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Review Article on The Current Status of Food Items and Food Contamination Chain in Bangladesh

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ABSTRACT: Nowadays, people of Bangladesh are facing various foodborne diseases due to the consumption of unhygienic food items such as street foods, mid-level or high-level restaurant foods, vendor juices, unhygienic fermented foods, and so on. Behind this illness, a group of foodborne pathogens is responsible, which become associated with the foods during unhygienic processing, handling, supplying, and storage. People from different socioeconomic backgrounds and a variety of ages consume these foods as the foods are sold at an affordable price with a satisfactory taste. However, this causes a high morbidity and sometimes a mortality rate in Bangladesh. Therefore, proper steps should be taken to provide safe, healthy, and hygienic food to consumers. This review article was conducted over the last 8 years, from 2014 to 2021 to reflect the importance of different food items in Bangladesh, as well as the present unhygienic status of these foods, foodborne pathogens associated with the diseases caused by the consumption of these foods.

Keywords: food-borne pathogens, food hygiene, food pathogens, cross-contamination

INTRODUCTION

As a densely populated country, Bangladesh sustains its diverse socioeconomic groups through a wide range of food items. These foods can be broadly categorized into low-, mid-, and high-tier groups based on production investment and market price. People across all socioeconomic strata, age groups, and genders consume various types of food, including street foods, unhygienically prepared homemade foods, fermented or semi-fermented products, and vendor-sold juices. The widespread consumption of such foods, often prepared and handled under poor sanitary conditions, contributes significantly to foodborne illnesses. The seller juices are unpasteurized, unfermented, cloudy, untreated, but prevalent to the customers due to the "fresh flavor" qualities and low cost (Khan *et al.*, 2015). The low-mid food manufacturers of Bangladesh are not much concerned about the microbiological safety and cleanliness of foods, soft drinks, or seller juices due to a lack of law enforcement. Subsequently, the spread of some foodborne illnesses via juice, foods, and other beverages becomes a real concern (Tasnim *et al.*, 2010). According to the WHO's 2015 report Estimates of the Global Burden of Foodborne Diseases, approximately 600 million people (nearly 1 in 10 globally) fell ill in 2010 due to food contaminated with 31 hazards, including bacteria, viruses, parasites, toxins, and chemicals. These illnesses resulted in an estimated 420,000 deaths, including 125,000 children under five years of age, who account for only about 9% of the global population. (WHO, 2015). Conversely, around 30 million people in Bangladesh suffer from some form of foodborne illness annually (Al Banna *et al.*, 2021). Particular concern arises from the consumption of unsafe food by high-risk populations, including young children, older adults, pregnant women, and those with compromised immune systems due to infection, medical treatment, or underlying physiological conditions. (FDA, 2016). In this way, the microbiological quality of the food and food items is imperative. Microbiological quality is commonly classified into four categories based on standard plate counts, levels of indicator organisms, and the presence or absence of pathogenic microorganisms. These categories include satisfactory, marginal, unsatisfactory, and potentially hazardous. Satisfactory results indicate good microbiological quality, whereas marginal results fall within acceptable limits but may signal deficiencies in hygiene or food handling practices. Unsatisfactory microbiological levels reflect inadequate sanitation or improper handling, posing an increased risk to consumer health. Levels in this range are possibly destructive, and incite activity ought to be taken to avoid food-borne illness (Ohiduzzaman *et al.*, 2022).

To date, no comprehensive regulatory framework has been effectively implemented to ensure that locally produced foods are produced, prepared, and distributed hygienically in Bangladesh. Evidence from multiple studies indicates that microbial contamination of these foods is largely associated with inadequate sanitation practices, improper handling, poor worker health and hygiene, and inadequate temperature control. Additionally, environmental factors such as moisture conditions may facilitate microbial survival and proliferation, further compromising food safety. Subsequently, this calls for the need to administer and uphold clean rules for food generation, manufacturing, preparation, handling, supply, and capacity retailers to control the threat of food poisoning and health danger (Rakha *et al.*, 2022). Proper instruction and open mindfulness have become required for all dealers and businessmen related to food production and supply. Prompt activity to improve the microbiological quality of food in Bangladesh is apparently required (Saak, 2018). The presence of contaminants and the poor microbiological quality reported within the current consideration are the result of failure to preserve the quality and to adequately follow the directions of the Bangladesh Government within the production of foods and beverages.

Bangladesh is a highly populated nation in the world, and it is still underdeveloped. Thus, ensuring food safety has emerged as a significant concern in Bangladesh, but most past studies on food safety in the country have focused on the qualities of food components, such as their microbiological, chemical, and physical properties. Food handlers have not been a priority in these studies. A recent review of the knowledge, attitudes, and practices of food handlers worldwide did not include any research from Bangladesh. As a result, as food security is a major issue, the quality of each and every item ought to be maintained to decrease the serious consequences of food-borne illness. Hence, in this study, an overview was conducted from 2014 to 2021 on different food items to observe the quality of the devoured food in Bangladesh and how the circumstances can be improved to advance the nation and human well-being.

FOODS AND THEIR CURRENT STATUS IN BANGLADESH

In a low-income nation like Bangladesh, street foods are exceptionally prevalent due to their reasonable costs for the lower and middle class income, and they are acknowledged for their unique flavors and convenience (Simpoulos, 2000, pp. 57; FAO, 1986). Diverse sorts of ready-to-eat foods and refreshments that are arranged and sold in an unsafe way in the roads by sellers and vendors at different lorry terminals, by the roadside or by vagrant sellers or expended by the clients on the streets without advance arrangement is famous as street foods (Simpoulos, 2000, pp. 56; Simpoulos, 2000, pp. 61). Regarding the previous inquiry, these street food vendors are often impoverished, lack education, and require information on safe food handling, environment, sanitation, cleanliness, food display methods, food safety, hand washing, sources of raw materials, and the use of potable water. As a result, street foods pose a major public health hazard. The use of street food causes foodborne illnesses due to multidrug-resistant microbial characteristics that make food safety more vulnerable to public health (Rane, 2011). Each year, about 30 million people in Bangladesh experience foodborne illnesses resulting from either organism-related poisoning or the body's reactions to these pathogens (Tabashsum *et al*., 2013). Unhygienic arrangement handle, destitute individual cleanliness of food handlers, open foods subjected to flies, and a need for appropriate infrastructure, such as clean running water, toilets, and solid waste removal, are among the most common causes of contamination of street foods (Fitzgerald *et al.*, 2004; Dumanovsky *et al.*, 2009). According to the study of FAO 2010, 25% street food vendors are uneducated, and as the street food business requires low speculation, 88% vendors begin the trade effectively without formal certification. These vendors typically work 13-18 hours a day in conditions without basic amenities, such as toilets. Reportedly, 68% seller shops were set on the footpath independent of areas, 30% near the metropolitan drain, and 18% close to the sewerage. Microbiological testing of different food products, drinking water, and hand swabs revealed a predominance of very high counts of oxygen-consuming microbes, coliform bacteria, and pathogens (Bowers, 2000).

Benjamin studied street food vendors in Dhaka over three years, from 2007 to 2010. His research showed that between 90,000 and 100,000 people sell food on the streets. Approximately 418,000 people, or 2.9 percent of Dhaka's total population, rely on the income from these street vendors. On average, 84 customers are served by each vendor every day. Also, eight million people, or 55 percent of Dhaka's population, eat street food every day (Story *et al.*, 2002; Rydell *et al.*, 2008).

Several street foods & their comparison:

People are more drawn to non-homemade items like those from restaurants and the street. Foods that are not prepared at home are prepared and presented in ways that appeal to the people. It is frequently the right time to prepare food for eating, though, and it is not always about interest. For instance, people of all ages, from students to working adults, must rely on foods that are not prepared at home due to time constraints. Most of the time, non-homemade foods are not sterile; sellers routinely sacrifice food quality in order to boost customer happiness and boost revenues with less effort. People suffer greatly as a result of eating unsanitary food. Meals are essentially divided into three groups based on the microbial loads of meals from various locations, which vary for various reasons. Hasan (2012), detailed in his research that foods such as rice, dal, and sugarcane juice collected from streets, mid-level, and high-level restaurants of Paribagh appeared to have a higher population of *E. coli, Staphylococcus*, fungi, coliform, and other enteric pathogens, where these microbial populations were higher in high-level restaurants than in the others. It could be because the restaurants were not maintaining good food safety practices. But as it were, in high-level restaurants, cake and bread have shown three types of microbial counts: total viable count (4.1×10^6, 3×10^2), staphylococci count (1×10^4, 5×10^2), and fungal count (1×10^2, 2×10^2). However, in the case of street foods and mid-level restaurants, cake and bread have shown total viable count (4×10^5, 4×10^4) and (2.1×10^6, 6×10^2); staphylococci count (3.2×10^5, 3×10^3) and (9×10^4, 2×10^3); fungal count (7×10^5, 3×10^3) and (7×10^4, 1×10^2) individually (Afzal, 2014) **(**Table 1**)**. All these pathogens are transmitted through poor food planning, personal hygiene, or public sanitation practices. Subsequently, to ensure food safety, manufacturers and vendors must maintain a clean environment, minimize contact with food products after production, and maintain a high standard of personal cleanliness.

Milk & milk products

Milk, produced by the mammary glands of mammals, is widely regarded as one of the most nutritionally complete natural foods (Ntuli *et al.*, 2023). It constitutes a fundamental component of the human diet, and both liquid and powdered forms contribute significantly to meeting growing nutritional needs and supporting food security, particularly in developing countries such as Bangladesh (Ntuli *et al.*, 2023; Haldar *et al.*, 2022). It is a well-known, delicious, and valuable diet. Be that as it may, whole or skim milk is the major ingredient of yogurt production, which is an exceptionally well-known and nutritious dish in Bangladesh (Minj *et al*., 2020). Milk and yogurt are both profoundly vulnerable to bacterial contamination and are consequently perishable (Girma *et al.*, 2014). After that, checking milk and its products for microbes, along with methods to reduce money losses by finding problems like poor preparation, packaging, or storage early on, should be done to protect people's health. Healthy hygienic milk and milk items can be accomplished by observing the microbiological quality of raw milk supplies, bulk milk, and finished milk products promptly after generation and amid capacity (Robinson, 1993).

Along these lines, a study reported that 20 raw milk and 10 yogurt samples from selected regions of Bangladesh contained high bacterial load 1.24×10^6 to 4.17×10^7 CFU/ml and 35.31×10^6 to 5.04×10^8 CFU/ml, including coliform 2.87×10^4 to 3.94×10^5 CFU/ml and 1.12×10^4 to 4.51×10^2 CFU/ml individually (Hasan, 2016). This report demonstrates that the microbiological quality of most of the raw milk and yogurt tests collected from distinctive regions of Bangladesh was unpleasant. Subsequently, safety measure is required to handle, prepare, package, and finally supply raw milk, yogurt, or other dairy products. Both businesses and family zones, including shops, are recommended to embrace legitimate clean conditions to create high quality of yogurt (Hasan, 2016). Agreeing to another inquiry about the Microbiological Quality examination of raw milk, pasteurized milk, and UHT (Ultra High Temperature-processed) milk samples, the extent of TVBC (Total Viable Bacterial Count) and TCC (Total Coliform Count) in raw milk samples was 5.2×10^8 to 1.3×10^7 CFU/ml and 4.2×10^4 to 1.0×10^4 CFU/ml, respectively whereas the quality of pasteurized and UHT-treated milks was great as the TVBC was 1.8×10^3 to 1.1×10^2 CFU/ml, indicating the effectiveness of the heat treatment process in killing bacteria (Banik *et al*., 2015) **(**Table 1**)**.

Furthermore, a study of microbiological quality analysis of a total of 300 different milk and yogurt samples collected from Dhaka city in 2015, found that *Escherichia coli, Salmonella* spp., *Shigella* spp., *Vibrio* spp., and *Listeria monocytogenes* were prominent in the tests. The study shows that raw milk samples collected from Moghbazar and Mohammadpur range noticed most significantly TVBC (4.2×10^6 CFU/ml) and the lowest number (3.5×10^3 CFU/ml), respectively, while the coliform number was highest (4.1×10^3) within the

samples collected from Siddeswari region. The extent of total bacterial count in all the pasteurized milk samples was 1.9×10^2 to 2.8×10^3 CFU/ml. They recognized coliforms (1.4×10^1) in as it were one commercial pasteurized milk brand sample, brand three, which is not satisfactory per BSTI rules. On the opposite, open yogurt tests from the areas extended TVBC from 9.1×10^3 to 8.2×10^7 CFU/ml, and as it were Dhanmondi area appeared nearness of coliform (2.8×10^3 CFU/ml), which was a basic point of concern. Commercially packaged yogurt samples exhibited low levels of heterotrophic microorganisms, with a maximum count of 3.2×10^3 CFU/ml, and no coliform bacteria were detected. In contrast, raw milk samples obtained from five different locations were contaminated with pathogenic bacteria, including *Escherichia coli*, *Salmonella* spp., *Shigella* spp., and *Vibrio* spp. The detection of these pathogens in food products is unacceptable due to their established role in causing foodborne diseases. This considers that bacterial contamination of these items is attributed to poor sanitation standards of the handler and improper handling, storage, and promotion methods (Rahman *et al*., 2015) **(**Table 1**)**.

Another examination (Uddin *et al*., 2013) showed that the microbiological quality of traditional sweets like Chamcham, Kachhagolla, Sandesh, and sweet items such as Rasmalai, Sweet Yoghurt, and Cream Toast were collected from three distinctive brands named Muslim brand, Bikrampur brand, and Bhayzakul from distinctive places of Bangladesh. This study inspected six bacterial genera: *Streptococcus* spp., *Klebsiella* spp., *E. coli*, *Proteus* spp., *Bacillus* spp., and *Corynebacterium* spp. According to this inquiry, the total viable bacterial count (TVBC) in Chamcham and Kachagolla samples was higher in the Bhayzakul brand, with 5.4×10^5 CFU/g and 3.4×10^5 CFU/g, respectively. In Sandesh samples, the Muslim brand showed an even higher TVC of 8.5×10^6 CFU/g. Higher TVC levels of sweet product (5.6×10^2 CFU/g) were found in Rasmalai, while higher TVC levels of sweet yogurt (8.2×10^4 CFU/g) were observed in the Bikrampur brand and of cream toast (5.8×10^5 CFU/g) in the Bhayazakul brand (Uddin *et al*., 2013) **(**Table 1**)**. The results suggest that strict hygienic practices are necessary to produce contamination-free sweets and confectionery items, ensuring good health for all consumers, and for that following reasons of contamination are important to know:

1. Extensive bacterial contamination of sweets occurred during handling and processing.
2. The sweets may have absorbed sufficient moisture to facilitate the growth and proliferation of these contaminants.
3. Unhygienic practices during processing, handling, marketing, and retail distribution may increase the risk of disease transmission and pose significant health hazards to consumers.
4. Inadequate quality control measures at production facilities facilitate microbial contamination of sweets and related products during processing and handling under unsanitary conditions, thereby reducing their shelf life.
5. These conditions facilitate microbial entry and contamination of sweets and related products. Moreover, many of these items are marketed without appropriate packaging, increasing their exposure to airborne microbial contaminants.
6. Boor (1998) reported that the quality of bacteria in raw milk is increasingly affecting the quality of the final product, as they are responsible for the poor quality of raw milk.

Fast food

Apart from street foods, fast food is also increasingly becoming a popular and significant part of the diet for upper and middle-class people in Bangladesh. KFC, McDonald's, Pizza Hut, Shawarma House, and Domino's Pizza are the popular fast-food chains in Bangladesh. Fast food, e.g., sandwiches, burgers, pizza, French fries, pasta, fried chicken, rolls (meat, chicken & beef), and spaghetti, are ready-to-eat foods that are simple to prepare and can be eaten easily or taken away. They currently constitute a crucial part of helpful food preparation practices, resulting in genuine health issues all over the world, including Bangladesh (Adams & Greenery, 2000; FDA, 2000). For example, Sultana (2016) detailed that *Staphylococcus* spp. was prominent in chicken rolls collected from the fast-food restaurant of the Bangladesh Agricultural College campus.

Furthermore, Hasan (2012) detailed the quantitative microbial investigation of sandwiches collected from diverse zones, among which the star kabab beef sandwich appeared with a Total Viable Bacterial Count (TVBC) of around 6.0×10^8 CFU/ml, counting *Enterobacter* spp., *E. coli, Klebsiella* spp., *Staphylococcus* spp., and *Vibrio* spp. These are all the pathogenic strains that can cause various types of infections in the human body, such as diarrhea, cholera, and food poisoning. Also, the egg salad sandwich from all the fast-food shops appeared to have moderate

growth, around 3.7×10^6 CFU/ml containing *Staphylococcus* spp., which may cause food poisoning within the human body, and the vegetable sandwich from Best Bites appeared to have the least growth, around 2.3×10^4/ml. In that regard, consider that staphylococci occupied the highest rate of event proximity to a high number of pathogenic staphylococci in fast food, which might be due to poor hygienic handling, which is disturbing. Following staphylococci, coliforms are in second place. The high *E. coli* levels indicate poor hygiene practices, unsanitary conditions during handling and transportation, and reliance on fast food. Living beings that picked up the fast food were not the cause of the deterioration and decay, but they were responsible for warning of the imminent outbreak of many foodborne diseases (Hasan *et al*., 2014) **(**Table 1**)**. Manesha (2002) reported that serving utensils used in fast-food outlets are often contaminated with *Micrococcus* spp., likely originating from vendors' hands through contact with food preparation surfaces, dishes, cleaning cloths, or water during dishwashing and handwashing. This highlights the potential for cross-contamination among utensils, food contact surfaces, and the food itself (Mensah *et al*., 2002).

Fresh juices

Fruit juices not only impress buyers with their extraordinary taste but also provide nutritional and health benefits (Ahmed *et al*., 2010; Mosupye *et al*., 2000). Nevertheless, these unpasteurized, unfermented, clouded, untreated juices, arranged by mechanically squeezing fresh fruits or may be extricated by water, are favored by the consumers due to the "fresh flavor" qualities and low cost; sometimes also causes food borne Illnesses (Khan *et al*., 2015). A few factors include using unsanitary water for dilution, changing the pH, adding ice to dressing, storing things for a long time without refrigeration, using unsanitary raw materials, contaminated hardware or holders, handling them unhygienically, cross-contamination from spoiled vegetables and natural products, having an unsanitary environment with swarming houseflies and natural product flies, and airborne dust. These factors can harbor bacterial pathogens, including *Salmonella* spp., *Shigella* spp., *Escherichia coli*, coliforms, fecal coliforms, fecal *Streptococc*i, etc. This statement supports the study of Ahmed *et al*. in 2010, which found an extent of 3×10^2 to 9.6×10^8 CFU/ml of total microbial load, and total fungal count was 1×10^2 to 8.05×10^4 CFU/ml in naturally squeezed fruit juices, which were locally accessible and sold in Dhaka City (Ahmed *et al*., 2010) **(**Table 1**)**. Another study conducted by Rashed *et al.* in 2013 showed the microbiological status of 26 local vendor fruit juices and 15 packed juices, where tests were found to harbor reasonable microbes inside the range between 10^2 -10^7 CFU/ml, the range of total coliform bacteria was 10^2 -10^6 CFU/ml, including *Escherichia coli* and *Klebsiella* spp. conjointly displayed the presence of staphylococci. Fecal coliforms were found in 4 vendor fruit juice tests (10^2 CFU/ml), whereas they were completely missing within the packed juice. Furthermore, most of them were safe against ampicillin, ciprofloxacin, amoxicillin, erythromycin, chloramphenicol, ceftriaxone, piperacillin, trimethoprime-sulfamethoxazole, nalidixic acid, and vancomycin (Rashed *et al*., 2013). Also, Khan *et al*., (2015) detailed fruit juice samples collected from distinctive roads of Dhaka College campus contained an average extent total viable count (microbial load) and total coliforms, which were 7.7×10^3 - 9×10^8 CFU/ml and 210–1100 CFU/100 ml. The study uncovered that tukmaria sherbet was most contaminated with a count of 9×10^8 CFU/ml for TVBC, though TCC was 1100 CFU/100ml. The slightest defilement was observed in lemon sherbet, which was 7.7×10^3 for TVBC and 210 for TCC. On the opposite, TVBC & TCC count of 1.98×10^6 CFU/ml and 460 CFU/100ml was observed in papaya juice, and for wood apple sherbet, counts were 3.4×10^5 CFU/ml and 240 CFU/100ml. It was noticeable that Total coliforms were present in all samples, and the average count for total coliforms was higher in tukmaria sherbets than in others. Different pathogenic species of bacteria such as *Proteus* spp., *Enterobacter* sp, *E. coli*, *Shigella* sp, *Citrobacter* sp, *Vibrio* spp., *Yersinia* spp., and *Hafnia* spp. were confined from the juices and sherbets (Khan *et al*., 2015) **(**Table 1**)**. Generally, the study illustrates that the quality of the juices was unsuitable, and consequently, pathogens with such drug resistance properties may render these pathogens cause serious health hazards due to ineffective treatment of the sufferers by the commonly endorsed anti-microbials. Although packaged fruit juices generally exhibited lower microbial growth compared to vended juice samples, their microbial counts often exceeded acceptable safety limits. Increasing awareness of safe juice preparation practices and identifying potential contamination sources are essential to reducing pathogen levels in these beverages. It is crucial that individuals involved in the preparation and handling of fruit juices receive proper training in safe fruit handling techniques. Routine quality monitoring of fruit juices intended for consumption is advisable to help prevent

potential bacterial outbreaks. Ensuring the production of safe fruit juices or soft drinks relies on implementing Good Hygienic Practices (GHP), as outlined in the Codex *General Principles of Food Hygiene*, in conjunction with a Hazard Analysis and Critical Control Points (HACCP) system (Codex, 1997).

Frozen Snacks

Frozen snacks stored in local markets for extended periods must remain free from contamination and pathogenic microorganisms. Additionally, during consumption, they should not cause any taste or quality issues health. Chakra Borty *et al*. (2015) tested four types of snacks—French fries, deshi porotha, dal-puri, and aloo-puri—collected from the Gazipur market for microorganism isolation and total aerobic counts. The results showed that French fries had counts ranging from 1.10×10^6 to 2.20×10^6 CFU/g. The counts for deshi porotha ranged from 1.56×10^6 to 2.58×10^6 CFU/g; for aloo-puri, they ranged from 1.68×10^6 to 2.36×10^6 CFU/g; and for dal-puri, they ranged from 1.88×10^6 to 2.56×10^6 CFU/g. Out of the total 35 samples tested, Staphylococcus aureus was the most prevalent bacteria, found in 35% of the samples. This was followed by *Bacillus cereus* (31%), *Klebsiella aerogenes* (20%), and *Proteus mirabilis* (14%) across all four types of frozen foods examined in this study. These pathogens deteriorate the frozen food item and create unpleasant odors, tastes, and surfaces, especially when there is any variation in capacity temperature, or in case they are contaminated during preparing, manipulation, packaging, and storing (Chakraborty *et al*., 2015) (Table 1).

Preservatives

Key functions of food additives—such as antioxidant, antimicrobial, and anti-enzymatic properties—help prevent chemical spoilage, over-ripening, fermentation, and microbial growth in products, while also enhancing preservation through methods like canning, pasteurization, exposure to light, filtration, and the addition of natural or synthetic substances. However, certain synthetic additives, including nitrates, benzoates, sulfites, sorbates, and formaldehyde, may pose serious health risks (Sultana *et al*., 2014). In Bangladesh, commonly used food additives include high levels of sugar (primarily for jams and jellies) and salt (for meat and fish), as well as pickling agents such as salt, vinegar, lemon juice, or mustard oil (for vegetables). However, some of these preservatives can harbor significant bacterial contamination due to improper storage at ambient temperatures, poor hygiene, and unsanitary handling practices. Sultana *et al*. (2014) reported that nine preservatives were contaminated with microbes, with counts reaching 10^5 CFU/g, and fungal counts ranged from 10^1 to 10^2 CFU/g. *Escherichia coli*, *Pseudomonas* spp., and *Staphylococcus* spp. were commonly found in most samples. Nevertheless, according to this investigation, sodium sulfite and citric acid were found to be satisfactory preservatives in terms of microbiological criteria and their antibacterial activity (Sultana *et al*., 2014).

Fish and Fish Products

In Bangladesh, people have been drying salted fish in the sun for many years. They clean the fish and add salt to remove water, then leave it outside so the sun and air can dry it. Dried salted fish serves as a significant source of animal protein and is widely appreciated as a delicious food across the country. Fish is among the most perishable and challenging foods to handle. Its rapid perishability has been the biggest hurdle to its conservation. Bacterial growth is by far the foremost critical factor affecting fish quality, and bacteria are considered to play a dominant part in fish contamination (Huss, 1974). Small-scale vegetation found in fish is associated with various factors, including the fish's developmental stage, stomach tract structure, water temperature, location, food availability, and physiological condition. This study discovered that total plate count (TPC) in retail markets and control samples varied from $5.75\pm0.35\times10^6$ to $8.74\pm0.39\times10^7$ CFU/g and $2.23\pm0.15\times10^5$ to $3.13\pm0.20\times10^5$ CFU/g, respectively. In the retail market test, total fungal count (TFC) extended from $5.67\pm0.30\times10^4$ to $7.43\pm0.25\times10^4$ CFU/g, while in the control test, TFC varied from $1.15\pm0.10\times10^2$ to $2.47\pm0.21\times10^2$ CFU/g. The study also revealed that the total coliform count (TCC) in retail showcase and control tests varied from 73.27±16.74 to 94.03±20.14 MPN/g and 20.11±2.39 to 31.45±5.74 MPN/g, respectively. Across all checks, the highest TPC was found in the Narsingdi test, and the lowest in the Chandpur test. The highest percentage of Salmonella (76%) was found in the retail showcase in Narsingdi, followed by Chittagong with 36% and Chandpur with 32% separately. For control, *Salmonella* was identified in Narsingdi. Samples from retail markets in Chandpur (06%), Chittagong (09%), and Narsingdi (16%) showed contamination with *V. cholerae*. Notably, *V. cholerae* was absent in the control tests. The findings of this study demonstrated that the retail advertising and control tests in Chandpur were of high quality. In contrast, the tests in Chittagong and Narsingdi

were of lower quality, reflecting the unhygienic conditions of the markets (Majumdar, 2017) (Table 1).

A 2016 study examined public health safety and international trade aspects by microbiologically analyzing export-oriented frozen fishes, specifically jewfish, tongue sole, cuttlefish, ribbon fish, and queenfish etc. The TVAC for all tests was assessed at 5×10^5 CFU/g. Meanwhile, the results for total coliforms and fecal coliforms were below the standards set by the International Commission on Microbiological Specifications for Food: below 100 MPN/g and below 10 MPN/g, respectively. From this study, it can be concluded that the examined frozen fish were qualified for trade reason conjointly secure for human consumption (Sanji *et al*., 2016) (Table 1).

Meat & Meat Products

Ensuring food security has become increasingly crucial, and maintaining food safety is a major public health priority both globally and in Bangladesh. Meat and meat products are particularly important, as they can serve as significant sources of zoonotic infections caused by a variety of bacteria, viruses, and parasites. Annually, over 90% of foodborne illness cases are attributed to pathogens such as *Staphylococcus aureus*, *Salmonella* spp., *Clostridium perfringens*, *Campylobacter* spp., *Listeria monocytogenes*, *Vibrio parahaemolyticus*, *Bacillus cereus*, enteropathogenic *Escherichia coli*, and *Shigella* spp. (Smith, 2003). Incredible differences of organisms possess new meat generally, but distinctive sorts may become prevailing depending on pH, composition, surfaces, temperature, and transportation means (Ercolini, 2006). Meat available at retail outlets passes through a long process of butchering and transportation, with each stage potentially introducing microbial contamination hazards. Considering all these factors, a research from 2018 was conducted to survey the microbial load of the meat products from different zones. TVC for the Haluaghat, Sreepur, and Madhupur were log 8.30, log 7.94, log 8.15, while total *Staphylococcus* Count (TStaC) was log6.21, log 6.40, log 5.43, and Total *Salmonella* Count (TSC) was log 4.76, log 4.82, log 4.56 CFU/gm separately, which surpassed the ICMSF suggested values. 46.67% (n=14) were found to be related to *Salmonella* spp. The result illustrates the reality that the unhygienic and destitute clean condition beneath which the meat and meat items were dealt with and prepared was not satisfactory from a sterile point of see and it has proven clearly the undesirable level of defilement which may have procured from the environment and agents (Hasan *et al*., 2018) (Table 1).

Another study was conducted to evaluate bacterial quality and determine the predominance of zoonotic microorganisms from broiler meat tests in 2020. The means of TVC, TCC, and TSC for the Krishi showcase, Agargoan market, Taltola market, Bihari camp market, and SAU Mini market were 5.67, 4.32, 2.96 log10 CFU/g, 5.88, 4.64, 3.56 log10 CFU/g, 6.10, 4.68, 3.78 log10 CFU/g, 6.68,4.87, 3.84 log10 CFU/g, and 5.84, 4.25, 3.13 log10 CFU/g individually. The predominance of *Escherichia coli* and *Salmonella* spp. was 74% and 42%, respectively. The current study identified several microbial genera classified as foodborne pathogens, capable of causing foodborne illnesses and intoxication. Therefore, the broiler meat sector requires urgent governmental intervention to enforce strict biosecurity measures and hygienic practices in both poultry farms and live bird markets nationwide (Sultana, 2020) (Table 1).

Vegetables

Vegetables are widely consumed worldwide because of their nutritional benefits and availability. In Bangladesh, a variety of vegetables are commonly consumed by the population. However, improper handling, non-sterile post-harvest practices, the use of contaminated water for washing, and inadequate packaging and transportation systems increase their risk of microbial contamination. Additionally, differences exist between vegetables sold in local markets and those in supermarkets due to variations in storage and handling practices. Considering these truths, microbiological appraisal and comparison of four sorts of vegetables collected from two distinct market conditions in a study that was conducted in 2021. The total viable bacterial count (TVBC) of the samples collected from local markets and supermarkets ranged from 10^5 to 10^7 CFU/g. The highest TVBC was observed in lady finger (3.2×10^7 CFU/g) and coriander (2.6×10^6 CFU/g). The maximum total fungal count of *Klebsiella* spp., *Staphylococcus* spp., *Bacillus* spp., and *Listeria* spp. found in all tests within the range of 10^2 to 10^3 CFU/g. Fecal coliform, *Pseudomonas* spp., and *Salmonella* spp. were detected in only two tests, and *Vibrio* spp. could not be separated in any test. On the other hand, supermarket vegetables were found to harbor *Escherichia coli, Staphylococcus* spp., and *Pseudomonas* spp. at a concentration ranging from 10^2 to 10^3 CFU/g. However, all tests on vegetables collected from the supermarket showed no presence of fecal coliforms, *Bacillus* spp., *Listeria* spp., *Salmonella* spp., or *Vibrio* spp. Most importantly, total coliform (4.8×10^3 CFU/g) was found in green chili of the local market, while at least 3.0×10^2

Table 1. Summary of the microbiological analysis of some food items

SL No.	Author	Year	Title	Sample Variation	Name of the samples	Summary of findings	Highest Microbes Present (each product
1.	Afzal *et al.*	2014	Microbiological qualities of some foods sold in the street and in the mid-level and high-level restaurants	**Street foods**	Cake (high level restaurant; street food; mid-level restaurant)	TVBC=4.1×10^6; 4×10^5; 2.1×10 TSA=1×10^4; 3.2×10^5; 9×10^4 TFC=1×10^2; 7×10^5; 7×10^4	*Staphylococcus aureus* >Total Fungal Count>Total Viable Bacterial Count
					Biscuits	TVBC=3×10^2; 4×10^4; 6×10^2; TSA=5×10^2 3×10^3; 2×10^3 TFC=2×10^2; 3×10^3; 1×10^2	Total Viable Bacterial Count> *Staphylococcus aureus*> Total Fungal Count
2.	Hasan *et al.*	2016	Microbiological quality analysis of raw milk and yogurt available in some selected areas of Bangladesh.	**Milk & Milk Products**	Milk	TVBC=1.24×10^6 to 4.17×10^7 CFU/ml TCC=2.87×10^4 to 3.94×10^5 CFU/ml	Total Viable Bacterial Count > Total Coliform Count
					Yogurt	TVBC=35.31×10^6 to 5.04×10^8 CFU/ml TCC=1.12×10^4 to 4.51×10^2 CFU/ml	
3.	Banik *et al.*	2014	Microbiological quality analysis of raw, pasteurized, UHT milk samples collected from different locations in Bangladesh		Raw milk	TVBC=5.2×10^8 to 1.3×10^7 CFU/ml TCC= 4.2×10^4 to 1.0×10^4 CFU/ml	
					Pasteurized milk	TVBC=1.8×10^3 to 1.1×10^2 CFU/ml	Total Coliform Count is absent.
					UHT	TVBC=1.8×10^3 to 1.1×10^2 CFU/ml	
4.	Uddin *et al.*	2013	Microbiological status of different sweet and sweet products in Dhaka city, Bangladesh.		Chamcham	TVBC=5.4×10^5 CFU/g	Total Viable Bacterial Count was observed only
					Kachagolla	TVBC=3.4×10^5 CFU/g;	
					Sandesh	TVBC=8.5×10^6 CFU/g	
					Rasmalai.	TVBC=5.6×10^2 CFU/g	
					Sweet Yoghurt	TVBC=8.3×10^4 CFU/g	
					Cream Toast	TVBC=5.8×10^5	
5.	Rahman *et al.*	2015	Microbiological analysis of raw milk, pasteurized milk and yogurt samples collected from different areas of Dhaka city, Bangladesh.		Raw milk (Moghbazar & Mohammadpur)	TVBC=(4.2×10^6 CFU/ml) and (3.5×10^3 CFU/ml)	Total Viable Bacterial Count is present
					Raw milk (Siddeswari)	TCC=4.1×10^3	Total Coliform was observed.
					Pasteurized milk	TVBC=1.9×10^2 to 2.8×10^3 CFU/ml	
					Yogurt samples (Open)	TVBC=9.1×10^3 to 8.2×10^7 CFU/ml	
6.	Hasan *et al.*	2012	Microbial quality of selected sandwiches sold at fast food shops in Dhaka city, Bangladesh	**Fast Foods**	Beef sandwiches	TVBC=6.0×10^8 CFU/ml	Total Viable Bacterial Count was observed only
					Egg salad sandwich	TVBC=3.7×10^6 CFU/ml	
					Vegetable sandwich	TVBC=2.3×10^4 CFU/m	

7.	Sultana *et al.*	2016	Bacteria in chicken rolls sold by a fast food restaurant and their public health significance		Chicken rolls	TVBC=4.4 log CFU/g TSA= 4.2 log CFU/g	Total Viable Bacterial Count> Total *Staphylococcus aureus*
8.	Rashed *et al.*	2013	Microbiological study of vendor and packed fruit juices locally available in Dhaka city, Bangladesh	**Fruit Juice**	Fresh Fruit Juice	TVBC=10^2 -10^7 CFU/ml TCC=10^2 -10^6 CFU/ml	Total Viable Bacterial Count>Total Coliform Count
					Packed Juice	TCC=0	Total Coliform was absent.
9.	Ahmed *et al.*	2010	Microbiological Quality of Local Market Vended Freshly Squeezed Fruit Juices in Dhaka City, Bangladesh		Fresh Fruit Juices (local markets)	TVBC=3×10^2 to 9.6×10^8 CFU/ml TFC=1.00×10^2 to 8.05×10^4 CFU/ml	Total Viable Bacterial Count > Total Fungal Count
10.	Khan *et al.*	2015	Assessment of microbiological quality of some drinks sold in the streets of Dhaka University Campus in Bangladesh		Tukmaria sherbet	TVBC=9×10^8 CFU/ml TCC=1100 CFU/100ml	Total Viable Bacterial Count>Total Coliform Count
					Lemon sherbet	TVBC=7.7×10^3 TCC=210 CFU/100ml	
					Papaya juice	TVBC=1.98×10^6 CFU/ml TCC=460 CFU/100ml	
					Wood Apple sherbet	TVBC=3.4×10^5 CFU/ml TCC=240 CFU/100ml	
11.	Chakraborty *et al.*	2015	Isolation and identification of bacteria from four different frozen snacks of gazipur district of Bangladesh	**Frozen Snacks**	French Fry	TVBC=1.10×10^6 to 2.20×10^6 CFU/g	Total Viable Count was observed.
					Deshi Porotha	TVBC=1.56×10^6 to 2.58×10^6 CFU/g	
					Aloo Puri	TVBC=1.68×10^6 to 2.36×10^6 CFU/g,	
					Dal Puri	TVBC=1.88×10^6 to 2.56×10^6 CFU/g	
12.	Sultana *et al.*.	2014	Microbiological analysis of common preservatives used in food items and demonstration of their in vitro anti-bacterial activity	**Preservative**		TVBC= up to 10^5 CFU/g TFC=10^1-10^2 CFU/g	Total Viable Bacterial Count>Total Coliform Count
13.	Majumdar *et al.*	2017	Microbiological Properties of Dry Salted Hilsa, Tenualosa ilisha (Hamilton, 1822) Fish of Bangladesh	**Fish & Fish products**	Dried salted Hilsa (Chandpur; Chittagong; Narsingdi)	TVBC=$5.75\pm0.35\times10^6$; $7.17\pm0.68\times10^6$; $8.74\pm0.39\times10^7$	Total Viable Bacterial Count >Total Fungal Count> Total Coliform Count; *Salmonella* spp.> *Vibrio cholerae*
						TFC=$5.67\pm0.30\times10^4$; $4.88\pm0.37\times10^4$; $7.43\pm0.25\times10^4$	
						TCC=73.27±16.74; 81.83±10.19; 94.03±20.14 (MPN/g)	
						Salmonella spp.=09,11,19 (MPN/g)	
						Vibrio Cholerae = 6;9;16	

14.	Sanjee *et al.*	2016	Microbiological Quality Assessment of Frozen Fish and Fish Processing Materials from Bangladesh		Jew fish (*A. hololepidotus*), Queen fish (*S. commersonnianus*), Tongue Sole fish (*C. broadhursti*), Ribbon fish (*L. savala*), and Cuttle fish (*S. officinalis*)	TVBC= 2.8×10^5 to 4.9 $\times10^5$ CFU/g TCC= 5 MPN/g to 28 MPN/g Total Fecal Coliform= 3 MPN/g to 8.3 MPN/g.	Total Viable Bacterial Count>Total Coliform Count
15.	Hasan *et al.*	2018	Bacteriological quality assessment of buffalo meat collected from different districts of Bangladesh with particular emphasis on the molecular detection and antimicrobial resistance of the isolated Salmonella species	**Meat & meat products**	Buffalo meat samples (Haluaghat, Sreepur, and Madhupur)	TVC= log 8.30, log 7.94, log 8.15 TStaC=log6.21, log 6.40, log 5.43 TSC = log 4.76, log 4.82, log 4.56 CFU/gm	Total Viable Bacterial Count>Total Staphylococcal Count>Total *Salmonella* Count
16.	Sultana *et al.*	2020	Microbiological quality assessment of marketed broiler meat in different markets of Dhaka city.		Raw broiler meat (Krishi market, Agargoan market, Taltola market, Bihari camp market, and SAU mini markets)	TVC= 5.67 ±0.49; 5.88±0.19; 6.10±0.16; 6.68±0.21; 5.84±0.33 TCC= 4.32±0.19; 4.64±0.35; 4.68±0.27; 4.87±0.31; 4.25±0.17 TSC= 2.96±0.39; 3.56±0.18; 3.78±0.38; 3.84±0.67; 3.13±0.53 *prevalence of *Escherichia coli* and *Salmonella* spp. Were 74% and 42% respectively	Total Viable Bacterial Count>Total Coliform Count>Total Staphylococcal Count
17.	Mamum *et al.*	2021	Comparative study on the microbiological quality of vegetables collected from local markets and super shops of Dhaka city	**Salad items**	Lady's Finger (Local Market; Super shops)	TVC= 3.2×10^7; 2.0×10^6 TF=1.5×10^6; 1.0×10^4 *E. coli*= 2.6×10^3; 2.5×10^2 *Klebsiella* spp.= 8.2×10^2;0 TFC=4.0×10^2 ;0 TSA=1.1×10^3; 2.0×10^4 *Bacillus* spp.= 2.6×10^2 ;0 *Pseudomonas* spp.= 0; 6.5×10^2 *Listeria* spp.= 1.8×10^2;0 *Salmonella* spp.= 8.5×10^2;0 *Vibrio* spp.=0; 0	Total Viable Bacterial Count>Total Fungal Count>Total Staphylococcal Count

CFU/g was found in coriander from the supermarket. The highest count of fecal coliform, 8.0×10^2 CFU/g, was found in coriander from the local market, although it was absent in the supermarket test. The presence of pathogenic microbial contamination in new vegetables is not desirable under any condition, as it may cause foodborne sickness in humans. Therefore, the government must deliver more consideration in assessment on the local markets and organize a few free sessions to proficient vegetables handler approximately sterile handling practices (Mamum *et al*., 2021) (Table 1).

STUDY LIMITATION

To highlight the overall consequence of food contamination and food safety, a more updated literature survey is required. This review is limited by the insufficient availability of recent and up-to-date literature on food items and the food contamination chain in Bangladesh. A detailed picture of the current state of food safety is limited by the dependence on older and dispersed studies. To appropriately emphasize the current state of food safety and new issues in Bangladesh, a more thorough analysis of recent research is therefore required.

CONCLUSION

The incidence of foodborne diseases is expanding day by day. This circumstance has led to a developing awareness of the need to list and assess pathogens related to the decay of strong or fluid foods. All the fixings in food products must be approved to use under the appropriate regulations governing concentrations and acceptable daily doses. Ensuring food safety is the duty of each

individual involved in food production, handling, providing, and consuming. Additionally, it could be a collective endeavor of the government and authorities at the local, state, and government levels. This review article reflects the current status of distinct food items at numerous levels and numerous previous inquiries about these food products, which portrays the causes of foodborne illness. However, the food industry's negative reputation occurs due to flare-up of foodborne illness, the presence of hair, insect droppings, or body parts, or sign of spoilage in the food served, as well as unhygienic service and dirty toilets. In addition, the major reason behind these infections and cross-contamination is the poor management s and the lack of proper legislation in the food sector. It is imperative to implement effective measures to avert the proliferation of pathogens and avert foodborne illnesses.

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