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## **Food Poisoning from Local Food Processing Methods: A Review**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author CJM designed the study and wrote the first draft. Author AAN managed and edited the draft. Author AAN also managed the literature. All authors read and approved the final manuscript.*

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### **ABSTRACT**

Food processing links food production to the provision of food of improved quality and nutrient availability, acceptability, preservation to curtail losses and availability in time of need. To maintain these attributes, a critical look at our local food processing methods is required, with a view to improving it; for instance through the application of modern technology, so as to minimize food poisoning, and improve local food stability. In this review, we wish to highlight the various possible pathogenic poisoning routes of some African food processing methods and possible preventive measures. The food processes involved are fermentation, drying and salting. The source of food contaminant is evidently a portal for contamination by more potent pathogenic microbes, which may cause an epidemic, considering the popularity of the food products. The influx of contaminants; which may be a source of food-borne disease(s), maybe through the original food materials, unhygienic practices of the handlers or the process machinery. The incidence of food poisoning in local food processing can be drastically reduced with improved process operations, increased sensitization of food handlers on their possible contributions to food contamination, regular medical checkups and mandatory certification of vendors, etc. The standard for processing and preparing human food should be improved and researches should be carried out, to ascertain

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facts and prevent death due to ingestion of poisoned food. Investments in biotechnology should also be made in the most conscious and profound manner, to provide species for better food fermentation processes, and as well, advanced sensitive screening procedures to ascertain contamination, especially by non-culturable microorganisms. Hygienic practices in food processing and preservation are indispensable in food security, as we try to sustain food abundance and minimize food poisoning.

*Keywords: Food processing; fermentation; drying; salting; contamination.*

## 1. INTRODUCTION

Food is one of the essentials of life. From antiquity, man found different ways of getting food. This started from hunting, setting traps for animals, washing leaves, to eating any wild fruits. With the continual evolution of man, he sought to keep some of his games for further use. It was surprising to him that what he kept got spoiled. Though he could not get the reason for the food spoilage as demonstrated by Leeuwenhoek, he intuitively set fire and placed the games over it. He also took advantage of the microorganisms that spoil meat to produce sausage and those that spoil milk to form yoghurt and cheese, which are in themselves very nutritious and possess longer shelf life than their precursors; this translates to food processing. Food processing is any deliberate change in a food, which occurs before it is available. Some foodstuffs, for instance, Cassava, which in itself is not readily available for consumption, can be processed into a more stable food with good nutritional value [1]. Food processing has been a key aspect of the food production chain that links agricultural production with the provision of food to people in the form, and at the time it is required [2]. Food processing is required to increase the useful life of foods, optimize nutrient availability and food quality, and reduce losses and waste [3]. As it stands in our century; it is evident that man should increase his efforts at preserving foods, because of the world population, which is estimated to increase to 9 billion by 2050 [4]. It should be fed by the increase of agricultural productivity of about 30-40% in order to meet the dietary energy needs of the population; this supposing means that wastage of foods should be curtailed, while increasing food production in order to meet this energy gap [5]. In Africa where an outrageous quantity of food is being wasted, there is erratic power supply and poor technological advancements. However, in some places where one could manage to have technological advancements, there are low technical know-how and poor management of

resources which make food technological advancements very difficult, if not impossible. One of the greatest challenges facing food Scientists/Technologists in West Africa today is the upgrading of the traditional technologies of food processing and preservation. In most cases, the traditional methods of food processing and preservation in West Africa remain at the empirical level. Some processes are still rather crude, not standardized, and are not based on sound scientific principles, making them, in their present form, unsuitable for large-scale industrial production [6]. If the productivity of food systems should focus on innovations in order to improve nutritional needs, and providing aid to farmers, to adopt innovations for sustainable intensification and novel food sources as elucidated [7], there is an increased need to look at our local food processing methods in order to see what can be done to improve them, for instance by employing modern technologies. This is to minimize food poisoning and improve local food stability. After all, it is proven that people prefer foods which are affordable, safe, convenient, fresh or probably minimally processed, and if possible without preservatives and in addition, no negative attributes [8]. African local processing methods offer minimal processing. Food processing causes changes in the biochemistry of the involved food and some of these changes can result in both detrimental, as well as beneficial effects on the food quality, depending on the process used [9]. African food processing methods retain most of the essential root compounds of the food and slightly modify them for longer shelf life. However, most modern processing methods upset the food biochemistry and add more calories [10-12], this undoubtedly increases the prevalence of non-communicable, chronic diseases such as cardiovascular diseases [13] and metabolic diseases and diabetes [14] with the inclusion of certain cancers [15]. It was estimated that halving the intake of ultra-processed foods in the United Kingdom, by replacing these with minimally processed and culinary ingredients would result

in approximately 14,235 fewer coronary deaths and approximately 7,820 fewer stroke deaths by 2030, comprising an almost 13% mortality reduction [16].

In this review, we wish to highlight the various possible pathogenic poisoning routes of some African local food processing methods and possible preventive measures.

## 2. FERMENTATION

Before the advancement of science, fermentation was thought to be spontaneous, as there was no inoculation or any conscious practice before fermented foods were produced [17]. It is a conscious and controlled phenomenon, unlike that of spoilage which is uncontrolled. Fermentation is a primary means of producing ATP by the degradation of organic nutrients anaerobically, in presence of suitable microorganisms [18]. It is a valued means of preserving food, because it alters the food's pH, thereby creating a condition unsuitable for the growth of unfriendly/unwanted microorganisms [19]. The wonders of fermentation entail the improved organoleptic properties and prolonged shelf life of the food; which serves as a substrate for the involved microorganisms. The changes can also be due to the fact that the fermenting microbes secrete bioactive molecules such as conjugated linoleic acids, vitamins, peptides, exopolysaccharides neurotransmitters ( $\gamma$ -aminobutyric acid; GABA), and oligosaccharides. [20]. Most of these secretions possess antimicrobial activity, in addition to their nutritive values. This helps in extending the shelf life of the food, as it must have altered its chemistry. Specific starter cultures were used to control the fermentation process and lactic acid bacteria (LAB) are commonly used as a starter culture [17]. In fermentation, the food which is fermented does not matter as much as it does to the organisms or group of organisms that ferment it, because each organism is unique in terms of the chemicals secreted in the presence of a particular substrate [21]. It is also important to understand that one can obtain varieties of foods from particular food material and fermenting microbes, once the methods of fermentation are different for the involved foods. For instance, milk is the base ingredient for Koumiss, Kefir, Ayran, Torba, and Kurut, which are prepared with different processing methods, thereby giving different foods [22].

During fermentation, there could be contamination or influx of contaminants, which

may come through the original food materials, the pilots of the process or the machinery. Toxins from fungi were found in South African locally brewed beers. When further investigated to see the mycotoxin producer, it was discovered that the grains used in brewery contained *Aspergillus spp*, *Penicillium spp*, *Mucor spp*, and *Rhizopus spp*. Ochratoxin A and Zearalenone are toxins seen in locally brewed beverages, while some aflatoxins are seen in commercial beverages [23]. The traditional Nigerian condiments Iru and Ogiri as well as their raw materials, locust bean and melon seeds, respectively, were studied for mycotoxins and microbial contaminations. Pathogens such as *Bacillus anthracis*, *Staphylococcus sciuri subsp. sciuri*, *Alcaligenes faecalis*, and *Proteus mirabilis* were found in many samples, and about 25% and 23.5% of the pathogens detected in the samples belonged to *Bacillus*, and *Staphylococcus spp*. family, respectively [24]. The results suggest that some of the Nigerian raw materials and condiments are severely contaminated with deadly pathogens, which are probably from humans who handled them. [24]. Even the most common food; cassava, when fermented into Attieke; a common fermented food in Cote d'Ivoire, contains some elements of mycotoxins, Ochratoxin and other chemicals in trace amounts. On deeper investigation, it was found that it is still good for consumption [25]. Though the level of toxins found in these food materials is quite low to cause any unhealthy physiological results, one cannot attest the same to other untested food materials in the market. [24]. Apart from that, it is not advisable to eat contaminated foods, because they will eventually accumulate in the body and cause liver and kidney problems [26]. It is quite frightening to acknowledge the fact that most of the pathogenic microorganisms cannot be identified, without the use of molecular techniques, as in the case of a locally processed food; *Ugba*, which was seen to harbor *Acinetobacter bauanii* and other four pathogenic organisms [27]. This experience can be observed in other food materials. Other fermented food samples namely: maize gruel, sorghum gruel, locust bean, melon seeds, and African oil bean seeds were found to contain mycotoxins. About 82% of the tested samples gotten from the above foods had mycotoxin contamination. Fumonisin B1 was found to be dominantly present in sorghum andgruel samples, where African oil bean seeds had aflatoxin B1 (3–36  $\mu\text{g}/\text{kg}$ ), and sterigmatocystin.

One of the samples was found with multi-mycotoxin contamination. [28]. Ochratoxin A is a potent carcinogen and nephrotoxin [29]. When Ochratoxin A popularly known as OTA is ingested into the body, it binds to the blood albumin and later goes down to the kidney to cause Focal Segmental Glomerulosclerosis, when it accumulates to its threshold concentration. (Hope and Hope, 2012). When a contaminated food contains  $> 5 \mu\text{g}$  of Ochratoxin/kg of the sample, which is regarded as unsafe to human health as per the European Union standard [21], it is most advisable to destroy the food. It is worthy of note that the minimum concentration required for a particular toxin to be potent on a consumer varies from one toxin to another. The fermentation and storage temperature, storage time, acidity, pH, heat processes, toxin concentration, and strain used for the fermentation process are the major factors that influence the free toxins in fermented food products [30].

Nevertheless, the traditional preparation (fermentation, draining of water, washing, milling, and sieving) of *Ogi*; a complementary diet made from maize, significantly reduced (up to 90%), the added mycotoxin levels. The process of soaking for 48 hours accelerated the mycotoxin elimination from the *Ogi*. The results provided information to produce safe and mycotoxin-free *Ogi* [31]. Hygienic practices in food processing and preservation are indispensable in food security as we try to sustain food abundance. [32]. Studies claimed that people were not aware of toxins, their consequences, and the unhygienic practices. [28]. Just like the contaminants of milk product are pathogenic human and livestock-associated *Staphylococcus aureus* strains (HLSA) which contained some enterotoxins, toxic shock syndrome toxins etc. [32]. People also do not know that in most cases, they are the carriers of these contaminants which cause both food spoilage and food poisoning. Nasal and skin carriage among others are frequent vehicles in the transportation of *S. aureus* and other microbes because they are part of human normal microflora or human microbiota [33]. Therefore, hygiene and cleanliness are required to minimize food poisoning.

### 3. DRYING

With what is known in food preservation, drying is one of the oldest available local forms of preservation methods [34]. It is indispensable in food security because it uses the science of

dehydration of the concerned food. Drying can also be the preliminary stage of food processing of some produces, especially if the foods are going to be turned into flour e.g. maize and cassava. Drying seems to be indispensable in most African communities because it is relatively cheaper and reliable. A study carried out in Uganda revealed that as many as 95% of respondents used sun drying as the major indigenous practice for food processing [35], while a survey carried out in Anambra state of Nigeria, showed that more than 80% of the respondents still used sun drying for food preservation. [36]. Ordinarily, drying is in form of sun-drying, which literally involves spreading food materials on the floor, road sides and rooftops. It is the most common and cheapest way of preserving food. Sun-drying has been used to keep foods for a long time without spoilage, examples of food that can be sun-dried are tubers, cereals, vegetables, fruits, breadfruit etc. Animal-based foods can be dried over smoke which adds flavor besides prolonging shelf life [37]. In Sudan, meat is first cut into long pieces, salted and rubbed with powdered coriander and finally dried for about a week to form *Shermout* [38]. A similar procedure is practiced in Ethiopia and Northern Kenya [39]. Some edible foods like ants, termites and caterpillars can also be dried to give a wonderful delicacy. Some food materials like *Garri* are produced by drying after fermentation to about 10% moisture content. This is done through frying at high temperatures which probably resulted in partial dextrinization of starch [40], destruction of enzymes and microorganisms and the expulsion of cyanide gas from the product [41,42]. This makes it a very stable food that is common all year round [43].

In the course of drying, there are so many ways in which dried foods get contaminated. These could range from the contact of food with soil where the food material is spread [36]. The environment where some dried foods are displayed in the market are usually unhygienic and could constitute another avenue for microbial contamination and subsequent food poisoning. [44,45]. Most microbial contaminations emanate from post-processing, handling and storage and eventually lead to spoilage and poisoning [46]. The contamination could be through improper ventilation, easy access of pests into the storage environment or poor handling practices, while some could be from the air, the source of the food, or from other degrading substances [47]. Some of the pests

may be carriers of pathogenic microbes [48]. It is reported that when foods like fish are not well dried, they are usually disposed to both bacterial and fungal contaminations [47]. The source of food contaminant is evidently a portal for contamination by more potent pathogenic microbes, which may cause an epidemic considering the popularity of the food products [49]. *Penicillium spp.* was the most predominant organism isolated from white Garri sample [50], while *Aspergillus niger* was the most predominant in yellow Garri and has long been implicated as one of the most important fungi that causes black mold disease in fruits [51], ear infections in human and food poisoning [52,53]. Consequently, most mycotoxins released by these fungi are stable compounds that are not destroyed during food processing or home cooking [54]. Some of fungi in spore forms can even be activated by the means of increase in temperature due to drying to release mycotoxins. Change in temperature metamorphoses spores which are vegetative to active fungi. This microbial contaminant may be a source of food-borne disease [55, 56].

#### 4. SALTING

Salt is widely perceived to be a chemically pure and sterile food ingredient [57]. It is both industrially and domestically used in the processing and preserving food. Salt has a unique way of reducing water activity values (*aw*) in foods and hence slows down or even interrupts vital microbial processes [58].

Another muse for its wide usage is based on the fact that it has been demonstrated that monovalent cations, such as Na<sup>+</sup> in salt, inhibit protease activity which are necessary for the deterioration of protein. It has also been established that monovalent ions such as Na<sup>+</sup> present in salt reduce the effects of divalent ions which are needed for protein degradation [59]. When the NaCl content in a food material increases, protease activities decrease and this prevents food spoilage [60]. Specifically, table salt exerts influence on the activity of different proteases and proteins such as Ca-dependent protease; Cathepsin D and Cathepsin L. In fact, the addition of NaCl to pre-rigor ground beef decelerates the rate of metmyoglobin formation. [61].

On the other hand, Cl<sup>-</sup> in sodium chloride is said to increase the water-binding capacity of protein food material, thereby making unavailable water which is essential for the actions of mesophilic

microorganisms [58]. As much as it is known in some vegetable products, salt does not play a direct role as a preservative, because a low level of added salt initiates a competitive and selective microbiological growth process, favoring the development of lactic acid bacteria [62].

However, sea salt can initiate food poisoning [63]. Salt can contain contaminants because, in the course of its industrial production, it is allowed to slowly evaporate its water contents in shallow ponds called salterns, therefore it is enriched with halophiles which can grow in salty environment; the very condition relied upon as an important principle of food preservation [63-66]. As sea water is progressively concentrated through evaporation during salt production, the increasingly saline waters harbor distinctive communities of microbes including bacteria, archaea and fungi [43]. The microbial communities in the saltern can be carried over into finished salt during salt production. [57]. The most abundant genera of microbes found in slatterns include *Aspergillus*, *Cladosporium* and *Penicillium* [67]. Microbes found in salt have significant potential to spoil food, introduce mycotoxins or allergens when salt is used as a food ingredient. [63-72]. Salting process alone is inadequate as a sole preservation method in ready-to-eat products [58], because there seems to be no standard for salt production, though it is commonly thought that it is sterile because of its chemical property [67].

#### 5. PREVENTIVE MEASURES

The incidence of food poisoning in local food processing can be drastically reduced with the increasing knowledge of the food handlers [48], therefore, there should be a regular awareness/sensitization programme for them. Regular medical checkup should be mandated for all food vendors to ensure that they are not carrier of any pathogenic organisms. There should be enforcement of standards for processing and preparing human food. A particular quantity of coliforms may serve as a threshold for acceptance of any food substance. Autopsies need to be conducted before the issue of death certificate to document the cause of death and if the cause is ingestion of poisoned food [73]. Researches should be initiated to ascertain the facts and prevent subsequent death due to such. There should be a communal drying place or machinery as the case may be, to enable efficient drying

procedure without creating an avenue for the influx of contaminants or growth of fungi due to poor drying. The three registered microbial culture collection centers are not adequately cared for and therefore can only house a little less than a hundred microbes [74]. One of the aims of collection centers is to make readily available all starter cultures for inoculation in foods and other industrial uses. This is to avoid introducing contaminants, instead of the required microbes. Since people trust and use salt without restraint, there should be a stringent industrial standard and protocol for purifying salts before usage, to avoid preventable contamination of foods. Investment in biotechnology should be made in the most conscious and profound manner to provide more suitable species for better food fermentation practices.

## 6. CONCLUSION

The routes through which foods are poisoned during processing are implicitly shown in the three most common methods of local food processing. It clearly shows that there are lots of modifications and upgrade to be considered and adopted. It seems that no one process is the most efficacious, multiple hurdles of food processing should be employed to safeguard food and reduce the exposure to, and evidently the influx of pathogenic microbes. Conscious research should be encouraged to enhance local food processing methods.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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