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Article

Microbial profile of chicken-based ready-to-cook frozen foods sold in Mymensingh city, Bangladesh

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Abstract: Demand for quick meals, such as ready-to-cook (RTC) foods, has been rising among modern consumers due to changing lifestyles worldwide, including in Bangladesh. However, these foods have been linked to several foodborne diseases, posing a significant threat to public health. As a result, assessing the microbial quality of RTC food products has become essential. This study aimed to evaluate the microbial quality of commonly available chicken-based RTC frozen foods in the markets of Mymensingh city. A total of 50 samples from five distinct types, collected from various retail points, were analyzed for total counts of aerobic bacteria, *Staphylococcus* spp., and *Enterococcus* spp., to determine how these loads compare against established safety standards. Correlations between different microbial loads were also examined. Generally, high levels of contamination were observed in almost all samples, except for low enterococcus counts in spring rolls. The mean counts of aerobic plate count (APC), total staphylococci count (TSC), and total enterococci count (TEC) across different food types ranged from 4.56 to 7.14 log CFU/g, 1.30 to 6.14 log CFU/g, and 1.24 to 3.56 log CFU/g, respectively. Two items, samosa and sausage, were identified as the most unsatisfactory in terms of microbial quality. Food manufacturers and regulatory authorities should focus on reducing contamination risks and regularly monitoring the food production chain. Consumers should also carefully follow cooking instructions and, if possible, avoid high-risk products. These findings underscore the need for strengthened hygiene practices, stricter regulatory monitoring, and improved quality control measures to ensure safer production and distribution of RTC chicken products in Bangladesh.

Keywords: ready-to-cook (RTC) foods; chicken products; microbial quality; food safety

1. Introduction

In the 1960s, rising consumer demand for standardized meals in the United States led to the emergence of the home meal replacement (HMR) concept. Observing this trend, Professor Masayuki Yoshikawa later proposed the "3R food" concept in Japan during the 1980s, categorizing prepared foods into "ready-to-eat," "ready-to-heat," and "ready-to-cook" (Cui *et al*., 2024). Global demand for ready meals—including ready-to-cook (RTC) and ready-to-eat (RTE) products—has increased steadily due to convenience, reduced preparation time, perceived freshness, and wide availability (Sen *et al*., 2021; Rebezov *et al*., 2022). Lifestyle changes have also contributed significantly to the growing preference for such foods (Rahman and Kabir, 2012). RTC foods are preprocessed products that require minimal cooking steps, whereas RTE foods can be consumed without additional preparation (Mengistu *et al*., 2022; Cui *et al*., 2024). To meet rising consumer demand in Bangladesh, an expanding variety of RTC products—over 40 types including nuggets, wings, sausages, burgers, spring rolls, samosas, aloo-puri, and chapati—are now marketed, with a value exceeding 95 million USD (Shamimuzzaman *et al*., 2022).

Most RTC foods are marketed in frozen form to extend shelf life, although freezing does not eliminate pathogenic microorganisms and may adversely affect product texture (Fallah *et al*., 2010). Psychrotrophic bacteria such as Pseudomonas spp. and *Brochothrix thermosphacta* may survive and grow under frozen conditions, leading to spoilage (Osaili *et al*., 2022). Improperly processed frozen foods have been associated with several foodborne illness outbreaks, underscoring the importance of monitoring raw materials and production steps (Shamimuzzaman *et al*., 2022). In the United States, not-ready-to-eat breaded stuffed chicken—an RTC product—has been linked to 11 salmonellosis outbreaks (Ford, 2023). Similarly, human *Salmonella enteritidis* infections in Canada have been associated with raw or frozen chicken items (Al-Maaqar *et al*., 2024).

Globally, poultry consumption has risen due to its high nutritional value, affordability, and ready availability (Uddin *et al*., 2019; Parvin *et al*., 2021). Bangladesh reflects this trend, with frozen chicken and chicken-based RTC items widely available in supermarkets and expanding annually (Hossain *et al*., 2023). Popular RTC chicken items include nuggets, wings, sausages, cutlets, strips, samosas, and spring rolls (Shamimuzzaman *et al*., 2022). As consumption increases, consumers expect safer products free of pathogenic microorganisms (Uddin *et al*., 2019). Microbial safety has therefore become a major public health concern, especially given the rapidly expanding frozen chicken market (Parvin *et al*., 2021; Hossain *et al*., 2023).

Chicken meat is highly susceptible to microbial contamination due to its high water activity and nutrient-rich composition (Odeyemi *et al*., 2020). Although processing steps aim to reduce contamination, poor handling often results in processed chicken carrying higher microbial loads than fresh meat (Al-Maaqar *et al*., 2024). A South Korean study reported that 93.5% of bacteria detected in final chicken products originated from the processing environment (Park *et al*., 2023). Additional risk factors include temperature abuse, prolonged storage, and high initial microbial loads in raw materials (Osaili *et al*., 2022).

Common pathogens associated with poultry include *Salmonella* spp., *Campylobacter*, *Arcobacter*, *Escherichia coli*, *Listeria monocytogenes*, *Yersinia enterocolitica*, and *Aeromonas hydrophila*, as well as toxin-producing *Clostridium botulinum*, *Clostridium perfringens*, *Bacillus cereus*, and *Staphylococcus* (Bhaisare *et al*., 2014; Osaili *et al*., 2022). Fungal species including *Penicillium*, *Aspergillus*, *Mucor*, *Fusarium*, *Cladosporium*, *Rhizopus*, *Candida* spp., *Geotrichum*, *Eupenicillium*, *Scopulariopsis*, and *Acremonium* have also been detected in poultry products (Al-Maaqar *et al*., 2024).

In Bangladesh, ineffective food safety administration and inadequate oversight across slaughtering, handling, transport, and retail contribute to high contamination levels (Rahman and Rahman, 2012; Shamimuzzaman *et al*., 2022). Multiple studies report bacterial contamination in frozen chicken across major cities, including multidrug-resistant *S. aureus*, enterotoxigenic and multidrug-resistant *E. coli*, high microbial loads in RTC foods, extended-spectrum β-lactamase-producing *E. coli*, and zoonotic *Aliarcobacter cryaerophilus* in RTC poultry (Uddin *et al*., 2019; Parvin *et al*., 2020; Parvin *et al*., 2021; Shamimuzzaman *et al*., 2022; Hossain *et al*., 2023; Mahmud *et al*., 2023).

We have limited understanding of the microbiological quality and safety of chicken-based RTC frozen foods available in Mymensingh, despite rising national consumption and documented contamination in major Bangladeshi cities. The central problem is whether these widely consumed RTC chicken items carry microbial loads that exceed acceptable limits, posing potential public health risks. Based on previous reports of contamination and multidrug-resistant pathogens in frozen poultry products in Bangladesh, the study hypothesizes that chicken-based RTC frozen foods sold in Mymensingh contain significant levels of pathogenic and spoilage microorganisms that may compromise consumer safety. Accordingly, the research questions focus on identifying the types and levels of microorganisms present in selected RTC chicken products, determining whether these levels exceed recommended microbiological standards, and assessing whether specific product types show higher contamination patterns. This study is conducted to evaluate the microbiological quality of five commonly available RTC chicken-based frozen food items in Mymensingh using standard bacteriological methods to generate evidence that reflects their safety and compliance with microbial guidelines. The findings will have important implications for food safety regulation, industry hygiene practices, and consumer protection, offering critical insights that may guide improved monitoring of frozen food production, targeted interventions to reduce contamination, and policymaking aimed at strengthening food safety oversight in Bangladesh.

2. Materials and Methods

2.1. Ethical approval

No formal ethical approval was required, as this study was thoroughly carried out on commercially available, inanimate food products and did not involve any human or animal subjects.

2.2. Study area and period

A total of 50 samples were collected from various locations in Mymensingh city, including the Bangladesh Agricultural University campus, Charpara, Noton Bazar, Tajmohol Mor, and Maskanda from April 2022 to August 2022 (Figure 1).

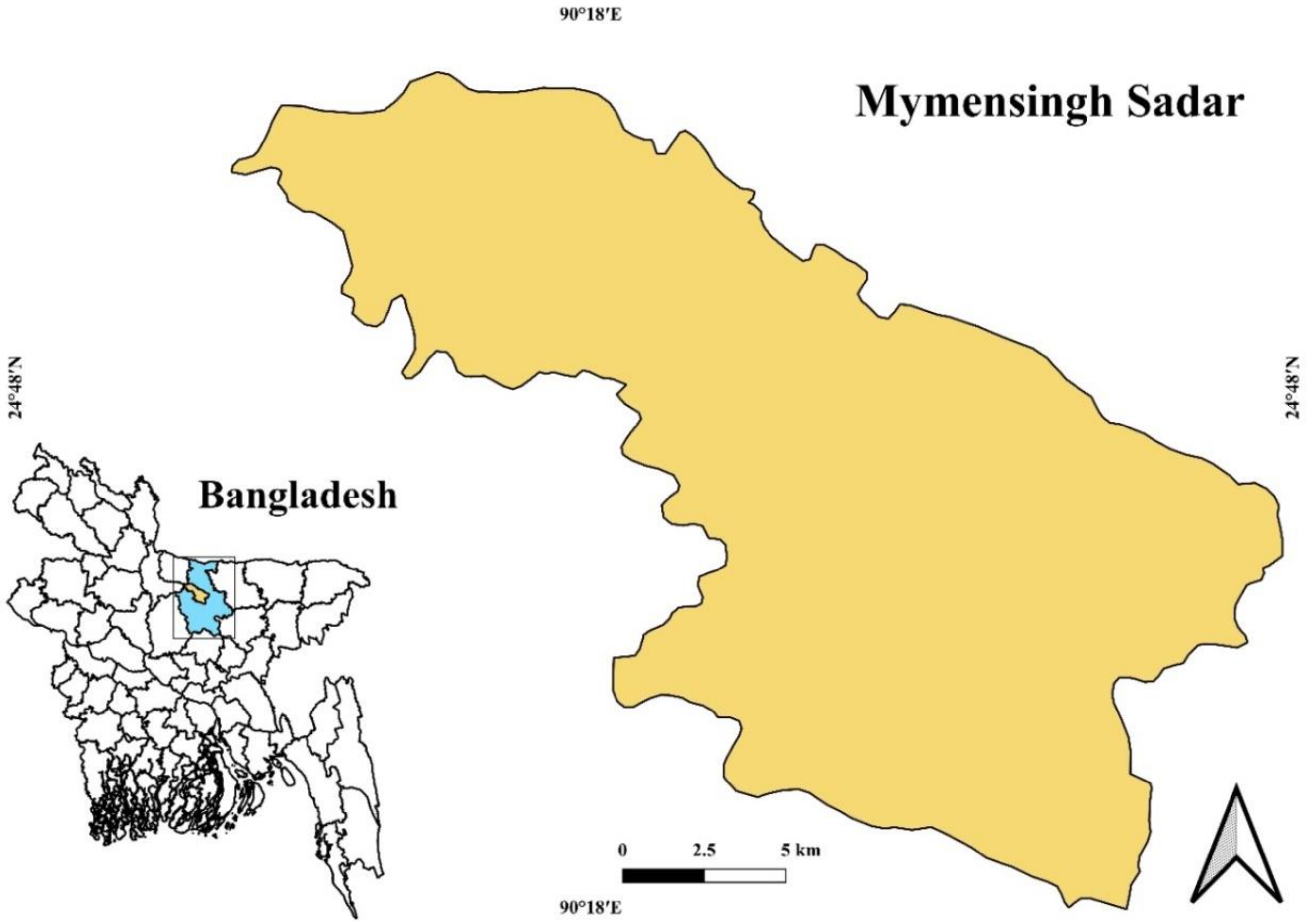

Figure 1. Samples were collected from different parts of Mymensingh city.

2.3. Collection and preparation of samples

The samples consisted of five types of chicken-based RTC frozen food items: nuggets (n=10), sausage (n=10), samosa (n=10), meatballs (n=10), and spring rolls (n=10). The samples were collected aseptically in sterile containers and transported to the laboratory for processing within 30 minutes to assess the microbiological load and identify different microflora present in the meat. During transportation, the sterile containers were kept cool in iceboxes filled with ice. Each sample was macerated in a mechanical blender using a sterile diluent, following the recommendations of the International Organization for Standardization (ISO, 1995). One gram of the chicken-based RTC frozen meat sample was aseptically taken with sterile forceps and transferred into sterile containers containing 9 ml of 0.1% peptone water. A homogenized suspension was created in a sterile blender, resulting in a 1:10 dilution of the samples. Subsequently, using a whirly mixer, different serial dilutions ranging from 10^{-1} to 10^{-6} were prepared according to standard methods (ISO). Strict hygienic measures were maintained at every step of sample handling.

2.4. Enumeration of aerobic plate count (APC)

To determine the total aerobic count, 0.1 ml of each ten-fold dilution was transferred and spread onto duplicate plate count agar (PCA) for mesophilic bacteria, using a fresh pipette for each dilution. The diluted samples were spread quickly on the plate surface with a sterile glass spreader, with one spreader used for each plate. The plates were then incubated at 37 °C for 24-48 hours. The average number of colonies from a particular dilution was multiplied by the dilution factor to obtain the total viable count. The APC was calculated according to ISO (1995).

2.5. Enumeration of total *Staphylococcus* count (TSC)

To determine the TSC, 0.1 ml of each ten-fold dilution was transferred and spread onto mannitol salt agar using a sterile pipette for each dilution. The diluted samples were spread rapidly across the surface of the plate with a sterile glass spreader, with one spreader used for each plate. The plates were then incubated at 37 °C for 24 to 48 hours. The results of the total staphylococcus count were expressed as the number of organisms or colony-forming units per gram (CFU/g) of the RTC frozen meat sample.

2.6. Enumeration of total *Enterococcus* count (TEC)

To determine the TEC, 0.1 ml of each ten-fold dilution was transferred to enterococcus differential agar base using a sterile pipette for each dilution. The diluted samples were spread quickly on the surface of the plate with a sterile glass spreader, using one sterile spreader per plate. The plates were then incubated at 37 °C for 24 to 48 hours. The results were expressed as the number of organisms, or colony-forming units per gram (CFU/g), of the RTC frozen meat sample.

2.7. Morphological identification by Gram's staining

Gram staining of the pure culture was performed according to the method described by Cheesbrough (2005). Briefly, a single colony was picked with a bacteriological loop, smeared onto a glass slide, and fixed by gentle heating. Crystal violet was applied to the smear and allowed to stain for two minutes before being washed with running tap water. A few drops of Gram's iodine were then added for a few seconds. After washing with water again, safranin was used as a counterstain for two minutes. The slides were subsequently washed with water, blotted dry, and examined under a light microscope (100X) using immersion oil.

2.8. Statistical analysis

Data on APC, TSC, and TEC from bacteriological examinations of samples collected across multiple locations in Mymensingh city were analyzed under a completely randomized design (CRD), and variance analysis was performed using SPSS software (version 26). Differences between means were assessed using ANOVA and Tukey-Kramer HSD post-hoc analysis (Gomez and Gomez, 1984). The regression-based correlation analysis of microbial loads was performed using Microsoft Excel 2016, and the study area map was generated with QGIS version 3.42.

3. Results

3.1. Microbial load of ready-to-cook frozen chicken food samples

The one-way ANOVA revealed that the mean values of APC, TSC, and TEC differed significantly across the product types ($P \leq 0.001$), indicating that the nature of the food item had a strong influence on its microbial contamination levels. Subsequent Tukey-Kramer HSD post-hoc comparisons further showed statistically significant pairwise differences among all product categories for each microbial parameter assessed. Across all samples, chicken samosa exhibited the highest microbial burden, recording mean APC, TSC, and TEC counts of 7.14, 6.14, and 3.56 log CFU/g, respectively. These values were substantially higher than those observed in the other RTC products, highlighting samosa as the most contaminated item. In contrast, chicken meatball demonstrated the lowest APC of 4.56 log CFU/g, suggesting comparatively better microbial quality among the evaluated items. Spring roll showed the lowest TSC, with a mean count of 1.30 log CFU/g, and its TEC was too few to count (TFTC), indicating minimal Enterococcus contamination in this product category. Chicken nuggets and chicken sausages exhibited intermediate microbial loads. Nuggets recorded APC, TSC, and TEC levels of 5.96, 1.93, and 1.34 log CFU/g, whereas sausages showed similar APC values (5.96 log CFU/g) but notably higher TSC (3.09 log CFU/g). Meatballs, despite having the lowest APC, had comparatively higher TSC and TEC than some other items, suggesting possible post-processing contamination or inadequate control during handling (Table 1).

Table 1. Distribution of mean and range of microbial counts (log CFU/g) in different RTC chicken food samples.

Type of sample	Total sample (n)	APC***	TSC***	TEC***
Nugget	10	5.96 ± 0.089[a] (4.80-5.98)	1.93 ± 0.12[a] (1.72-2.21)	1.34 ± 0.60[a] (1.08-1.94)
Sausage	10	5.96 ± 0.23[b] (4.40-6.73)	3.09 ± 0.76[b] (2.14-4.23)	1.24 ± 0.34[b] (1.02-2.21)
Samosa	10	7.14 ± 1.18[c] (5.24-7.93)	6.14 ± 1.10[c] (5.93-7.49)	3.56 ± 0.24[c] (3.40-3.73)
Meatball	10	4.56 ± 0.65[d] (4.03-4.96)	3.75 ± 1.12[d] (3.56-5.18)	1.96 ± 0.54[d] (1.64-2.41)
Spring roll	10	5.41 ± 0.54[e] (5.03-5.79)	1.30 ± 1.01[e] (1.76-2.18)	TFTC
Total	50			

APC=aerobic plate count, TSC=total staphylococcus count, TEC=total enterococcus count, TFTC=too few to count. Significant values were obtained by one-way ANOVA and Tukey-Kramer HSD post-hoc analysis. The values represented here indicate mean±SD, n, number of samples, ***highly statistically significant ($P \leq 0.001$).

3.2. Frequency of positive and unsatisfactory RTC chicken samples

Aerobic bacteria were detected in all five RTC product types, with overall positivity ranging from 70% to 100%. Samosa exhibited the highest contamination, with all samples (100%) testing positive, followed by spring rolls (90%), and both nuggets and sausages (80%). Meatballs had the lowest positivity rate at 70%. When evaluated against the European Commission's microbial criterion for unsatisfactory frozen food items (APC > 10^6 CFU/g), samosas again showed the highest proportion of unsatisfactory samples (90%). Spring rolls had 70% unsatisfactory samples, while meatballs, sausages, and nuggets each had 60% of samples exceeding the acceptable limit. *Staphylococcus* contamination was also widespread across all sample types. The highest prevalence occurred in samosas (70%), followed by sausages (60%), and both nuggets and meatballs (40%), whereas spring rolls showed the lowest prevalence (10%). Using the United States Food and Drug Administration (USFDA) criterion (TSC > 10^3 CFU/g), samosas recorded the highest proportion of unsatisfactory samples (60%), followed by sausages (50%), and both nuggets and meatballs (30%). Spring rolls had the lowest unsatisfactory rate (10%), consistent with their lower contamination level.

For *Enterococcus*, contamination was absent in spring rolls but detected in all other food categories. Nuggets, sausages, and samosas showed the highest prevalence (40% each), whereas meatballs showed slightly lower contamination (30%). Based on the TEC safety threshold (>10^3 CFU/g), 30% of nugget, sausage, and samosa samples were unsatisfactory, compared to 20% of meatballs. All spring roll samples met the satisfactory criteria, indicating better hygienic quality relative to other product types (Table 2).

Table 2. Frequency percentage of positive and unsatisfactory ready-to-cook chicken food samples according to different microbial parameters.

Type of sample	APC	TSC	TEC
Nugget	8/10 (80%)[a] 6/10 (60%)[b]	4/10 (40%) 3/10 (30%)	4/10 (40%) 3/10 (30%)
Sausage	8/10 (80%) 6/10 (60%)	6/10 (60%) 5/10 (50%)	4/10 (40%) 3/10 (30%)
Samosa	10/10 (100%) 9/10 (90%)	7/10 (70%) 6/10 (60%)	4/10 (40%) 3/10 (30%)
Meatball	7/10 (70%) 6/10 (60%)	4/10 (40%) 3/10 (30%)	3/10 (30%) 2/10 (20%)
Spring roll	9/10 (90%) 7/10 (70%)	1/10 (10%) 1/10 (10%)	0/10 (0%) 0/10 (0%)

APC=aerobic plate count, TSC=total staphylococcus count, TEC=total enterococcus count, Microbial standards for unsatisfactory frozen items: APC, European Commission (EC) > 10^6/g; TSC, United States Food and Drug Administration (USFDA) 10^3/g; TEC, 10^3/g. [a]number of positive samples/total samples analyzed (% of positive samples); [b]number of unsatisfactory samples/total samples analyzed (% of unsatisfactory samples).

3.3. Correlations between different microbial loads

Across most food categories, APC showed weak and statistically non-significant associations with both TSC and TEC. In nuggets, sausages, meatballs, and spring rolls, the correlation coefficients (r) for APC versus TSC and APC versus TEC were close to zero, and all r^2 values were extremely low (<0.10), indicating minimal shared variance between microbial indicators. These findings suggest that higher general microbial loads do not reliably predict the presence or levels of *Staphylococcus* or *Enterococcus* in these products. For spring rolls, correlation analysis with TEC was not applicable because TEC values were consistently below the detection threshold. Samosas were the only product category where a statistically significant correlation was observed. APC exhibited a strong positive correlation with TSC ($r^2 = 0.581$), indicating that approximately 58.10% of the variation in *Staphylococcus* contamination could be explained by changes in aerobic bacterial loads. This suggests that samosas may present a greater risk of co-contamination, potentially due to more extensive handling, inadequate hygiene during preparation, or higher exposure to cross-contamination pathways. However, no significant correlation was found between APC and TEC in samosas, similar to other products (Table 3).

Table 3. Summary of correlation between microbial loads.

Food product	Microbial pair	Regression equation	r^2 value
Nugget	APC vs. TSC	Y = 0.05 x + 5.6	0.007
	APC vs. TEC	Y = 0.04 x + 5.64	0.003
Sausage	APC vs. TSC	Y = -0 .01 x + 5.97	0.002
	APC vs. TEC	Y = -0.03 x + 6.01	0.006
Samosa	APC vs. TSC	Y = 0.83 x + 2.06	0.581
	APC vs. TEC	Y = -0.33 x + 8.32	0.004
Meatball	APC vs. TSC	Y = 0.08 x + 4.37	0.013
	APC vs. TEC	Y = -0.43 x + 5.51	0.093
Spring roll	APC vs. TSC	Y = -0.03 x+ 5.46	0.017
	APC vs. TEC	N/A	N/A

r^2 = coefficient of determination; N/A=not applicable.

Notably, a strong, positive, and statistically significant correlation was detected between APC and TSC in chicken samosas (Figure 2). The relatively high coefficient of determination ($r^2 = 0.581$) indicates that 58.10% of the variation in aerobic plate counts can be attributed to corresponding changes in *Staphylococcus* levels within this product type. This pronounced association suggests that samosas may share a common source of contamination or are subjected to environmental or handling conditions that simultaneously favor the proliferation of both general aerobic bacteria and *Staphylococcus* spp.

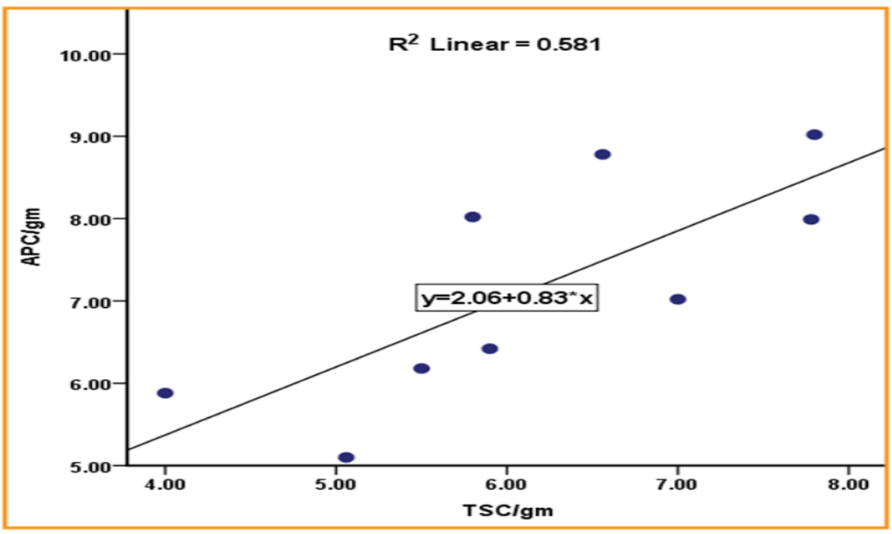

Figure 2. Correlation between APC and TSC in samosa.

4. Discussion

The results demonstrated clear and substantial variation in microbial contamination across the five RTC chicken products, with one-way ANOVA confirming highly significant differences in APC, TSC, and TEC among product types ($P \leq 0.001$). Chicken samosas consistently showed the greatest microbial burden, with mean APC, TSC, and TEC values exceeding 7, 6, and 3 log CFU/g, respectively—levels notably higher than those found in any other item—suggesting that the formulation, filling moisture, and extensive manual handling during preparation may increase susceptibility to contamination (Shaltout *et al.*, 2018; Ain *et al.*, 2022). In contrast, chicken meatballs exhibited the lowest APC (approximately 4.6 log CFU/g), indicating comparatively better microbial quality, though their moderate TSC and TEC values point to potential hygiene shortcomings after processing or during retail storage. Spring rolls demonstrated the lowest TSC (around 1.3 log CFU/g) and nondetectable TEC, likely reflecting reduced exposure and effective thermal or structural barriers inherent in their preparation. Nuggets and sausages showed intermediate levels of contamination, but sausages had a distinctly higher TSC despite similar APC levels, suggesting that surface contamination or inadequate sanitation practices may disproportionately affect staphylococcal load in this category. Regardless of the processing used in food processing industries, microorganisms may still remain viable in the final food products, posing a serious health risk to the consumers (Adetunji and Odetokun, 2012). Among all the food items analyzed, chicken samosas consistently exhibited the highest levels of contamination across all microbial parameters (APC, TSC, and TEC). The significant variation in microbial load among product types can be attributed to differences in ingredient composition, processing methods, and hygiene practices during production, as previously reported (Odeyemi *et al*., 2020). The pattern observed in this study aligns with earlier investigations that similarly documented elevated microbial loads in certain chicken-based RTC products, including samosas (Sultana *et al*., 2014; Chakrabarty *et al*., 2021; Shamimuzzaman *et al*., 2022).

The frequency distribution of positive and unsatisfactory samples revealed widespread microbial contamination across all RTC chicken product categories, indicating that hygienic lapses occur throughout the processing and handling chain rather than being confined to specific food items (Shamimuzzaman *et al*., 2022). In this study, the magnitude of contamination varied noticeably, with aerobic bacteria detected in 70–100% of samples. Samosas demonstrated the greatest vulnerability, with 100% positivity for APC and the highest proportion of samples exceeding the EC unsatisfactory threshold (90%), reflecting substantial contamination pressure likely linked to extensive manual handling and multiple ingredients (Khaledian *et al*., 2020). Spring rolls also showed a high APC positivity rate (90%) and a 70% unsatisfactory proportion, despite their comparatively low TSC and TEC levels, suggesting that general bacterial contamination originates primarily from raw materials rather than pathogens associated with poor handling (Azad and Shakerian, 2023). In contrast, *Staphylococcus* contamination—an indicator of human contact—was most pronounced in samosas (70%) and sausages (60%), while spring rolls showed minimal prevalence (10%), implying better personnel hygiene during their preparation. *Enterococcus* contamination followed a similar pattern, being completely absent from spring rolls but present in 30–40% of nuggets, sausages, samosas, and meatballs, underscoring potential fecal or environmental contamination in these products. When assessed against international safety criteria, samosas consistently emerged as the highest-risk item, with the greatest proportion of samples falling into the unsatisfactory category for all three microbial parameters, whereas spring rolls displayed comparatively superior hygienic quality, particularly regarding TEC (Khaledian *et al*., 2020; Azad and Shakerian, 2023).

The correlation analysis highlights notable variability in how different microbial groups co-occur across ready-to-cook chicken products, underscoring that contamination dynamics are not uniform across food categories. In most items—including nuggets, sausages, meatballs, and spring rolls—the extremely low correlation coefficients, all below a moderate digit ($r < 0.10$), indicate negligible shared variance between APC, TSC, and TEC, demonstrating that general aerobic loads are poor predictors of specific pathogenic or hygiene-indicator bacteria (Ain *et al.*, 2022). This pattern aligns with the understanding that *Staphylococcus* and *Enterococcus* often originate from distinct contamination pathways—typically handling-associated and fecal/environmental sources, respectively—rather than from the same microbiological pressures driving total aerobic proliferation (Khaledian *et al*., 2020). The absence of detectable TEC in spring rolls further supports the premise that microbial risks vary considerably depending on processing and ingredient composition. In striking contrast, samosas exhibited a meaningful departure from this trend, with a strong and statistically significant correlation between APC and TSC ($r^2 = 0.581$), suggesting that more than half of the variability in *Staphylococcus* levels was explained by changes in total aerobic counts. This convergence of microbial indicators points toward shared contamination routes or preparation practices that facilitate simultaneous bacterial growth, such as frequent manual handling, repeated filling and folding steps, and exposure to contaminated preparation surfaces. The lack of correlation between APC and TEC even in samosas, however, reinforces that *Enterococcus* remains governed by separate contamination mechanisms (Sultana *et al*., 2015; Mengistu *et al*., 2022).

The findings of the present study have significant implications for public health and food safety. Although the high numbers of APC, TSC, and TEC observed should not be directly linked to disease causation—since these RTC frozen food items are typically heated or cooked before consumption, which may kill or reduce pathogen loads—certain bacterial growth, such as *Staphylococcus* spp., is associated with the production of heat-stable toxins. These toxins can remain active in foods even after heat treatment or cooking, thereby increasing the risk of foodborne intoxications and overall deterioration of food quality (Ain *et al.*, 2022). Additionally, foods with high initial microbial loads, such as the samosa and sausage samples in this study, pose an elevated risk of foodborne illnesses if they are undercooked prior to consumption. Furthermore, since *Staphylococcus* spp. are commonly found on skin and in nasal passages, and *Enterococcus* spp. are typically present in the intestines of humans and animals, the high APC, TSC, and TEC numbers obtained in this study can likely be attributed to improper handling, storage, or inadequate hygiene during the food production process. However, the limited number and variety of samples collected from a few retail points in Mymensingh city restrict the authors from making any generalizations about the overall microbial profile of chicken-based RTC frozen foods sold in the area.

5. Conclusions

The analysis of 50 chicken-based RTC frozen food samples revealed that a significant proportion of products sold in Mymensingh city exceed established microbial safety standards. Chicken samosas and chicken sausages consistently showed the highest levels of contamination, highlighting their potential to pose serious public health risks if consumed without proper cooking. These findings emphasize the need for strict adherence to hygienic practices at all stages of preparation, handling, storage, and distribution. Strengthening food safety education for consumers and improving sanitary compliance among producers and vendors are crucial steps toward reducing microbial hazards associated with RTC poultry products. Future research should involve larger sample sizes, broader geographic coverage, and the inclusion of multiple brands to provide a more comprehensive assessment of product safety in the region. Overall, the results highlight an urgent need for enhanced regulatory oversight and targeted interventions to mitigate the microbial risks associated with RTC chicken products and safeguard consumer health.

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Data availability

The datasets used or analyzed in this study are available from the corresponding author upon reasonable request.

Conflict of interest

None to declare.

Authors' contribution

Al Arafat, Md. Abdullaha-Al-Masud, Md. Ashikur Rahman and Md. Tanvirul Islam: investigation, methodology, writing-original draft; Md. Roisul Momen and Mohammad Arif: data analysis, writing-review & editing; Md. Tanvir Rahman: supervision, writing-review & editing; S. M. Lutful Kabir: conceptualization, supervision, writing-review & editing. All authors have read and approved the final manuscript.

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