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DISCUSSION PAPER ON TRADITIONAL UNDERGROUND GROUND OVEN COOKING IN THE SOUTH WEST PACIFIC: FOOD SAFETY CONSIDERATIONS

(Prepared by Vanuatu, Cook Islands, Fiji, New-Zealand, Samoa, Solomon Islands, Tonga and the International Union of Food Science Technology (IUFoST)[1])

Background

1. The Second Codex Colloquium for North America and the Southwest Pacific held in Fiji from 26-28 February 2024, resulted in a recommendation to develop a discussion paper that addresses the safety of **traditional methods of food preparation practiced in the South-West-Pacific, including underground cooking**. "The discussion paper should aim to support fact-finding on such practices and their possible food safety challenges", with the intent to develop recommendations where applicable and to promote a culture of food safety in association with the adoption of such traditional cooking practices.

2. The objective of this discussion paper is to offer a review of some traditional food preparation practices in the South-West Pacific region, with emphasis on underground cooking, with considerations of food safety challenges and recommendations to be possibly developed and adopted and which could lead the way to a Regional Code of Practice to be developed by the FAO/WHO Coordinating Committee for North America and the South West Pacific (CCNASWP).

Introduction to underground cooking practices

3. Cooking food in underground ovens is a traditional method used in different regions of the world, including the Southwest Pacific. Despite the variety of ethnic groups present, food traditions in the Southwest Pacific are characterized by their continuity across cultures (Haden, 2009). In this context, the underground oven remains a common element throughout the region (Table 1). A wide variety of foods may be cooked in underground ovens, including meats (e.g., pork, chicken, fish), fruits (e.g., bananas, breadfruit), and vegetables (e.g., sweet potatoes, taro).

Table 1. Underground oven names used in the Southwest Pacific

Ethnic group / region	Underground oven traditional name
Hawaii	Imu
Fiji	Lovo
Maori (New Zealand)	Hangi
Aboriginal and Torres Strait Islanders (Australia)	Kup mari
Solomon Islands	Motu
Vanuatu	Laplap Bunia Tuluk

4. In the Southwest Pacific, cooking food in underground ovens is an essential element of traditional family and community gatherings (e.g., family gatherings, festivals, weddings), and is recognized as a valuable

[1] This document was prepared by the Group of Experts of the Global Food Regulatory Science Society (GFoRSS), the Disciplinary Group for of the International Union of Food Science and Technology (IUFoST).

social, cultural, and historical heritage. Beyond the underground oven's role within local communities, the region's tourism industry regularly includes this tradition in events (e.g., lovo nights or luaus in hotels and resorts) aiming at introducing visitors to local cuisine and culture (Chong & Stephenson, 2022). Preserving such traditions is of utmost importance, especially considering the effects of globalization and westernization of food and culinary habits (Chong & Stephenson, 2022).

5. Food regulatory authorities, however, face a dilemma. They should encourage and support the production of local traditional foods, but they may not be produced in compliance with food safety and/or hygiene standards and thus, are considered a consumer risk under conventionally accepted food safety standards (Benkerroum, 2013). The risk posed by traditional foods of different regions has not been formally estimated, mainly due to the lack of consumption and epidemiological data, as well as appropriate surveillance programs (Benkerroum, 2013). Nevertheless, it is generally assumed that traditional foods, compared with prepackaged industrial foods, are produced under less hygienic conditions and without clearly defined control measures (van der Meulen et al., 2016).

6. Thus, an assessment of potential food safety concerns associated with foods cooked in underground ovens, according to Southwest Pacific practices, would contribute to the identification of control measures adapted to these foods and their preparation processes, the mitigation of the risk for consumers, and the preservation of this tradition.

Underground cooking processing steps

7. In the Southwest Pacific, underground ovens are prepared by digging a pit, lining the bottom of the pit with stones or coral, heating stones on burning logs, placing the food in the oven on a layer of plant materials or wrapped in leaves, and covering the pit with earth for the duration of the cooking process (Shah et al., 2018; Chong & Stephenson, 2022). This cooking process relies on the generation of steam – and not dry heat – from the plant materials.

8. Preparing food in an underground oven is a lengthy process involving several steps (Sellars & Heggie, 2005; Labiste, 2013), as follows:

(1) Oven design and construction

- A round pit with sloping sides is dug onto the earth, to a depth of 0.5-1.5 m. The depth and the diameter of the pit will vary depending on the amount of food to be cooked, as it must be large enough to contain the food, the stones, and the plant materials.
- The excavated earth is placed near the pit (it will be used later for covering).
- Kindling material (e.g., small branches) is placed at the bottom center of the pit.
- Larger wood (e.g., dry hardwood) is placed around the kindling material.
- Stones the size of a closed fist or larger are placed on top of the larger wood.

(2) Heat source

- The kindling material is lit. As the larger wood turns to charcoal, the stones drop inward on the hot coals.
- When the stones reach their maximum heat – after several hours – they are leveled out to an even floor on top of the coals.

(3) Materials and staging

- Food, plant materials, and covering materials are brought near the pit.
- A first layer of plant materials (e.g., banana stumps, coconut husks) is added directly over the hot stones.
- A second layer of plant materials (e.g., ti leaves, palm leaves) is added on top of the first layer.
- The food – wrapped in leaves or not – is added on top of the second layer of plant materials, directly or in a rack. All food is placed in the oven at the same time.
- A third layer of plant materials (e.g., ti leaves, banana leaves) is added, covering the food.
- The covering material (e.g., mats, cloth) is extended at the pit's surface level.
- A layer of loose dirt or dug up earth is added on top of the covering material.

(4) Cooking process

- The oven is maintained covered for the entire duration of the cooking process.

- The temperature is not monitored at any point during the cooking process.
- The cooking time is estimated based on traditional knowledge considering the oven's heating capacity, the thickness of the plant layers, and the type and amount of food.

(5) Finished product handling

- At the end of the cooking process, the different covering layers are removed one by one.
- The food is usually served and consumed during the gathering.

Food safety considerations

9. Like most traditional food preparation methods, cooking food in underground ovens is not a standardized process. As such, variations in parameters that may affect the safety of the cooked food are expected. Considering the main processing steps described in the Section above, an analysis of elements and practices that could impact the safety of the food prepared using this method is presented below.

(1) Oven design and construction

- Food safety objective: optimize heat distribution.

10. The dimensions of the oven (depth and diameter) should be adapted to the amount and type of food that will be cooked. Avoiding large gaps between the last layer of plant materials and the covering material will prevent large temperature gradients, allowing the steam to be evenly distributed within the oven.

11. The stones used to build the oven should be of similar size, for even heat distribution, and non-porous (e.g., basalt). Stones that may contain moisture (e.g., porous rocks like limestone) should be avoided, as they may explode when heated.

(2) Heat source

- Food safety objective: optimize heat level and distribution.

12. As in an open pit, the initial set up of kindling and hardwood material will determine the level of burning heat obtained and the time required to convert wood into coals. The process may be lengthy and requires close monitoring. Usually, when coals are grey and produce glowing embers (not flames), they have reached a consistent heat level. The stones would have dropped on top of the coals at this point. When this happens, the stones should be arranged in an even, flat layer, such that the plant materials that will generate steam are heated evenly.

13. Underground oven cooking does not allow for access or modifications to the heat source during the cooking process. Thus, the initial set up of wood and stones must ensure the generation of sufficient heat throughout the cooking process.

(3) Materials and staging

- Food safety objective: maximize steam generation and preservation

14. Underground oven cooking relies on the production of steam to heat the food. Steam is produced when the moisture in the plant materials is heated by the hot stones. Thick materials like banana stumps or coconut husks may be used in the first layer in direct contact with the stones and may be cut and/or pounded with a rock to release moisture and facilitate steam production. These conditioning steps should be conducted in advance such that the materials are ready to be placed in the oven as soon as the stones reach their maximum heat level.

15. To prevent the steam from escaping, the covering layer (e.g., mats, cloths) should extend beyond the diameter of the pit's opening and should be fully covered with loose dirt.

- Food safety objective: prevent the presence, introduction or proliferation of contaminants in the food

16. Handling of food and food contact materials must follow good hygiene practices.

17. All materials should be of high hygienic quality and must be kept away from the soil.

18. All plant materials collected for use in an underground oven must be, at a minimum, free of visible contamination.

19. Special attention should be given to raw food and food contact materials (e.g., food contact layers or food wrapping materials), which should meet relevant food safety standards.

20. Food should be prepared as close as possible and kept at room temperature not more than one hour prior to the time of placement in the oven to avoid microbial proliferation. Raw meats should be held at refrigeration until placement in the oven. The food items must be covered or kept in closed container to avoid

contamination.

21. Frozen foods must not be placed in the oven, as reaching safe cooking temperatures is unlikely (Sellars & Heggie, 2005).

- Food safety objective: prepare and stage foods in the oven such that they are adequately cooked.

22. Food size, food type, and separation from the heat source are used to control the time needed to cook the different foods. For example, large cuts of meat are placed on the bottom of the oven and vegetables on the top (Sellars & Heggie, 2005). This step must be carefully considered since the oven remains closed during the cooking time and no adjustments can be made once the foods are placed. Cooking whole animals is also a common practice (e.g., pork, deer) and requires special measures (e.g., larger pit, longer cooking time, placing of stones inside the carcass).

(4) Cooking process

- Food safety objective: eliminate microbial contamination.

23. The oven remains sealed during the entire cooking process. Any steam leaks should be quickly controlled by adding or adjusting covering materials. The temperature inside the oven is not monitored and the end of the cooking process is determined based on traditional knowledge. For example, a whole pig may take up to 8 hours to cook, whereas different meat cuts may take between 2 and 3 hours, depending on the size of the cut and the type of meat.

(5) Finished product handling

- Food safety objective: prevent the introduction or proliferation of contaminants in the food

24. At the end of the cooking process, the covering layers should be removed preventing dirt or other materials from being in contact with the food.

25. The cooked foods should be handled following good hygiene practices.

26. Generally, foods cooked in an underground oven are consumed during an event (e.g., festival, wedding), and should be maintained at safe hot holding temperatures (>60 °C or national standard) throughout.

27. If foods prepared using this method are to be stored (McNamara & Prasad, 2014), cooling time and temperature guidelines should be followed to prevent microbial growth and spore germination, and they should be stored refrigerated until the time of reheating and consumption.

Challenges

28. The underground oven cooking method, when managed appropriately, can produce safe and tasty foods. This may be supported by a safe history of use – although the prevalence of unreported, small-scale outbreaks, causing only mild symptoms and/or associated with microbial agents requiring a long incubation time, cannot be discarded. Indeed, heat transfer from steam to food is a standard and effective cooking technology. This effectiveness, however, relies on the applied cooking time and temperature – parameters that need to be validated for specific foods and process characteristics, and that need to be monitored during processing. Thus, the lack of validation and monitoring of these parameters is the main challenge for objectively establishing the safety of meals cooked in underground ovens.

29. Currently, traditional knowledge is used to determine processing parameters, including time and temperature. Only one study systematically measured cooking temperatures reached in underground ovens (Sellars & Heggie, 2005) and found important variability between event locations and temperature probe placements inside the oven. Furthermore, samples from 1 of the 4 events studied contained high levels of *Bacillus cereus* – a pathogen commonly found in soil and vegetation, and associated with foodborne illness caused by consumption of contaminated starchy foods (FDA, 2012). In addition, although not linked to foods cooked in underground ovens in the scientific literature, *Clostridium perfringens* may proliferate in meat-based products subject to uneven and insufficient cooking temperatures (e.g., donner kebab – Cagri-Mehmetoglu, 2018). Thus, further studies documenting cooking temperatures and microbial quality of foods cooked in underground ovens would greatly contribute to objectively assessing the performance of this method.

30. The handling of foods and food contact materials is also currently performed based on traditional customs, which do not necessarily align with good hygiene practices or recognized food safety standards. For example, Sellars and Heggie (2005) noted that the banana leaves used in one of the events studied had significant contact with the soil. Other risky practices that could affect the safety of the cooked food include but are not limited to holding raw meat near the oven for extended periods (microbial proliferation), placing frozen meat directly in the oven (insufficient temperatures reached at the end of the cooking process), or unsanitary handling of raw materials (introduction of *Staphylococcus aureus* from food handlers and formation of enterotoxins in the food). Thus, the development of hygiene and processing guidelines specific to this method is warranted but should accompany an education effort on more basic food hygiene awareness. Consultation

with hotels and other tourism venues using this cooking method under more standardized practices and stricter hygiene controls would be beneficial and informative.

31. Control measures related to safe handling of ingredients and cooking are dependent on the hygienic quality of the raw materials. Chong and Stephenson (2022) noted that hotels adhering to corporate policies on food safety are likely to rely on imported ingredients when using underground ovens, due to the low quality of local meat and seafood and the lack of food safety standards. Native communities, however, are more likely to use local ingredients, which may carry pathogens of public health significance (*Salmonella* spp., *Listeria monocytogenes,* pathogenic *E. coli*). Thus, enhancing and standardizing the hygienic quality of domestic raw ingredients is a foundational requirement for the safety of foods cooked using traditional methods.

32. Yet, as in most thermal processes, pathogen lethality is controlled with the achieved cooking parameters. Sellars and Heggie (2005) suggest that the users should be well versed in the underground oven method so that the temperatures achieved in the food can be relied upon as a pathogen reducing step. However, considering the variability between community-specific cooking practices and the inconsistent microbial quality of the raw materials, the only option to ensure the safety of the cooked foods is to monitor the achievement of previously validated cooking time and temperature. This measure is feasible with handheld, battery-operated temperature probes; however, it is unlikely to be implemented in traditional settings. In these cases, the acceptance of "residual" risk (Benkerroum, 2013) could be considered, where consumption of potentially hazardous foods (e.g., meat, poultry) cooked in underground ovens without temperature monitoring – but following all other feasible food safety and hygiene measures – is not recommended for vulnerable populations (e.g., pregnant women, young children, elderly, immunocompromised individuals). The implementation of basic preventive measures, following a Hazard Analysis Critical Control Point (HACCP) approach, would be essential to limit this "residual" risk as much as possible. Although a formal HACCP program is unlikely to be adopted in traditional settings, training and capacity building initiatives based on this framework and on relevant Codex Alimentarius guidance should be encouraged.

33. Finally, it is well-known that traditional food preparation methods face important challenges when confronted with national food hygiene legislation, usually designed for large businesses and likely to drive traditional producers to the informal market (van der Meulen et al., 2016). To preserve their role in the economy, the society, and the food security of their region, an incremental approach to food safety is recommended, based on the development of fundamental capacities on food hygiene, the enhancement of raw materials' hygienic quality, and education efforts targeting producers and consumers on the risks associated with the finished products.

Proposed next steps

34. This discussion paper sheds light on an important traditional food preparation practice, underground cooking, and attempts to identify most likely food safety challenges with possible mitigation strategies to be applied.

35. This discussion paper, supported with additional facts and data gathered from food producers and hospitality settings (including hotels and restaurants) to further document best practices to be followed when this technique is applied in order to mitigate food safety hazards.

36. The discussion paper could then be a basis for the development of a proposal of new work for a regional Code of Practice associated with the safety of underground food preparation, which could serve as regional guidance to underpin food safety education associated with this approach.

Recommendations

37. CCNASWP17 is invited to

(i) consider this discussion paper; and

(ii) consider whether there is sufficient interest to prepare a project document on a new work proposal for a Regional Code of Practice on traditional underground ground oven cooking in the South West Pacific for consideration by CCNASWP18.

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