and hang in fermentation area. Take initial pH; ferment for 24-48 hours. Final pH must be at or below 5.3. Based on manufacturer's recommendations, fermentation was employed at a constant 30°C (86°F) for 24 hours with a pH of 5.0 taken at the end of fermentation. Degree-hours must be verified as acceptable at this step. 11. Hot smoke (for this recipe the casing diameter was less than 55 mm). Have a system in place to monitor internal cooking temperatures. Close smoker and smoke the sausage at 44°C (110°F) for 1 hour followed by increasing the smoker temperature to enable the internal temperature of the sausage to reach 54.4°C (130°F). Once it reaches 54.4°C (130°F) hold at this temperature for a minimum 121 minutes. 12. Once smoking is complete, submerge sausages in cold running water and let bloom for 2 hours. 13. For drying follow manufacturer's recommendation. For Bactoferm F-RM-52 fast fermenting culture the manufacturer recommends a temperature range of 12°C (53.6°F) to 16°C (60.8°F) with a humidity of 80-90%. The drying time would be 2 to 40 days (the length of the drying time depends on preference for the level of dryness but generally a 30% weight loss is desirable). Controllers are needed to monitor temperature and humidity during this process. Sausage was dried for 15 days at 12°C (53.6°F) with the humidity set to 85%. 14. Store finished product at or below 4°C (40°F). Product could be shelf stable if a water activity meter was used and the end-product meets the parameters for shelf stability.

Recipe check and calculations:

Nitrite calculation:
Salt calculation:
Starter culture amount calculation:
Nitrite concentration calculation:
Are temperature and humidity values acceptable during fermentation and drying?
Were the number of degree-hours met during fermentation?
Did the cooking step meet Health Canada's criteria for *E. coli* O157:H7?
What other questions do you have for the Operator?

Answers

Calculation to determine weight of sodium nitrite in Cure #1 (Prague Powder)
Cure #1 contains 6.25% sodium nitrite. 5 g x 0.0625 = 0.313 g sodium nitrite
Calculation to determine how much salt (NaCl) to add
For this recipe 3% salt is used. To calculate the weight of salt, multiple the weight of the meat and fat by 0.03. Total meat and fat weight = 2000 g X 0.03 = 60 g NaCl
Calculation to determine amount of F-RM-52 Starter Culture to add.
F-RM-52 Starter Culture is added at a ratio of 25 g culture to 100 kg mixture $$\frac{25\ g\ culture}{100\ kg\ mixture} = \frac{X}{2.100\ kg}$$ $$X = \frac{25\ g \times 2.100\ kg}{100\ kg} = 0.53\ g\ culture$$ Note: 2.100 kg is calculated based on 2000 g (meat and fat) + 100 g (other ingredients not including the water) = 2100 g = 2.100 kg
Calculation to determine if the amount of sodium nitrite is acceptable (100 to 200 mg/kg or ppm range)
The total weight of the sausage mix or emulsion = 2.1525 kg The weight of Cure #1 = 5 g = 0.005 kg Cure #1 = 6.25% sodium nitrite, therefore 5 g Prague Powder = 0.313 g sodium nitrite Divide weight of sodium nitrite by the weight of the emulsion and then convert units into mg/kg or ppm. 0.313 g ÷ 2.1525 kg = 0.1454 g/kg x1000 mg/g = 145.4 mg/kg which is equivalent to 145.4 ppm Based on the calculation the amount of sodium nitrite used in this recipe is within the acceptable range of 100 to 200 ppm. Formula for the calculation can be found here: Preventive control recommendations on the use of nitrites in the curing of meat products- inspection.canada.ca
Are temperature and humidity values acceptable during fermentation and drying?
Answer: Yes, the temperature and humidity of the fermentation area and the drying area met the target values in Table 6.
Were the number of degree-hours met during fermentation?
Yes, the number of degree-hours to achieve a pH of 5.3 was met during fermentation. Calculation: (30°C- 15.6°C) x 24 hours = 345.6 degree-hours The degree-hours limit for the corresponding temperature (30°C) and time (24 hours) is 665 or below. The degree-hours equalled 345.6. Preventive control recommendations for manufacturing fermented and dried meat products- inspection.canada.ca
Did the cooking step meet Health Canada's criteria for *E. coli* O157:H7?
Answer: Yes, the cooking times and temperatures during the hot smoking step met Health Canada Intervention 1 for *E.coli* O157:H7. Interim guidelines for the control of verotoxinogenic Escherichia coli including E. coli O157:H7 in ready to eat fermented sausages containing beef or a beef product as an ingredient- Canada.ca