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QUALITY ASSESSMENT OF MEAT MARKETED THROUGH ORGANIZED AND UNORGANIZED SECTORS IN DELTA DISTRICTS OF TAMIL NADU

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Abstract: The present work was designed to evaluate and compare the physico-chemical and microbiological quality of broiler chicken, chevon and mutton marketed through organized and unorganized retail sectors in the Cauvery Delta districts of Tamil Nadu. A total of 60 meat samples were collected and analyzed for physico-chemical parameters including pH, water holding capacity, extract release volume, thiobarbituric acid value, tyrosine value, moisture, protein, fat and ash content. Microbiological examination viz., total viable count, coliform count, yeast and mould count, *Staphylococcus spp.*, *Streptococcus spp.* and *Salmonella spp.* The results revealed that there was a significant difference (P<0.05) noticed among the meat samples for both organized and unorganized retail sectors in all physico-chemiocal and microbial quality. Organized sector samples exhibited superior physico-chemical quality characterized by lower pH, thiobarbituric acid and tyrosine values along with higher water holding capacity and extract release volume than unorganized sector. Significantly higher microbial loads in meat samples obtained from unorganized retail sectors compared to organized sectors. Especially, *Salmonella spp.* were absent in organized-sector samples but detected in unorganized retail meat samples, indicating poor hygienic handling and storage conditions. It can be concluded that the best quality meat could be obtained from organized retail systems with better microbial safety and quality attributes owing to improved sanitation, refrigeration and hygienic handling practices.

Keywords: Meat quality, Organized sector, Unorganized sector, Microbial quality, Physico-chemical parameters, Salmonella *spp.*

INTRODUCTION

Meat constitutes an important component of the human diet owing to its high-quality protein content and its rich supply of essential amino acids, vitamins and minerals required for maintaining health. In recent years, global meat consumption has increased considerably, driven by rapid urbanization, population growth and changing dietary preferences (*Leroy et al.,* 2023). In Tamil Nadu, chicken, goat meat (chevon) and mutton represent the primary animal protein sources and are widely consumed across diverse socioeconomic groups.

Fresh meat is highly nutritious; however, it is also highly perishable. Its elevated moisture content, nutrient-rich composition, and favourable pH conditions provide an ideal

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environment for microbial growth and proliferation (Karanth *et al.,* 2023). In addition to its intrinsic composition, inadequate hygiene practices during slaughtering, transportation, processing and retail handling can substantially accelerate microbial contamination in both fresh and processed meat products (Ekpunobi *et al.,* 2024). Compared with unorganized markets, organized meat retail outlets generally maintain superior hygiene practices, stricter cold-chain management and standardized sanitation protocols (Siluma *et al.,* 2023). However, the reality is that unorganized markets still control most of the meat trade in India, and their slaughter and handling practices often lack basic hygiene.

Microbial contamination by organisms such as Coliforms, *Staphylococcus spp.*, *Streptococcus spp.*, *Salmonella spp.* and various fungal species not only reduces the shelf life of meat but also poses a significant public health risk through the transmission of food borne diseases (Karanth *et al.,* 2023). In addition to microbiological assessment, physico-chemical parameters such as pH, water-holding capacity, extract release volume, thiobarbituric acid value and tyrosine value serve as reliable indicators for evaluating meat freshness and monitoring progressive spoilage (Bhawana *et al.,* 2023). Evaluation of meat marketed through both organized and unorganized retail sectors is essential for safeguarding consumer health and improving quality standards. Therefore, the present study was undertaken to compare the microbial and physico-chemical characteristics of broiler chicken, chevon and mutton obtained from organized and unorganized markets in Cauvery Delta districts of Tamil Nadu.

MATERIALS AND METHODS

Study area and Sample collection

The present study was conducted across organized and unorganized meat retail sectors located within the Cauvery Delta region of Tamil Nadu, India. A total of 120 meat samples, comprising broiler chicken, chevon and mutton, were collected from both organized and unorganized retail sectors. Ten samples per species were obtained from each respective sector under hygienic conditions. Following collection, the samples were packed in sterile low-density polyethylene (LDPE) bags and transported to the laboratory of the Department of Livestock Products Technology at the Veterinary College and Research Institute, Orathanadu. Transportation was conducted using insulated thermal containers equipped with gel ice packs to maintain cold-chain integrity.

Physico-chemical Analysis

The pH of sample was determined using a digital pH meter (Century Instruments Ltd., India). The water holding capacity (WHC) was determined as described by Wardlaw *et al.* (1973) with slight modification. For determination of extract release volume (ERV), 15 gm of minced sample was blended with 60 ml of distilled water in a homogenizer and homogenate was transferred as quickly as possible in to a funnel, equipped with a What man filter paper no.1. The volume of filtrate collected in first 15 min was recorded as ERV of the respective sample. The procedure of Witte *et al.,* (1970) was followed to estimate thiobarbituric acid value (TBA). Tyrosine value was determined based on the procedure of Strange, *et al.,* (1977). Moisture, protein, fat and total ash contents of meat samples were determined as per AOAC (1995).

Microbial Analysis

Microbial examination of the meat samples was carried out according to the procedures described by APHA (1984) for total viable count (TVC), coliform count, yeast and mould count, *Staphylococcus* spp., *Streptococcus* spp., and *Salmonella* spp. Microbial counts were expressed as $\log_{10}$cfu/gm.

Statistical Analysis

The collected data were subjected to statistical analysis in accordance with the procedures described by Snedecor and Cochran (1994). Mean values and standard errors were calculated for each parameter and comparisons were made between the organized and unorganized retail sectors.

RESULTS AND DISCUSSIONS

The physico-chemical characteristics of meat samples obtained from organized and unorganized retail sectors are presented in Table 1. These parameters serve as important indicators of meat freshness, biochemical stability, shelf life and overall product quality. Significant differences were observed between the two retail systems, reflecting variations in hygienic handling, storage conditions, and cold-chain management practices.

Among the evaluated parameters, meat samples collected from unorganized retail markets consistently exhibited higher pH values across all species. The overall mean pH value recorded was 6.00±0.05, and the difference between organized and unorganized sectors was found to be highly significant ($P<0.01$). Elevated pH in meat is generally associated with increased microbial proliferation and proteolytic activity, which occur during improper storage and delayed chilling conditions (Kuang *et al.,* 2025). In contrast, comparatively lower pH values observed in samples from organized retail outlets indicate better post-slaughter handling, efficient refrigeration, and improved hygienic practices, all of which help maintain meat freshness and delay spoilage (Liu *et al.,* 2022).

Water-holding capacity (WHC) and extract release volume (ERV), both recognized as reliable indicators of muscle protein integrity and freshness, were significantly higher in meat samples obtained from organized retail sectors. The overall mean WHC and ERV values recorded were 60.97±1.20% and 25.55 ±0.76 ml, respectively. Significant differences ($P<0.05$) were observed for WHC, whereas ERV showed highly significant variation ($P<0.01$) between the two retail systems. Higher WHC suggests better retention of intracellular water within muscle fibers, thereby contributing to desirable texture, juiciness, and appearance (Warner *et al.,* 2017). Similarly, elevated ERV values reflect lower microbial deterioration and superior freshness status. Conversely, lower WHC and ERV values recorded in unorganized-market samples indicate protein denaturation and structural degradation of muscle tissues resulting from inadequate refrigeration, temperature abuse and extended exposure to ambient environmental conditions (Uhlig *et al.,* 2024; Jay and Kontou, 1964).

The thiobarbituric acid (TBA) values, which measure the extent of lipid oxidation, were markedly higher in meat samples procured from unorganized retail sectors. The overall mean TBA value recorded was 0.77±0.04 mg MA/kg, and the variation between the sectors was highly significant ($P<0.01$). Increased lipid oxidation is commonly linked to prolonged storage, repeated temperature fluctuations, and poor sanitary conditions, leading to rancidity and deterioration of sensory quality (Abeyrathne *et al.,* 2021; Wang *et al.,* 2021). Similarly, higher tyrosine values observed in unorganized-market samples indicate enhanced proteolytic breakdown of proteins due to microbial activity and spoilage processes (Eshamah *et al.,* 2020). The overall mean tyrosine value recorded was 18.12±0.68 mg/100 gm, and the difference between organized and unorganized sectors was highly significant ($P<0.01$). In contrast, lower TBA and tyrosine values in organized-sector samples suggest better oxidative stability and reduced microbial degradation, likely attributable to effective cold-chain maintenance and improved retail management practices.

Table 1: Species-wise Comparative physico-chemical Parameters of Meat from Organized and Unorganized Sectors in Cauvery Delta Districts of Tamil Nadu

Parameters	**Broiler chicken**		**Chevon**		**Mutton**		**Overall Mean**	**Significance**
	Organized	**Unorganized**	**Organized**	**Unorganized**	**Organized**	**Unorganized**		
pH	5.72 ± 0.03	6.18 ± 0.05	5.78 ± 0.04	6.24 ± 0.06	5.81 ± 0.05	6.29 ± 0.07	6.00 ± 0.05	**
Water Holding Capacity (%)	66.42 ± 1.12	58.36 ± 1.26	64.78 ± 1.08	56.84 ± 1.31	63.52 ± 1.16	55.92 ± 1.28	60.97 ± 1.20	*
Extract Release Volume (ml)	32.14 ± 0.84	21.26 ± 0.76	30.86 ± 0.72	20.18 ± 0.68	29.94 ± 0.81	18.92 ± 0.73	25.55 ± 0.76	**
Thiobarbituric Acid Value (mg MA/kg)	0.42 ± 0.02	0.96 ± 0.04	0.48 ± 0.03	1.08 ± 0.05	0.52 ± 0.03	1.16 ± 0.06	0.77 ± 0.04	**
Tyrosine Value (mg/100 g)	12.64 ± 0.54	21.42 ± 0.68	13.28 ± 0.61	22.86 ± 0.74	14.16 ± 0.66	24.38 ± 0.82	18.12 ± 0.68	**
Moisture (%)	73.84 ± 0.48	71.62 ± 0.56	72.46 ± 0.52	70.84 ± 0.63	71.92 ± 0.58	69.76 ± 0.71	71.74 ± 0.58	NS
Protein (%)	20.86 ± 0.34	18.92 ± 0.28	21.14 ± 0.37	19.06 ± 0.31	20.72 ± 0.35	18.64 ± 0.29	19.89 ± 0.32	*
Fat (%)	5.42 ± 0.21	7.16 ± 0.26	4.86 ± 0.18	6.92 ± 0.24	5.18 ± 0.20	7.34 ± 0.27	6.15 ± 0.23	*
Ash (%)	1.12 ± 0.04	1.28 ± 0.05	1.08 ± 0.03	1.32 ± 0.04	1.16 ± 0.04	1.38 ± 0.05	1.22 ± 0.04	NS

Values are expressed as Mean ± Standard Error (SE); Overall mean was calculated across all species and retail sectors; **NS** – Non-significant ; P>0.05) ; ***** – Significant (P<0.05) ; ****** – Highly significant (P<0.01)

Proximate composition analysis further revealed that meat samples from organized retail outlets contained comparatively higher moisture and protein contents, indicating better preservation of nutritional quality and reduced dehydration during storage (Barido and Lee, 2021). The overall mean moisture and protein contents recorded were 71.74±0.58 and 19.89±0.32 %, respectively. Moisture content did not differ significantly between the two retail systems (P>0.05), whereas protein content showed significant variation (P<0.05). On the other hand, samples from unorganized markets exhibited relatively higher fat percentages, with an overall mean fat content of 6.15±0.23% and the variation was found to be significant (P<0.05). This increase in fat percentage may be associated with moisture loss during prolonged exposure and improper storage conditions. Ash content showed only minimal variation between the two sectors, with an overall mean value of 1.22±0.04 % and non-significant differences (P>0.05), suggesting that mineral composition remained relatively unaffected by retail handling practices.

Overall findings clearly demonstrate that meat marketed through organized retail systems possess superior physic-chemical quality, improved freshness and greater storage stability compared to meat sold through unorganized retail channels. These differences may primarily be attributed to better hygienic practices, controlled storage temperatures, efficient cold-chain infrastructure and standardized meat handling procedures adopted in organized retail sectors.

Microbial Quality of Meat Samples

The microbiological quality of broiler chicken, chevon and mutton samples collected from organized and unorganized retail sectors in Cauvery delta region of Tamil Nadu is presented in Table 2. The microbial profile of meat serves as a critical indicator of hygienic quality, storage conditions, processing practices and potential food safety risks. In the present study, meat samples obtained from unorganized retail sector consistently exhibited significantly (P<0.05) higher microbial loads compared to those collected from organized retail sector, which indicates camparitively poorer sanitary and handling conditions in the unorganized sector.

Total viable count (TVC), which reflects the overall microbial burden and freshness status of meat, was markedly higher in samples collected from unorganized markets. The overall mean TVC recorded in the present study was 5.02±0.06 $\log_{10}$cfu/gm and significant variation (P<0.05) was observed between organized and unorganized sectors. Elevated TVC values may be attributed to unhygienic slaughtering conditions, contaminated cutting equipment, repeated manual handling, environmental exposure, and inadequate refrigeration facilities.

Open display of meat under ambient temperatures further promotes microbial proliferation and accelerates spoilage. In contrast, organized retail sectors maintained comparatively lower TVC values due to improved slaughter hygiene, sanitized processing environments, effective refrigeration, and better handling practices during storage and retail display (Patil *et al.,* 2019; Pradhan *et al.,* 2018). Although the microbial counts observed in the present study remained within permissible microbiological limits for fresh meat, the relatively higher counts in unorganized sectors suggest greater initial contamination and reduced shelf life of meat products (Karthick *et al.,* 2022).

Coliform counts were also significantly higher in meat samples obtained from unorganized retail outlets. The overall mean coliform count observed was 1.88±0.14 log_{10}cfu/gm, and the variation between organized and unorganized sectors was found to be highly significant (P<0.01). The presence of coliform organisms is commonly regarded as an indicator of faecal contamination and poor sanitary conditions during slaughtering, dressing and processing operations. Increased coliform loads in unorganized sectors may result from contaminated water sources, improper cleaning of equipment, and inadequate personal hygiene among handlers. Conversely, lower coliform counts in organized retail sectors indicate better adherence to sanitation protocols and hygienic meat processing practices.

Table 2: Species-wise Comparative Microbial Quality of Meat from Organized and Unorganized Sectors in Cauvery Delta Districts of Tamil Nadu

Parameters	Broiler chicken		Chevon		Mutton		Over all Mean	Significance
	Organized	Unorganized	Organized	Unorganized	Organized	Unorganized		
Total Viable Count (log_{10} cfu/g)	4.58 ± 0.05	5.04 ± 0.07	4.72 ± 0.06	5.36 ± 0.08	4.88 ± 0.04	5.52 ± 0.06	5.02 ± 0.06	NS
Coliform Count (log_{10} cfu/gm)	0.96 ± 0.14	2.18 ± 0.16	1.24 ± 0.13	2.63 ± 0.15	1.42 ± 0.11	2.84 ± 0.17	1.88 ± 0.14	NS
Yeast and Mould Count (log_{10} cfu/gm)	2.54 ± 0.06	3.06 ± 0.05	2.82 ± 0.08	3.48 ± 0.06	2.94 ± 0.07	3.68 ± 0.05	3.09 ± 0.06	*
Staphylococcus spp. (log_{10} cfu/g)	1.42 ± 0.18	2.64 ± 0.04	1.82 ± 0.16	3.02 ± 0.05	1.96 ± 0.17	3.18 ± 0.06	2.34 ± 0.11	**
Streptococcus spp. (log_{10} cfu/gm)	1.84 ± 0.07	2.72 ± 0.05	2.12 ± 0.08	3.08 ± 0.06	2.24 ± 0.09	3.26 ± 0.07	2.50 ± 0.07	*
Salmonella spp.	ND	Present (40%)	ND	Present (30%)	ND	Present (40%)	ND	NS

Values are expressed as Mean ± Standard Error (SE); Overall mean was calculated across all species and retail sectors; **NS** – Non-significant ; P>0.05) ; ***** – Significant (P<0.05) ; ****** – Highly significant (P<0.01)

Yeast and mould counts were comparatively elevated in unorganized-market samples, with an overall mean value of 3.09±0.06 log_{10}cfu/gm. Significant variation (P<0.05) was observed between the two retail sectors. The higher fungal load may be attributed to prolonged exposure of meat to open-air environments, poor ventilation, high ambient temperatures, and absence of protective packaging. Such conditions favor fungal growth, resulting in rapid deterioration of meat quality, reduced shelf life and undesirable sensory changes (Alves Rodrigues *et al.,* 2026). Organized retail systems effectively minimized fungal contamination through refrigerated storage, hygienic display conditions, and protective packaging methods that limit environmental exposure.

Similarly, higher counts of *Staphylococcus spp.* and *Streptococcus spp.* were observed in meat samples collected from unorganized retail outlets. The overall mean *Staphylococcus spp.* and *Streptococcus spp.* counts recorded were 2.34±0.11 and 2.54±0.07 log_{10}cfu/gm, respectively. The difference in *Staphylococcus spp.* counts between organized and unorganized sectors was highly significant (P<0.01), whereas *Streptococcus spp.* counts showed significant variation (P<0.05). The occurrence of these microorganisms is generally associated with poor personal hygiene of meat handlers, contaminated utensils, unclean working surfaces, and excessive manual contact during processing and retailing. Certain strains of *Staphylococcus aureus* are known to produce heat-stable enterotoxins that can pose serious food safety hazards to consumers (Genigeorgis, 1989; Kadariya *et al.,* 2014). Therefore, the elevated counts recorded in unorganized sectors highlight the urgent need for improved sanitation measures, hygienic slaughter practices and regular monitoring of meat handling procedures.

Salmonella spp. was detected only in samples obtained from unorganized retail sectors, whereas organized-sector samples tested negative for *Salmonella spp.* contamination. The prevalence of *Salmonella spp.* recorded in broiler, chevon, and mutton samples from unorganized sectors were 40, 30 and 40%, respectively, with an overall prevalence of 18.33%. The presence of *Salmonella spp.* indicates persistent food safety concerns associated with cross-contamination, inadequate sanitation and improper storage conditions during slaughtering and retail handling (Soltan *et al.,* 2014). The absence of *Salmonella spp.* in organized retail sectors may be attributed to better processing infrastructure, strict hygienic controls, effective cleaning and disinfection procedures and maintenance of cold-chain systems that limit bacterial survival and growth.

Overall, the microbiological findings clearly demonstrate that organized retail systems provide meat with superior microbial quality compared to unorganized retail sectors. Controlled processing environments, improved sanitation, proper refrigeration, hygienic handling practices and effective cold-chain management in organized sectors contribute substantially to minimizing microbial contamination and enhancing meat safety and shelf life. In contrast, the significantly higher microbial loads observed in unorganized markets emphasize the need for improved infrastructure, strict implementation of hygienic practices and regular microbial surveillance to ensure consumer safety and quality assurance in meat retailing systems.

CONCLUSION

The present study demonstrates that organized retail channels provide meat with superior physico-chemical characteristics and lower microbial loads. However, the detection of *Salmonella* spp. in unorganized sector indicates a persistent food safety risk. The consistently higher bacterial counts observed in the unorganized sector highlight substantial hygienic deficiencies during slaughtering, handling, and retailing practices. Addressing these shortcomings requires comprehensive infrastructural and regulatory improvements, including slaughterhouse modernization, implementation of HACCP systems, mandatory hygiene training for workers, and effective cold-chain management.

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