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Microbiological safety of ready-to-eat meat products: Food safety, hygienic handling and socio-economic implications in the Cauvery delta region of Tamil Nadu

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Abstract

The present study evaluated the microbiological quality of processed meat products marketed in the Cauvery Delta region of Tamil Nadu. A total of 90 samples comprising Chettinad chicken gravy, fried chicken, grilled chicken, chicken shawarma, mutton chukka, mutton kola, chicken lollipop, chilli chicken and chicken manchurian were analyzed for total viable count (TVC), coliform count, yeast and mould count, *Staphylococcus* spp., *Streptococcus* spp. and *Salmonella* spp. Significant variations were observed among the products, with chicken shawarma showing the highest microbial load and grilled chicken recording the lowest counts for most of the parameters. The detection of *Salmonella* spp. in selected products indicates potential food safety risks. The findings emphasize the need for proper hygienic handling, adequate cooking and appropriate storage practices to maintain the microbiological safety and quality of processed meat products.

Keywords: Processed meat products, microbiological quality, food safety, awareness

Introduction

Processed meat products constitute an important segment of the modern food industry due to their convenience, palatability and consumer acceptance (Schilling *et al.*, 2025) [9]. Products such as Chettinad chicken gravy, fried chicken, grilled chicken, chicken shawarma, mutton chukka, mutton kola, chicken lollipop, chilli chicken and chicken manchurian are widely consumed in urban and semi-urban regions of Tamil Nadu. The increasing demand for ready-to-eat and ready-to-serve meat products has contributed to the rapid expansion of restaurants, street-food outlets and fast-food establishments. Although thermal processing eliminates most microorganisms, processed meat products remain susceptible to microbial contamination during post-cooking handling, storage, transportation and retail display (Karanth *et al.*, 2023) [7]. Contamination may arise from food handlers, processing equipment, environmental exposure, cross-contamination and inadequate temperature control. The presence of pathogenic microorganisms in processed foods poses a public health concern because of their association with food-borne illnesses (Bintsis, 2017) [2]. Microbiological quality assessment is an important tool for evaluating hygienic practices, storage conditions, product safety and shelf life (Tamiru *et al.*, 2024) [10]. Therefore, the present study was undertaken to evaluate the microbiological quality of selected processed meat products

marketed in the Cauvery Delta region of Tamil Nadu (Wang *et al.*, 2020; Elson *et al.*, 2004) [11, 3].

Materials and Methods

Study Area and Sample Collection

The study was conducted in selected restaurants, fast-food outlets and retail food establishments located across the Cauvery Delta region of Tamil Nadu to evaluate the microbiological quality of commonly consumed processed meat products. A total of 90 processed meat product samples were collected under aseptic conditions, comprising Chettinad chicken gravy, fried chicken, grilled chicken, chicken shawarma, mutton chukka, mutton kola, chicken lollipop, chilli chicken and chicken manchurian. Ten samples of each product were obtained from different food establishments to ensure representative sampling. Immediately after collection, the samples were individually packed in sterile polyethylene bags, properly labelled and transported to the laboratory under refrigerated conditions in insulated containers to maintain product integrity and prevent microbial changes during transit. Upon arrival, all samples were subjected to microbiological analysis following standard laboratory procedures.

Microbiological Analysis

Microbiological examination of the processed meat product

samples was carried out using standard procedures recommended by the American Public Health Association (ICMSF, 1996) [4] for the microbiological analysis of foods. The microbial quality of the samples was evaluated by determining total viable count (TVC), coliform count, yeast and mould count, *Staphylococcus* spp. count, *Streptococcus* spp. count and the presence of *Salmonella* spp. Total viable count was determined to assess the overall microbial load and hygienic quality of the products, while coliform count was used as an indicator of sanitary conditions and possible post-processing contamination. Yeast and mould counts were estimated to assess fungal contamination and storage stability. Enumeration of *Staphylococcus* spp. and *Streptococcus* spp. was performed to assess contamination arising from food handlers, processing equipment and environmental sources. Detection of *Salmonella* spp. was carried out to evaluate the microbiological safety of the products and the potential risk of food-borne infections. All microbial counts were expressed as log₁₀ colony-forming units per gram (log₁₀ cfu/g) of sample.

Statistical Analysis

The collected data were subjected to statistical analysis. Mean values and standard errors were calculated for each parameter. Significant differences among the processed meat products were determined at appropriate probability levels.

Results and Discussion

The microbiological quality of processed meat products marketed in Cauvery Delta region of Tamil Nadu is presented in Table 1. The microbial profile of processed meat products serves as an important indicator of hygienic quality, processing conditions, storage practices and potential food safety risks (Al-Mazrouei *et al.*, 2024) [1]. In the present study, significant variations were observed among the processed meat products for total viable count (TVC), coliform count, yeast and mould count, *Staphylococcus* spp. and *Streptococcus* spp. The presence of *Salmonella* spp. in selected products further highlights the importance of maintaining adequate hygiene during preparation, handling and storage (Wang *et al.*, 2020; Al-Mazrouei *et al.*, 2024) [11, 1].

Total viable count is widely used as an indicator of the overall microbiological quality and freshness of food products. The TVC values recorded in the present study ranged from 4.62±0.05 to 5.88±0.09 log₁₀ cfu/g, with an overall mean value of 5.34±0.08 log₁₀ cfu/g. Highly significant differences ($p < 0.01$) were observed among the processed meat products. Among the products analyzed, chicken shawarma recorded the highest TVC (5.88±0.09 log₁₀ cfu/g), followed by chilli chicken (5.72±0.08 log₁₀ cfu/g) and chicken manchurian (5.64±0.09 log₁₀ cfu/g). The elevated microbial load observed in shawarma might be attributed to prolonged holding of cooked meat on vertical rotisseries, repeated slicing during serving and continuous exposure to the environment. Frequent handling by food workers and inadequate temperature maintenance after cooking might also contribute to increased microbial proliferation. In contrast, grilled chicken exhibited the lowest TVC (4.62±0.05 log₁₀ cfu/g), followed by fried chicken (4.86±0.06 log₁₀ cfu/g). The comparatively lower

counts in these products might be due to effective thermal processing and limited post-cooking handling. Similar observations have been reported in ready-to-eat meat products, where direct cooking and immediate consumption reduce microbial contamination (ISO 4833-1:2013) [5].

Coliform bacteria are commonly used as indicators of sanitary quality and post-processing contamination. The overall mean coliform count recorded in the present study was 2.08±0.12 log₁₀ cfu/g. Highly significant differences ($p < 0.01$) were observed among the products. Chicken shawarma showed the highest coliform count (2.68±0.14 log₁₀ cfu/g), followed by chilli chicken (2.54±0.15 log₁₀ cfu/g) and chicken manchurian (2.46±0.14 log₁₀ cfu/g). Higher coliform loads might indicate inadequate hygienic practices, improper handling after cooking, contaminated utensils, poor-quality water and cross-contamination during serving. The findings suggest that products involving multiple handling steps are more susceptible to contamination. Grilled chicken recorded the lowest coliform count (1.26±0.08 log₁₀ cfu/g), indicating better hygienic conditions and effective cooking practices. Lower coliform counts generally reflect improved sanitary measures and reduced opportunities for post-cooking contamination (Wang *et al.*, 2020) [11].

Yeast and mould counts are important indicators of environmental contamination and storage conditions. In the present investigation, yeast and mould counts ranged from 2.32±0.04 to 3.62±0.07 log₁₀ cfu/g, with an overall mean value of 3.08±0.06 log₁₀ cfu/g. Significant differences ($p < 0.05$) were observed among the processed meat products. Chicken shawarma exhibited the highest fungal count (3.62±0.07 log₁₀ cfu/g), followed by chilli chicken (3.46±0.07 log₁₀ cfu/g) and chicken manchurian (3.38±0.06 log₁₀ cfu/g). These products are often displayed at room temperature for extended periods, creating favorable conditions for fungal growth. Environmental exposure and repeated reheating might contribute to fungal contamination. The lowest yeast and mould count was observed in grilled chicken (2.32±0.04 log₁₀ cfu/g), which might be attributed to immediate consumption after cooking and reduced environmental exposure. Elevated fungal loads can negatively affect sensory quality, shelf life and consumer acceptability.

The occurrence of *Staphylococcus* spp. in food products is generally associated with contamination from food handlers, processing equipment and food-contact surfaces. In the present study, *Staphylococcus* spp. counts ranged from 1.64±0.05 to 3.12±0.09 log₁₀ cfu/g, with an overall mean value of 2.50±0.08 log₁₀ cfu/g. Highly significant differences ($p < 0.01$) were observed among the products. Chicken shawarma recorded the highest *Staphylococcus* spp. count (3.12±0.09 log₁₀ cfu/g), followed by chilli chicken (2.94±0.09 log₁₀ cfu/g) and chicken Manchurian (2.86 ± 0.08 log₁₀ cfu/g). The higher counts observed in these products might be due to extensive manual handling during slicing, mixing, garnishing and serving. Poor personal hygiene practices among food handlers might also contribute to contamination. Grilled chicken recorded the lowest count (1.64±0.05 log₁₀ cfu/g), indicating better hygienic handling and minimal post-cooking contamination. Since certain strains of *Staphylococcus aureus* produce heat-stable enterotoxins capable of causing food poisoning, the

presence of these organisms is of public health concern (Wang *et al.*, 2020)^[11].

The counts of *Streptococcus* spp. ranged from 1.88 ± 0.05 to 3.24 ± 0.08 log₁₀ cfu/g, with an overall mean value of 2.66 ± 0.07 log₁₀ cfu/g. Significant variation ($p < 0.05$) was observed among the processed meat products. Chicken shawarma exhibited the highest count (3.24 ± 0.08 log₁₀ cfu/g), followed by chilli chicken (3.02 ± 0.08 log₁₀ cfu/g) and chicken manchurian (2.94 ± 0.07 log₁₀ cfu/g). Higher counts might result from inadequate sanitation of equipment, contamination from food handlers and poor environmental hygiene. The lowest count was observed in grilled chicken (1.88 ± 0.05 log₁₀ cfu/g), suggesting effective cooking and better hygienic conditions during preparation and serving. The findings indicate that stricter sanitation measures are necessary to reduce microbial contamination in ready-to-eat meat products.

The presence of *Salmonella* spp. in processed meat products represents a serious food safety concern because of its association with food-borne gastroenteritis and enteric infections. In the present study, *Salmonella* spp. was detected in Chettinad chicken gravy (10%), chicken shawarma (20%), mutton chukka (10%), chicken lollipop (10%), chilli chicken (20%) and chicken manchurian (10%). However, *Salmonella* spp. was not detected in fried chicken, grilled chicken and mutton kola samples. The occurrence of *Salmonella* in selected products might be due to inadequate cooking, cross-contamination between raw and cooked products, contaminated utensils, poor personal hygiene and improper storage temperatures. The absence of *Salmonella* in grilled chicken and fried chicken demonstrates the effectiveness of thorough thermal processing in controlling pathogenic microorganisms (ISO 6579-1:2017; Wang *et al.*, 2020)^[6, 11].

Table 1: Comparative Microbiological Quality of Processed Meat Products

Parameters	Chettinad Chicken Gravy	Fried Chicken	Grilled Chicken	Chicken Shawarma	Mutton Chukka	Mutton Kola	Chicken Lollipop	Chilli Chicken	Chicken Manchurian
Total Viable Count (log ₁₀ cfu/gm)	5.42 ± 0.08^a	4.86 ± 0.06^{ab}	4.62 ± 0.05^a	5.88 ± 0.09^c	5.24 ± 0.07^{bc}	5.16 ± 0.08^b	5.48 ± 0.07^{cd}	5.72 ± 0.08^{dc}	5.64 ± 0.09^d
Coliform Count (log ₁₀ cfu/gm)	2.14 ± 0.12^c	1.42 ± 0.10^{ab}	1.26 ± 0.08^a	2.68 ± 0.14^c	2.04 ± 0.11^b	1.96 ± 0.09^{bc}	2.22 ± 0.13^{cd}	2.54 ± 0.15^{dc}	2.46 ± 0.14^d
Yeast and Mould Count (log ₁₀ cfu/gm)	3.24 ± 0.06^c	2.48 ± 0.05^a	2.32 ± 0.04^a	3.62 ± 0.07^c	3.06 ± 0.06^{bc}	2.94 ± 0.05^b	3.18 ± 0.06^c	3.46 ± 0.07^d	3.38 ± 0.06^d
Staphylococcus spp. (log ₁₀ cfu/gm)	2.64 ± 0.08^c	1.82 ± 0.06^a	1.64 ± 0.05^a	3.12 ± 0.09^c	2.46 ± 0.07^{bc}	2.32 ± 0.08^b	2.72 ± 0.08^c	2.94 ± 0.09^d	2.86 ± 0.08^d
Streptococcus spp. (log ₁₀ cfu/gm)	2.82 ± 0.07^c	2.04 ± 0.06^a	1.88 ± 0.05^a	3.24 ± 0.08^c	2.64 ± 0.07^{bc}	2.48 ± 0.06^b	2.86 ± 0.07^c	3.02 ± 0.08^d	2.94 ± 0.07^d
Salmonella spp.	Present (10%)	ND	ND	Present (20%)	Present (10%)	ND	Present (10%)	Present (20%)	Present (10%)

Conclusion

The present study demonstrated considerable variation in the microbiological quality of processed meat products marketed in the Cauvery Delta region of Tamil Nadu. Chicken shawarma exhibited comparatively higher microbial counts, whereas grilled chicken showed better microbiological quality. The detection of indicator organisms and food-borne pathogens in certain products indicates lapses in hygienic handling and storage practices. Adoption of Good Manufacturing Practices (GMP), Good Hygienic Practices (GHP), Hazard Analysis and Critical Control Point (HACCP) systems, proper cooking and effective temperature control are essential to improve the microbiological safety of processed meat products and protect consumer health.

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