SEVEN
publicações acadêmicas

Microbiological profile of foods marketed in the state of Pernambuco

Crossref doi
https://doi.org/10.56238/Connexpemultidisdevolpfut-091

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ABSTRACT

Food security is essential because it is directly related to human health and well-being. When food is contaminated by bacteria, fungi, parasites, chemicals or foreign bodies, it can cause a range of illnesses, from mild food poisoning to serious illnesses that can lead to death. Foodborne illnesses (EDDs) arising from the consumption of such contaminated food are substantially relevant to public health. Its occurrence systematically triggers damages to various spheres of society, including the economic sector, due to absenteeism, compromise of trade and depletion of industrial activities. Thus, food hygiene, in recent years, has been the subject of increasing interest. Objective: To review the literature regarding the microbiological profile of foods marketed in the state of Pernambuco. Literature Review: Regarding the bacterial profile, the studies included in this review identified contamination in the samples in the following proportions: fecal coliforms (20%), Salmonella (55%), Escherichia coli (72%), Staphylococcus genus (71%), Listeria monocytogenes (25%). Regarding the mycological profile, contamination by Aspergillus flavus (70%), Penicillium (60%), Fusarium (80%), Aspergillus parasitic us (80%) was identified. In addition, bacterial and fungal toxins were identified in 65% of the samples. Final considerations: The presence of different bacteria and fungi with pathogenic potential, in addition to their toxins, in foods marketed in Pernambuco reflect the importance of promoting good food handling practices as a preventive strategy for DTA.

Keywords: Food contamination, food microbiology, Pernambuco.

1 INTRODUCTION

Food security is essential because it is directly related to people's health and well-being. When food is contaminated by bacteria, fungi, parasites, chemicals or foreign bodies, they can cause a range

of illnesses, from mild food poisoning to serious illnesses that can lead to death (RASTOGI N, et al., 2019). By 2050, it is believed that the human population will reach the number of nine billion individuals (YU Z, et al., 2022). This population increase suggests the need for massive food production, with safety and quality assurance. Although there is still no international legislative standardization, worldwide procedures are already adopted to minimize risks in food consumption (AIYAR A and PINGALI P, 2020).

Foodborne illnesses (EDDs) arising from the consumption of such contaminated food are substantially relevant to public health. Its occurrence systematically triggers damages to various spheres of society, including the economic sector, due to absenteeism, trade impairment and depletion of industrial activities (MELO ES, et al., 2018).

When added together, the need for massive food production and the continuously growing demand contribute to quality deviations, increased incidence of contamination and disregard for legal regulations (NERIN C, et al., 2016). Thus, given the risks to human health that can affect food production on a large scale, food hygiene, in recent years, has been the target of increasing interest (JAFFEE S, et al., 2019). The lack of hygiene in the production and storage of food, as well as the lack of sanitary control during handling and consumption, are the main causes of chemical, physical and microbiological contamination (SILVA MA, et al., 2019).

As Anvisa's Resolution RDC No. 275/2002 points out, the excessive presence of chemical contaminants in food, such as pesticides, herbicides, heavy metals, dioxins, furans and some other chemical compounds, are potential aggressors for human health and environmental balance. The massive deposit of pollutants by the industrial and agricultural sectors suggests the need to adopt strategies that aim to minimize chemical food contamination as one of the priorities of environmental preservation and minimization of risks to the health of consumers. Even more so because some by-products of these organic pollutants of anthropogenic origin are persistent, that is, difficult to degrade in nature (GAUR et al., 2018).

Physical contamination of food is a constant concern for regulatory agencies around the world. According to the Pernambuco Health Surveillance Agency (Apevisa), the excessive presence of foreign bodies in food is unacceptable and should be avoided (APEVISA, 2021). This contamination can occur in the stages of production, storage and transportation, through pieces of glass, metals, hair, insects and parts of the human body, causing internal injuries, perforations and asphyxiation (NASCIMENTO et al., 2018). It is essential that industries adopt quality control measures and that regulatory agencies conduct frequent inspections, ensuring the safety of marketed food (VERDE E, et al., 2018).

Moreover, the microbiological contamination of food is an aggravation to public health that needs special attention. Toxic species of cyanobacteria, for example, are capable of producing toxins

that, when ingested through food or water, are capable of promoting severe health problems, including death (ABDALLAH MF, et al., 2021). Some fungal species that also produce toxins, such as secondary metabolites, also pose a considerable risk, potentially causing disease (Al-JAAL B, et al., 2019). One can cite, as examples of contaminating fungi, A. flavus, A. novoparasiticus or A. mottae, which are producers of aflotoxins, which act as carcinogenic substances (Jallow et al., 2021)

Currently, the agencies responsible for sanitary control have intensified inspection actions and improved the training of professionals involved in the production and distribution of food, as seen in Pernambuco with Apevisa; the Ministry of Agriculture, Livestock and Supply – Map; or. Pernambuco Institute of Technology – Itep and the Secretariat of Agrarian Development – SDA (BRAZIL, 1990). As highlighted by the World Health Organization, it is recommended that consumers also develop their role in promoting food safety by requiring safe food and that they adopt hygiene and safety measures in the preparation, storage and transport of food (SOUZA CS, et al., 2018).

Considering the current need to protect food production and the limitations of local food security, this article reviews the microbiological aspect related to the incidence of contamination of food marketed in the state of Pernambuco.

2 RESULTS

2.1 BACTERIOLOGICAL PROFILE

2.1.1 Faecal coliforms

Fecal coliforms include all bacteria in the form of gram-negative, non-sporogenic, facultative anaerobic rods, capable of fermenting lactose with gas production, in 24 hours, at a temperature between 44.5°C and 45.5°C, with the microorganisms Escherichia, Enterobacter and Klebsiella being the main ones (SILVA N, et al., 1997). Coliform contamination can occur in various types of food, especially in products made in food services and street vendors. The limited hygiene habits related to the absence of drinking water and food refrigeration, the lack of adequate areas for garbage disposal and public toilets in the places of sale, favor the contamination and deterioration of food sold on the streets (OLIVEIRA EA and MELLO PL, 2020).

A study conducted in 2019 by the Pernambuco Health Surveillance Agency (Apevisa) revealed that about 20% of food samples collected in commercial establishments in Pernambuco contained fecal coliforms above the limits allowed by legislation (CHAVES A, et al., 2019). Among the foods analyzed, animal products such as meat, poultry and dairy products stood out, which presented the highest rates of contamination. When working with the analysis of granola marketed in Recife, Albuquerque MCC, et al. (2019) identified the presence of thermotolerant and total coliforms with values of 23 NMP.g - ¹ in 3 and 75 NMP.g - ¹ in 2 samples, for a grand total of 10 samples, thus highlighting the importance of handling and packaging in the sanitary hygienic quality of food.

2.1.2 Salmonella

Salmonella spp. is a pathogen involved in DTA worldwide. It is a Gram-negative bacillus, belonging to the Enterobacteriaceae family, capable of moving with the aid of peritricial flagella. It is non-sporulated and facultative anaerobic, presenting fermentative metabolism (ORDÓNEZ AA, et al., 2011). Salmonellosis is a disease commonly transmitted by meats, caused by bacteria of the genus Salmonella spp., globally, it is widely recognized that it is one of the main causes of foodborne infections. According to Moura APBL, et al. (2022), animals and the environment are considered the main natural reservoirs of this microorganism.

A study conducted by Rodrigues LH, et al. (2015), evaluated the microbiological quality of freshly squeezed fruit juices sold on the streets of the city of Recife. The statistical analysis of the results obtained in this study revealed the presence of Salmonella in a significant percentage, about 71% of the samples of fruit juices showed contamination. Moura APBL, et al. (2022), when studying goat meat and quail carcasses, also marketed in the city of Recife, identified salmonella contamination in 55% of the samples analyzed.

2.1.3 Escherichia coli

Food contamination by Escherichia coli is associated with failures in the process of cleaning food, environments or in the personal hygiene of handlers. This pathogen can be found in soil, water and the gastrointestinal tract of humans and animals (OLIVEIRA NS and GONÇALVES TB, 2015). Normally, E. coli is mainly linked to contamination of foods of animal origin, such as meat, milk and its derivatives, and can also be found in water (PORTO ACS, 2003), a situation that can aggravate public health issues, because water can be consumed both directly and inserted in the formulation of other foods and beverages.

De Mattos MR, et al. (2010) analyzed samples from 53 different properties, located in the municipalities of Saloá, Águas Belas, São Bento do Una and Bom Conselho in Pernambuco, identifying E coli counts in a range of 3.6x10 3 CFU/mL and 1.08x10 5 CFU/mL. Silva LCC, et al. (2011) when analyzing the microbiological quality of raw milk in the municipalities of São Bento do Una, Bom Conselho and Àguas Belas, identified E. coli counts between 4.0x10'2 and 3.7x10'3 for milk at different post-milking cooling times and counts from 3 to 2.5x10'4 when analyzing samples from ceiling, initial jets of milk and hand of the handlers, also observing a count that varied from 7.3x10'1 for the hands of the handlers before milking to 2.0x10'1 after milking, a percentage of 72%.

2.1.4 Staphylococcus

The genus Staphylococcus belongs to the family Staphylococcaceae, order Bacillales, class Bacilli and phylum Firmicutes (BAIRD-PARKER, 1990). The contamination of food by coagulase-positive and negative enterotoxogenic Staphylococcus represents a public health problem, due to the risk of causing foodborne illness (DTA) (MARTIN S, et al., 2001). Staphylococcus poisoning occurs by ingestion of staphylococcal toxin, a substance produced during the multiplication of the microorganism in contaminated food, which can cause the consumer symptoms such as nausea, emesis, abdominal pain and diarrhea (SCHERRER D, et al., 2004).

Stamford TLM, et al. (2006) when submitting 109 strains of Staphylococcus isolated from the in natura milk of cows with subclinical mastitis, from the region of Garanhuns (PE), to the coagulase test identified that 71% of the strains (77 samples) presented positive coagulase. Studies conducted by Moura APBL, et al. (2022) evaluated the presence of coagulase-positive Staphylococcus (PCS) in goat meat sold in public and private markets compared to those marketed in supermarkets, located in Recife (PE), where 11 samples (45.83%) presented results ranging between 6.7 x and 2.03 x CFU/g, with 10 contaminated samples from markets and only 1 sample collected from supermarkets. Another 13 samples (54.17%) presented values below 1.0 x CFU/g that are in accordance with RDC N.12 (BRASIL, 2001).

2.1.5 Listeria

Listeria monocytogenes consists of a bacillus (0.4 to 0.5 × 0.5µm), Gram positive, facultative anaerobic, non-capsulated and non-sporulate, capable of growing in a temperature range of 0°C to 45°C, and a pH range of 4.7 to 9.2, being tolerant to high concentrations of sugar and salt and presenting development in water activity values (aw) lower than 0.93 (Ripollés-Ávila C, 2018; Trinity JA, 2013). These are microorganisms widely distributed in nature, possessing, among other characteristics, relative thermal resistance. It is a causative agent of serious diseases, both in humans and animals (ICMSF, 1996).

Duarte DAM, et al. (2022) when analyzing 127 samples of rennet cheese, from 21 municipalities in the state of Pernambuco, were able to identify contamination by Listeria innocuous in 12 samples, of which 7 also showed the presence of Listeria monocytogenes. Andrade JM et al, 2019 identified the presence of Listeria in sliced hams which were acquired in a sample form, totaling 40 samples of sliced hams and marketed in the city of Recife, these were analyzed through isolation and selective Agar supplemented for Listeria, contamination by Listeria Monocytogenes was detected in 25% of the samples where the products were ready for consumption, data that highlight the importance of hygiene in food handling.

2.2 MYCOLOGICAL PROFILE

2.2.1 Aspergillus flavus and Penicillium

Food contamination by Aspergillus flavus is a recurrent problem in many parts of the country and the aflatoxins associated with them can cause cancer, liver problems and other diseases (FERREIRA et al., 2016). According to a study conducted by Silva MS, et al. (2017), A. flavus contamination in peanuts and corn marketed in Pernambuco was detected in more than 90% of the samples analyzed in a product quality test. Another study conducted by Santos LA, et al. (2018) investigated A. flavus contamination in a chestnut sample marketed in Pernambuco. Contamination was found in more than 70% of the external samples. In both studies it was observed that the presence of A. flavus was associated with the production of aflatoxins in more than 70% of the contaminated samples.

With regard to Penicillium contamination, grains and fruits are the most affected. According to a study conducted by Rocha MRC, et al. (2019), Penicillium contamination in cereals marketed in Pernambuco was detected in 100% of the samples, with emphasis on the production of mycotoxins, such as patulin. A study conducted by Oliveira JTA, et al. (2018), investigated Penicillium contamination in tropical fruits marketed in the interior of the state. The presence of Penicillium was detected in more than 60% of the samples, in mangoes, papayas and bananas, a factor that affects the quality of these fruits and contributes to the production of patulin and citrinin.

2.2.2 Fusarium

Fusarium fungi are common to soil and produce a range of different toxins, including trichothecenes such as deoxynivalenol (DON), nivalenol (NIV) and toxins T-2 and HT-2, as well as zearalenone (ZEN) and fumonisins (RODRIGUES HF, 2002). Among its main characteristics is the ability to grow in pre-harvest stages and interact with different plant species, using grains and decomposing plant parts to survive and subsequently infect crops and produce toxins (MEIRELES PG, 2005). In his research, Rodrigues HF (2022) highlights that trichothecenes can be extremely toxic to humans, causing rapid irritation to the skin or intestinal mucosa and leading to diarrhea. Fumonisins have been linked to esophageal cancer in humans and liver and kidney toxicity in animals (WHO, 2022).

Rodrigues HF (2022) when conducting a bibliographic survey on mycotoxins present in food identified DON as the main mycotoxin produced by the genus Fusarium. Notaro KA, et al. (2013) identified the prevalence of Fusarium solani fungi associated with root rot in cassava from cultivated areas located in the municipalities of Jupi, Jucati and São João, in the agreste of Pernambuco. In the city of Jupi, of 5 properties analyzed, 4 presented Fusarium solani, evidencing in more than one municipality the importance of this genus associated with cassava root rot in the state of Pernambuco.

2.2.3 Aspergillus parasiticus

The growth of Aspergillus parasiticus in food products poses a significant risk to human and animal health (KHAN et al., 2021), as this fungus is capable of producing a variety of toxic secondary metabolites, including aflatoxins B1 (AFB1), B2 (AFB2), G1 (AFG1) and G2 (AFG2). AFB1 is considered the most abundant and dangerous mycotoxin among these metabolites, with deleterious effects on poultry productivity and increased susceptibility to diseases that can affect poultry farmers' incomes and human health. AFB1 is recognized as being hepatotoxic, carcinogenic, and mutagenic, and is considered the third most common cause of liver cancer (FOUAD et al., 2019).

It is relevant to note that Aspergillus parasiticus contamination is not restricted to birds only, but can occur in a wide range of crops, including corn, oilseeds, rice, nuts and cereals, both during the pre-harvest and post-harvest stages (KHAN et al., 2021). In addition, peanut bran and cottonseed bran may also be affected by contamination (FOUAD et al., 2019). The growth of the fungus in the fields and during storage is favored by high temperatures and high humidity, which increases the risk of contamination by A. parasiticus. It is crucial to adopt preventive measures during the storage and transport of food to minimize contamination by the fungus and thus reduce the risks to human and animal health (KHAN et al., 2021).

According to a study conducted by Oliveira et al. (2018), significant levels, $p<0.05$, of Aspergillus parasiticus contamination were found in food samples marketed in Pernambuco. The samples analyzed included grains, such as peanuts and corn, as well as products derived from these foods, about 53% of the samples analyzed were contaminated. Another study by Souza TB, et al. (2020) analyzed the presence of A. parasiticus in processed peanut-based foods, such as paçocas and pé-de-moleque. The results indicated that a proportion of 64 of the 80 samples analyzed were contaminated with the fungus, a percentage of 80%, increasing the risk of exposure to aflatoxins for consumers of these products.

2.3 FUNGAL AND BACTERIAL TOXINS

Fungal toxins, known as mycotoxins, are products of the metabolism of toxigenic fungi, especially those of the genus Aspergillus, Penicillium and Fusarium (PRESTES ID, et al., 2019), which can cause health problems for consumers, especially in chronic exposure to high doses (PLEADIN J, et al., 2019; OLIVEIRA LA, et al., 2019), since these may present hepatotoxic and nephrotoxic properties (OLIVEIRA LA, et al., 2019). In the work carried out by Araújo MC (2011), the author described the presence of the fungal toxin patulin in samples of yams naturally infected by Penicillium spp. from free markets and the Pernambuco Supply Center (CEASA). The author reported the presence of mycotoxin-producing genes in fungi isolated from these samples, reaching 65% positivity.

As far as bacterial toxins are concerned, some of the main producing microorganisms are Salmonella, Shigella, Escherichia Coli, Staphilococus and Clostridium. Being responsible for DTA, which occur by toxins, which can be released during the multiplication of organisms in food or after ingestion, already in the digestive tract (MALACRIDA AM, et al., 2017). In a study conducted by Lúcio EC, et al. (2018) in the municipality of Garanhuns-PE, the authors analyzed 93 samples of Staphylococcus aureus isolated from milk from animals with subclinical mastitis, and of these, 21.6% (20/93) had some gene related to the production of enterotoxins.

Kawashima LM and Soares LMV (2006) analyzed the presence of mycotoxins in 74 samples of corn-based products from the city of Recife - PE, between 1999 and 2001 through high performance liquid chromatography analysis with fluorescence detection and thin layer chromatography. Fumonisin B1 was identified in 94.6% of the samples at concentrations from 20 to 8600 µg/kg, aflatoxin B1 in 5 samples with a maximum content of 20 µg/kg and two samples exceeded the limit of 20 µg/kg for the sum of aflatoxins B1, B2, G1 and G2 (pre-cooked corn flour with 21.5 µg/kg and xerém with 23.3 µg/kg).

3 FINAL CONSIDERATIONS

The bacteriological and mycological profile of the foods analyzed in this review revealed the presence of different pathogenic and potentially toxigenic microorganisms. Contamination by fecal coliforms, including the bacteria Escherichia, Enterobacter and Klebsiella, was observed in several types of food, especially in products made in food services and street vendors. The presence of these microorganisms or their toxins in foods of animal origin, juices, grains, fruits, milk and water, highlight the need for producers, distributors and traders to follow sanitary standards and implement quality control measures at all stages of the food chain.

Constant monitoring of pathogenic and potentially toxigenic microorganisms is critical to ensure food safety and protect the health of consumers. In addition, the need for effective regulation and supervision by the competent authorities of the state to ensure the quality and safety of food available on the market is emphasized. Awareness of consumers is also essential, encouraging them to make informed choices and demand safe products. Food safety is a right of all and requires the joint effort of all involved to ensure the protection of public health.

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