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Safety of Fermented Foods

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

BC Centre for Disease Control
Provincial Health Services Authority
Alberta Health Services
Saskatchewan
Manitoba
Public Health Ontario | Santé publique Ontario
Québec
New Brunswick | Nouveau-Brunswick
Nova Scotia
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Additional fermented food guidance can be accessed at:
http://www.bccdc.ca/health-professionals/professional-resources/fermented-foods

List of contributors

Section 1 Introduction: L. McIntyre, A. Trmčić. Section 2 Starters and standards: L. McIntyre, A. Trmčić. Fermented Foods Sections: 3.1 Fermented Vegetables: L. Hudson, B. Coopland, K. Dale, L. McIntyre; 3.2 Sauerkraut: L. McIntyre; 3.3 Kimchi: S. Jang, L. McIntyre; 3.4 Dosa and Idli: K. Paphitis; 3.5 Fesikh: N. Parto, R. Shalansky; 3.6 Yogurt: L. Hudson, B. Coopland, Y. Nan; 3.7 Plant-based cheese made from nuts: L. McIntyre; 3.8 Natto: L. McIntyre, T. Yang; 3.9 Tempeh: L. McIntyre; 3.10 Koji and Miso: L. McIntyre; 3.11 Kombucha and Jun: L. McIntyre, K. Dale; 3.12 Kefirs (milk and water): N. Parto, C. Loewe; 3.13 Fermented sausages: D. Walker, C. Frigault, J. Thomas, J. Samson, K. Paphitis, L. McIntyre; 3.14 (non-fermented) Pidan Century Egg: N. Parto. Review of outbreaks and recall databases: N. Parto, K. Dale, L. McIntyre.

The following **National fermented food working group** members attended meetings, participated in discussions and reviewed this guidance. Members and agency names may have changed since publication (2024).
Lihua Fan – Agriculture and Agri-Food Canada
Dale Nelson – Alberta Health Services, Environmental Public Health
Lorraine McIntyre – Environmental Health Services, BC Centre for Disease Control
Gloria Yu – BC Island Health Authority
Barbara Adamkowicz – Manitoba Health
Leslie Hudson – Manitoba Agriculture
Douglas Walker – New Brunswick Department of Health
Rosalie Lydiate – Government of Newfoundland and Labrador
Sonya Locke – Nova Scotia Environment and Climate Change
Rick Kane – Nova Scotia Perrenia Food and Agriculture Inc.
Naghmeh Parto, Katherine Paphitis – Public Health Ontario
Ellen Stewart, Stephanie Walzak – Prince Edward Island Department of Health & Wellness
Julie Samson, Caroline Frigault, Yosra Ben Fadhel, Marie-Eve Rousseau – Quebec Ministère de l'Agriculture, des Pêcheries et de l'Alimentation
Kelsie Dale – Saskatchewan Ministry of Health

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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.

3.5 | Fesikh/Feseekh fermented salted fish

Authors: Naghmeh Parto and Rebecca Shalansky | Public Health Ontario

Overview

Description	 Fish is washed, eviscerated, ripened, salted and fermented. It is traditionally consumed in Egyptian culture during the Sham el-Nessim festival, a spring celebration. Fesikh is served as a ready-to-eat spread, however, when prepared using a traditional process that holds fish for 24 hrs without temperature control, opportunities for pathogen growth may be introduced. A heating step to 85°C or higher prior to consumption is recommended to reduce pathogen risk in traditionally prepared fesikh.
Starter culture	• Traditionally wild or spontaneous fermentation, with *Lactobacillus casei* and *Lactobacillus* spp. • Adding lactic acid bacteria (LAB) during salting will decrease fermentation time, prevent biogenic amine production, and enhance flavour.
Key features	• Fesikh is ready-to-eat, but cooking before service will reduce risk of pathogens. • Prior to fermentation, a ripening or putrefaction step occurs for 24 hours at 30°C. This step is recognized as high risk, allowing growth of pathogens. • Spontaneous fermentation occurs when fish are salted in layers and placed into deep containers such as barrels for 3 to 15 days (recommended) or longer up to several months. Fesikh should have a final salt concentration of 6 to 10% (typical) or higher (up to 30%). • The final product should have an available water (a_w) of <0.97 with pH of <6.5, and should be refrigerated at 4°C, regardless of final salt concentration. When packaged under reduced oxygen conditions, then refrigerated storage at 3.3°C or less is required. • The shelf life of fesikh prepared with lower salt levels (minimum of 6% final salt concentration) is 2 weeks and up to 3 months if higher salt levels (10% or over) is achieved. However, it is recommended to consume higher salt fesikh within 60 days to minimize BA production in fesikh.
Hazards of concern	• *Clostridium botulinum* outbreaks have been associated with uneviscerated fish used to prepare fesikh. • Biogenic amines (BAs) in fesikh increases during ripening and storage, after 60 days the product may be hazardous due to high levels of BAs.
Important control points	• Use fresh fish and LAB starter culture to decrease BA production. • Wash and eviscerate the fish prior to ripening and fermentation to decrease risk of *C. botulinum*. • Layer pickling salt between fish and use a minimum amount of 10 to 15% salt to fish (w/w) to achieve the final salt concentration of 6 to 10% in product. Higher salt amounts may be used but may retard LAB growth. • Ensure a final water a_w of <0.97 and pH of <6.5. • Refrigerate fish at 4°C or lower during storage or 3.3°C if hermetically sealed.

Background

Fesikh (or feseekh) is a traditional Egyptian salted and fermented fish.[1,2] Fesikh is commonly consumed during the Egyptian holiday of *Sham el-Nessim*, which is the celebration of spring. The celebration occurs one day after Coptic Easter.[1,3] Fesikh dates back to 2700 BCE.[3,4] It is said that the Egyptian pharaoh was considered the first to eat fesikh.[5] The process of making this dish is complicated and the production techniques traditionally have been passed down from generation to generation. In Egypt, people making fesikh are called "Fasakhani".[6]

Fermented fish dishes, including fesikh, are typically made from fatty or semi-fatty fish.[2] Semi-fat fish are fish that contain more than 2.5% fat without exceeding 6%, examples include bream, mullet, and sea bass. Oil rich fish are fish that contain over 6% fat content, examples include shad, sardine, herring and mackerel.[7] Mullet is typically used for fesikh, although shad fesikh has been documented as well.[8,9] The end product is wet and soft, with a pungent smell. Fesikh may be prepared as a whole fish or cut-up into pieces.[9,10] Fesikh is often portioned and spread on bread.[11]

Mullet fish live in the coastal waters of tropical, subtropical and temperate zones of all seas.[12] They are bottom-feeders and eat by sucking up mouthfuls of mud, and filtering food particles through their gills.[11] The fish will expel what is not edible, and swallow edible contents. If the mud contains *C. botulinum* spores, the gut or the gills of the mullet can become contaminated.[11] A recent (2022) study isolated *C. botulinum* from 40% of examined uneviscerated fesikh products in Egyptian markets.[13]

Outbreaks and Recalls

Two recalls of fesikh occurred in Canada linked to botulism concerns (Table 1). In Canada, *C. botulinum* was associated with recalled uneviscerated fesikh shad, fesikh sardines and whole and cut-up fesikh mullet in oil in Canada. We also identified three public advisories for consumption of fesikh and risk of botulinum in Canada from 2012 to 2014. No recalls were identified in the United States (U.S.),[14] Australia[15] and New Zealand[16]. In 2020, Cyprus recalled salted dried fish from the Netherlands due to contamination with *C. botulinum*, however, no information was available to determine if this product was fermented.[17]

Table 1 | Recalls and alerts related to fesikh products in Canada

Year(s)	Hazard Category	Hazard Detail	Number of Alerts and Recalls	Country	Product Description
2012[18]	Biological	*C. botulinum*	3	Canada	3 recalls for whole fesikh mullet and cut up fesikh mullet in oil and cured whole mullet and shad
2012-2014[9,19,20]	Biological	*C. botulinum*	3	Canada	3 alerts for consumption of un-gutted salted fish such as fesikh in 2012-2013 and 2014

Five *C. botulinum* outbreaks associated with consumption of fesikh were identified following a Google search of the first 100 results (conducted in March, 2022), a review of the Publicly Available International Foodborne Outbreak Database and review of the CDC outbreak database (NORS Dashboard).[21,22] A summary of identified outbreaks is presented in Table 2. In all cases, uneviscerated mullet, shad or sardines led to illnesses and deaths from botulinum intoxication. It should be noted that no botulism outbreaks were associated with eviscerated fish, highlighting the importance of this step.

Table 2 | Outbreaks associated with consumption of fesikh

Date	Country	Pathogen	No. Ill (fatalities)	Premises where outbreak occurred	Reason
1991[23]	Egypt	*C. botulinum*	91 (18)	Retail stores	Uneviscerated (salted mullet)
1992[24]	U.S.	*C. botulinum*	3 (0)	Retail stores	Uneviscerated
2005[25]	U.S.	*C. botulinum*	5 (0)	Home	Uneviscerated
2012[1]	Canada	*C. botulinum*	3 (0)	Retail stores	Uneviscerated (shad and sardines)
2018[26]	U.S.	*C. botulinum*	2 (0)	Home	Uneviscerated (salted mullet)

Description of food preparation for fesikh

In Canada, fesikh is either prepared at home for personal use, in food premises such as restaurants, or by small scale producers.[9] Methods of preparation may be hetrogeneous given the familial passing down of recipes.[3] Generally, fresh fish is obtained, washed, eviscerated, drained, ripened, salted, fermented, and packed. During the ripening or putrefaction step and the following salting and fermentation step, raw fish undergoes degradative changes through enzymatic and microbiological activity. These enzymes and microorganisms are naturally present inside and on the surface of the fish. Lactic acid bacteria (LAB), micrococcus and yeast, have been detected in fesikh.[2] While this is a spontaneous fermentation, it has been shown that adding LAB culture (*Lactobacillus casei* and *Lactobacillus* spp.) during salting can shorten the fermentation time and reduce biogenic amines (BAs) production.[27]

Step 1. Choosing fresh fish is a critical control point: It is recommended to obtain fresh fish to reduce BAs production. Choosing fish by colour alone is not a good index of freshness as fish quality is affected by other factors such as diet and the environment. Other factors to identify if fish are fresh:

- smell: avoid using fish that has fishy, sour or ammonia-like smell;
- eyes: fish's eyes should be clear and shiny;
- flesh: fresh fish has firm flesh; the flesh should spring back when pressed;
- discolouration or darkening: avoid fish that has discolouration, darkening or drying around the edges.[28]

Fish are perishable foods, and its quality is affected by time, temperature, and handling practices. After fish are caught, storage on board the vessel, during transport and during processing at high temperatures can rapidly decrease the quality and shelf life of the fish. It will accelerate microbial spoilage, enzyme breakdown, lipid hydrolysis and oxidative spoilage which causes quality deterioration and shelf life decrease.[20,29] Operators are recommended to source fresh fish for processing. Fish should be received on ice and stored in the refrigerator at 3.3°C or lower prior to processing. Another way to identify if the fish is fresh is by measuring the total volatile basic nitrogen (TVB-N). Volatile compounds (trimethylamine, ammonia and dimethylamine) are considered as TVB-N and are produced as a result of destructive activities of microorganisms. TVB-N is used in industry to monitor freshness, quality and the safety of seafood products. For example, the TVB-N for white fish should be <20mg N/100g.[11,30,31] Regulations under the European Council describe the method for testing TVB-N and TVB-N levels acceptable (25, 30 or 35 mg of nitrogen/100 g) under three categories of fishery products based on species.[32]

Step 2: Washing, evisceration, draining: Fish should be washed in potable water, then guts removed (eviscerated) along with the gills. Once fish are gutted, they should be rinsed in potable water, then drained. Draining should be done under refrigeration to minimize bacterial growth. Draining time ranges from 30 min to 24 hr, until excess fluids are removed. Traditionally, uneviscerated whole fish has been used; this is not recommended as consumption of uneviscerated fesikh has been associated with *C. botulinum* infection.[32,33] The U.S. Food & Drug Administration exempts fish from evisceration if they are five inches or less in length, processed in a manner that prevents toxin formation, and have a final pH ≤4.6 or water-phase-salt content of 10% or higher.[34] The Canadian Food Inspection Agency recommends use of only eviscerated fish for fesikh production. As the next step in fesikh processing does not prevent toxin formation, and because the final pH for fesikh is higher than 4.6, all fish should be eviscerated; this is a critical control step in this process.

Step 3: Ripening or putrefaction step: Fish are left at 30°C for up to 24 hours until they are soft and swollen.[30] During this stage, the fish undergo degradative changes through enzymatic or microbiological activity, more commonly known as spoilage. Leaving fish in the heat of the sun has traditionally been recorded in the literature, but this method is less controlled and therefore not recommended.[3] While this step is necessary for production of fesikh, putrefaction is not a recommended food safety practice, as it allows the growth of pathogens. In one research paper, soaking fish in reduced pH solution with spices for 4 hours and omitting the ripening step resulted in a product with lower BA levels (e.g., histamine).[35] Cleaning and sanitizing of equipment and premises and preventing fish from contamination via environmental cross contamination from pests or other biological or chemical hazards is a key food safety factor.

Step 4: Fermentation: Next, the fish are layered into deep containers such as barrels with a minimum of 10% to 15% (w/w) coarse pickling salt in between each layer, with salt also added at the top and bottom of the container.[11]

Higher salt levels may also be used, but may retard spontaneous fermentations with LAB. Use of non-iodized pickling salt is recommended as iodized salts, sea salts and other specialty salts may contain heavy metals, anti-caking agents and other agents that may interfere with fermentation, cause discolouring, or create other issues with fesikh.[36] The salted fish, with no other added ingredients, are stored at room temperature in containers sealed with airtight lids.[11] Reported holding times vary from 3 days to 15 days until sufficient pH drop (6-6.5) and water activity (<0.97) is achieved. Traditional holding times can vary from one week to several months, although this practice is not recommended by researchers as it increases risks for BAs formation when held for 60 days or longer.[11] The final concentration of salt in fesikh is usually between 6-10%, although higher concentrations of salt of up to 30% have also been reported in the literature.[34] Over the course of weeks, as the salt starts to draw liquid out of the fish, weights are placed on the fish to prevent fish from floating in the liquid.[11] This is a spontaneous fermentation of LAB, yeast, and other microorganisms naturally available on the fish and detected in fesikh.[2] Adding commercially sourced LAB during fish salting can shorten the curing time and enhance flavour.[2]

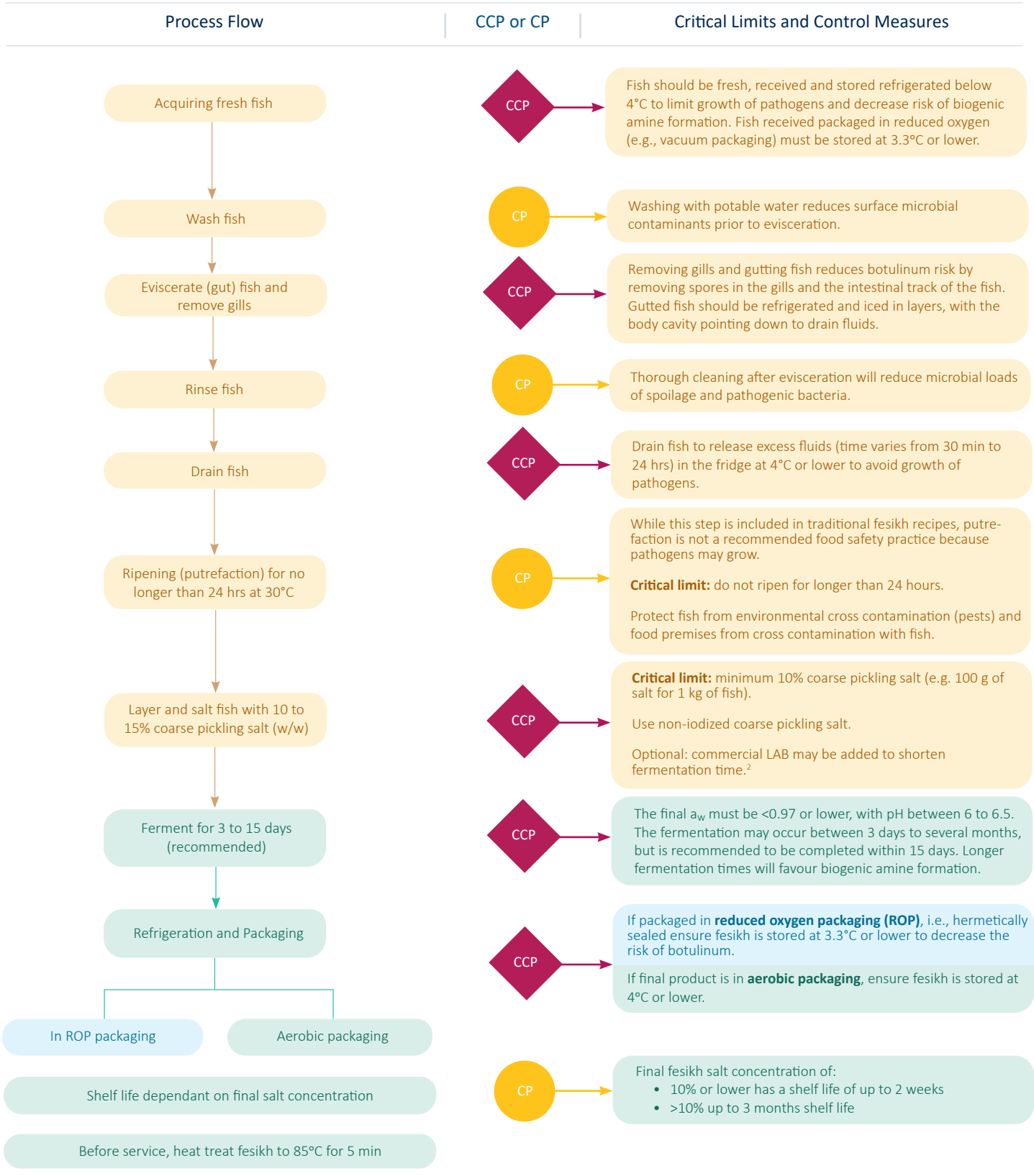
During this stage a decrease in bacterial load has been observed in the literature. A study by Boziaris et al. reported that after 2 days of salting, growth of LAB, in semi-anaerobic condition, was associated with a reduction of total bacterial load in fish. The decrease in total bacterial load has also been attributed to decrease in a_w.[37]

Prepared fesikh, regardless of final salt content, should be stored refrigerated at 4.0°C or below, unless the product is packaged into hermetically sealed containers (i.e. in reduced oxygen packaging of any type, such as sealed jars or vacuum-packaged), in which case the fesikh should be stored at 3.3°C or lower.[38] The finished product should have a final pH between 6-6.5, and a water activity below 0.97.[38,39] A minimum a_w of 0.97 will control for growth of *C. botulinum* Type E and *Vibrio cholera*, however lower a_w is desirable to control other potential pathogens.[40] The shelf life of fesikh is between 2 weeks for lower salt levels (6% final salt concentration) and up to 3 months if higher salt levels (>10%) is achieved.[10,41] Fermentation times of 60 days or longer will increase risks of BAs.[42]

Box 2 | Public health considerations for preparation of fesikh

Traditionally prepared fesikh includes putrefaction, which does not conform to food safety control practices. In this step, fish, a perishable and potentially hazardous food, is left out of temperature control for up to 24 hours at elevated temperatures of 30°C. During this time bacteria and spoilage microbes amplify. Of particular concern are botulinum bacteria. Public health jurisdictions should consider whether this food is appropriate to prepare and serve in food premises. This decision is made respecting the cultural traditions and values of Egyptian peoples and others who celebrate this food during cultural observances. Although good food safety practices are provided in this guidance document, the risk of botulism in this food cannot be understated. Botulinum toxin is heat sensitive. For this reason it is recommended that prior to serving fesikh, all fesikh spreads and dishes are heated through to an internal temperature of 85°C or higher. Should fesikh be prepared and served in food premises, we further recommend strict control of hygienic practices and limiting potential points of cross contamination between fesikh and other foods, and inclusion of menu label warning to inform consumers of risk. Where fesikh is retailed, consumer handling information should be included on packaged products, with instructions to keep fesikh refrigerated at 4°C (or at 3.3°C or lower if hermetically packaged), to reheat to 85°C for 5 minutes before consuming, and to include best before dates.

Fesikh food flow chart | Process flow and controls



Potential issues with fesikh food preparation

The main issues with fesikh production are the long processing time, variable quality of culture (wild fermentation), risks due to unhygienic conditions during production and raw consumption without heating to proper internal temperature.

Issue	Description
Lack of freshness and BA production	Use fresh fish to reduce BA production. Fish can be assessed by visual signs of freshness (e.g., clear eyes, not slimy), or by testing for TVB-N levels. TVB-N levels below 20mg N/100g indicate that the fish is fresh, and are rejected for human consumption if greater than 50mg N/100g.[2,30] Fish should be stored at or below 4°C, and if they are vacuum packaged, should be stored at 3.3°C or lower.[33]
Lack of evisceration	Intestines may contain *C. botulinum* spores. Uneviscerated fish increase the risk for botulinum spores to be present, for bacterial growth and toxin production. Evisceration is highly recommended.[38]
Rinsing and draining	Rinsing in potable water before and after evisceration is recommended. Draining should be done under refrigeration to minimize bacterial growth.
Putrefaction step	It is recommended to not ripen or putrefy fish. Ripening of fish for up to for 24 hours at 30°C is recognized as a high-risk step in this process. Pathogens and spoilage microbes may amplify during this period. Fish should be protected (covered) from pests, fluids allowed to drain, and if it is ripened, it is recommended that ripening occur in a separate area away from other foods to avoid potential cross contamination.
Long fermentation	Fermentation times longer than the recommended 3 to 15 days may result in BA formation. Total BA should be <3 mg/kg in the final salted fish product.[9]
Salt concentration	Fish should not be tightly packed, so that the salt can penetrate into all parts of the fish.[11] The final concentration of salt should be a minimum of 6-10%.[34] Low salt concentration: LAB fermentation will be delayed, and lower salt may allow *C. botulinum* (if present) time to grow and produce toxin before salt reaches the digestive system where pathogens are.[11] High salt concentration: retards the growth of LAB. Use non-iodized pickling salt.
Water activity too high	Refrigerated fesikh should have a_w <0.97 or lower.[38] Higher water activity promotes the growth of bacteria.[38]
Storage temperature too high	The final fesikh product should be stored below 3.3°C when packaged in reduced oxygen environments. Higher temperatures increase the risk of *C. botulinum* growth in anaerobic environments, and promotes other bacterial growth.[38]

Fesikh food safety control points

Food safety points described in this section are shown in point form below:

- Ensure that the original fish product is fresh and stored at 3.3°C if packaged in reduced oxygen (ROP) or at 4°C in aerobic packaging.[2,30,33]
- Ensure the fish is thoroughly eviscerated, washed and rinsed to reduce the risk of *C. botulinum*.
- Salting is the most important step for limiting bacterial growth. Fish should be layered with a minimum of 10% pickling salt (w/w) with the final salt concentration between 6-10%.[38] It is recommended to use smaller fish, provide space between fish, and to layer salt for penetration into all parts of the fish.[2,11]
- Post production, fesikh should be stored at or below 3.3°C when in ROP, and should have a_w <0.97 and pH of <6.5.[38,39]
- Prior to consumption, heat treatment is recommended for fesikh to inactivate botulinum toxin, for e.g., reheating to a temperature of 85°C for a minimum of 5 minutes.[38]

Potential health issues with fesikh

BAs can be produced during fesikh fermentation and are harmful if ingested in high concentrations. BAs occur primarily from metabolic activity by microorganisms during fermentation (see Box 3 below). Histamine, tyramine, putrescine, cadaverine, spermidine, and spermine are some of the main BAs associated with fesikh.[42] The highest levels of histamine reported for the category of fermented salted fish were 579 mg/kg, above the threshold of 80 mg/kg for causing illness.[43] For tyramine, the highest levels reported were 523 mg/kg and within reported levels that cause illness between 100 and 800 mg/kg. For phenylethylamine, the highest levels reported 162.4 mg/kg a level above the threshold of 30 mg/kg for causing illness.[43] For other BAs the highest levels reported for tryptamine was 69.4 mg/kg; putrescine was 241 mg/kg; cadaverine was 1205 mg/kg; spermidine was 351 mg/kg; and spermine was 77 mg/kg.[43]

Box 3 | 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 BAs intake does not cause illness as intestinal amine oxidases break down and detoxify the BAs.[44,45] If large amounts of BAs 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.[44,46,47] The toxic effects of BAs may vary between individuals depending on individual sensitivity and on the consumption of alcohol or drugs that are monoaminooxidase inhibitory.[48,49]

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.[50] However, there are no guidelines set for other fermented food products and BAs other than histamines in Canada, or elsewhere in the world. 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.[45]

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 to ensure the expected culture activity occurs within correct timeframes; and

(5) monitoring for expected pH and/or a_w.

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 BAs illness. Further information about BAs and testing is found in Section 2 of this guidance.

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