RISK INDEX OF TOXOPLASMA GONDII CONTAMINATION IN MEAT SOLD TRADITIONALLY IN PEKANBARU CITY AND SURROUNDING AREAS

(Indeks Risiko Kontaminasi Toxoplasma gondii pada Daging yang Dijual secara Tradisional di Kota Pekanbaru dan Sekitarnya)

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ABSTRACT

The hygiene and sanitation conditions of traditional markets selling meat are often less than optimal, so they tend to be at risk of transmitting zoonotic pathogens, including *Toxoplasma gondii*. The aim of this study was to measure the risk index of *T. gondii* contamination in chicken, beef and goat meat sold in traditional markets in Pekanbaru City. A cross-sectional survey design was employed, involving 278 chicken meat stalls, 104 beef stalls, and 105 goat meat stalls which were selected through purposive sampling. The survey evaluated five key components: facility sanitation, vendor hygiene, meat handling and storage, environmental conditions and pest presence, and equipment cleanliness. Each observation component was scored on a three-point scale: low (0), moderate (1), and high (2). Data were analyzed descriptively to determine percentage distributions, which were subsequently converted into qualitative risk indices. The results showed that the risk index of *T. gondii* contamination was 45.85% for chicken, 47.24% for beef, and 60.12% for goat meat. These values indicate a moderate level of contamination risk for all three meat types. The findings emphasize the importance of improving hygiene and sanitation standards in traditional markets to minimize the potential risk of *T. gondii* transmission to consumers.

Keywords : Toxoplasma gondii, meat contamination, risk index, hygiene, traditional markets.

INTRODUCTION

Toxoplasma gondii is an obligate intracellular protozoan parasite and the causative agent of toxoplasmosis, which is widely distributed worldwide. This parasite is estimated to infect approximately one-third of the human population, with seroprevalence rates varying geographically (Hamie et al., 2021; Sleda et al., 2024). *T. gondii* transmission is influenced by several factors, such as its ability to survive in various environmental conditions and its resistance to extreme conditions and its ability to infect a wide variety of hosts (Costa et al., 2025; Paredes-Núñez et al., 2025). *T. gondii* infection is a public health hazard that has the potential to cause serious complications, especially for immunosuppressed individuals or pregnant women (Ferreira et al., 2019; Symeonidou et al., 2023). Contamination of meat products, such as beef, lamb, and chicken, poses a significant risk for *T. gondii* transmission to humans, primarily through the consumption of tissue cysts found in raw or undercooked meat from infected animals (Hussain et al., 2017). This condition makes meat one of the food commodities with a high risk of transmission of this parasite.

Food safety and meat hygiene in traditional markets are important public health issues that affect the safety of meat consumption. Traditional markets are often potential sources of food contamination, where meat can be exposed to pathogens such as *Toxoplasma gondii*, *Salmonella*, and *Campylobacter*. Research shows that poor hygiene practices in meat handling and storage can increase the risk of infection (Nanfuka et al., 2025; Ollong et al., 2020). Therefore, assessing the risk of meat contamination by *T. gondii* is very important to carry out, especially in traditional markets which are the main source of meat supply for the community.

Traditional markets in Pekanbaru City serve as fresh meat distribution centers, providing a variety of meats to the community. In this context, traditional markets play a crucial role in meeting local consumers' animal protein needs and providing employment for vendors. Maintaining hygiene

and food safety in traditional markets is essential to improving the quality of meat sold and public health. Research shows that poor hygiene practices in markets often contribute to low product quality and the risk of disease (Latifah et al., 2025; Leal et al., 2025). To date, information on the risk level of *T. gondii* contamination in meat sold in traditional markets in Pekanbaru City and its surrounding areas is still limited, making this research highly urgent.

This study aims to measure the risk index of *T. gondii* contamination in meat sold traditionally in Pekanbaru City and its surrounding areas. The results are expected to provide a basis for the government, animal health authorities, and businesses to improve monitoring and risk mitigation efforts to ensure the safety of animal-derived food and protect public health.

MATERIALS AND METHODS

Tools and Materials

This study used a standardized observation sheet or checklist referring to the Risk-Based Food Hygiene and Sanitation Supervision Guidelines (Wati et al., 2021), designed to assess the hygiene and sanitation conditions of meat stalls in traditional markets. The observation sheet included assessment indicators for five main components: facility sanitation, vendor hygiene, meat handling and storage, environmental conditions and pest presence, and equipment cleanliness. Clipboards, stationery, cell phones, and data collection forms were used for the recording process. In addition, researchers brought personal protective equipment (PPE) such as masks, gloves, and hand sanitizer to ensure safety and prevent cross-contamination during the observation process.

Location and Time

The study was conducted in traditional markets selling chicken, beef, and goat meat in Pekanbaru City and its surrounding areas, including several traditional markets, flea markets, and small-scale chicken slaughterhouses. Observations and assessments were conducted between August and October 2025.

Research Method

This study used a survey method with a cross-sectional design (Sumiarto & Budiharta, 2021). The survey procedure was conducted through direct observation at each sample stall. A team of enumerators visited the stalls during sales activities to assess each indicator based on actual conditions on the ground. Observations were supplemented with photographic documentation and coordinate points to strengthen data validation. Information on the stall's identity, the type of meat sold, and specific environmental conditions were also recorded for analysis purposes. All observation data was double-checked before being entered into the electronic spreadsheet to ensure accuracy and consistency of recording. The research population was all stalls selling chicken, beef, and goat meat, while the sample selection was done purposively, involving 487 stalls consisting of 278 stalls selling chicken meat, 104 stalls selling beef meat, and 105 stalls selling goat meat.

Several variables observed included 1) facility sanitation, 2) vendor hygiene, 3) meat handling and storage, 4) environmental conditions and pest presence, and 5) equipment cleanliness. Each component was assessed using clearly defined operational indicators to ensure consistency between observers. Each indicator was scored on a three-point scale: 0 (poor condition), 1 (fair condition), and 2 (good condition). The calculation of the *T. gondii* contamination risk index is carried out by calculating the total score of each stall based on the sum of all component scores with a maximum value of 10. The total score is then converted into a percentage using the formula, the index values are then categorized into three risk levels, namely low (0–33%), medium (34–66%), and high (67–100%).

$$\text{Risk Index (\%)} = \left(\frac{\text{Score per Stall}}{\text{Maximum Score}} \right) x \; 100$$
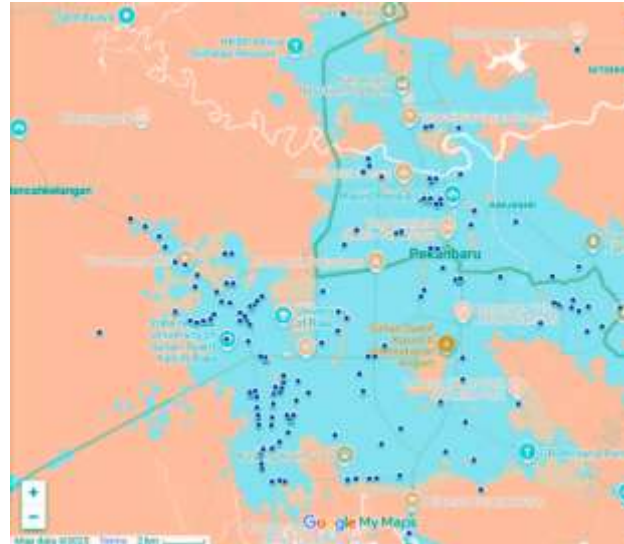
Data Analysis

Location point data is displayed using an interactive map, and the distribution of location points is presented using a scatter diagram, then discussed descriptively. The risk index is analyzed descriptively in percentage units, which are then converted into a qualitative risk index.

RESULTS AND DISCUSSION

Location Points

Figure 1 shows the spatial distribution of sampling locations for the study conducted in Pekanbaru City and its surrounding areas. Blue dots indicate meat vendors' stalls, which served as the observation units in this study. These locations encompass various types of meat vendors, such as traditional markets, flea markets, and several poultry slaughterhouses scattered throughout the city.

Gambar 1. Sebaran titik lokasi survei

Figure 1. Spatial distribution of sampling points of the study describing the observation coverage throughout the region and areas that cross the administrative boundaries of Pekanbaru City

The distribution of sample points appears to be evenly distributed across the urban core, including areas with high commercial activity, such as Marpoyan Damai, Tampan, Payung Sekaki, and Pekanbaru City. The relatively dense concentration of points in the western and southern parts of the city indicates the high number of meat vendors in these areas, which are known as centers of traditional trade and culinary delights. The distribution of points is also seen surrounding large residential areas and near main routes that serve as centers of economic activity.

In general, the distribution pattern of the points indicates that the sampling locations were not concentrated in a single area, but rather widely and evenly distributed across various parts of Pekanbaru City. This is in line with the city's characteristics, which have numerous activity centers such as traditional markets, flea markets, and poultry slaughterhouses spread across various sub-districts. The observation points were spread over a coordinate range of approximately 101.3°–101.6° in longitude and 0.3°–0.7° in latitude (Figure 2). This distribution reflects the core and surrounding areas of Pekanbaru, encompassing densely populated areas, commercial corridors, and suburban housing that also has meat sales activities. This even distribution indicates that the study encompassed a wide range of meat sales locations, from the city center to the suburbs.

Although the points are widely distributed, several density clusters are visible, with the area around the 101.4° longitude line appearing to have the highest concentration. This indicates the presence of a center of meat trading activity, likely a large traditional market and dense commercial area. Several points on the edges of the plot indicate sample locations located in flash markets or meat vendors operating in residential areas outside the city. This wide distribution of coordinates has several important implications, including 1) the study covers meat sales locations with varying environmental sanitation and hygiene conditions, 2) different locations can represent variations in market infrastructure,

human density, and potential environmental contamination, and 3) the study has the opportunity to assess differences in the risk of *Toxoplasma gondii* contamination between geographic areas and market types. In summary, the scatter plot shows a broad and even distribution of study locations, encompassing several density clusters, reflecting variations in sanitation conditions and potential contamination risks, and providing a strong basis for spatial analysis.
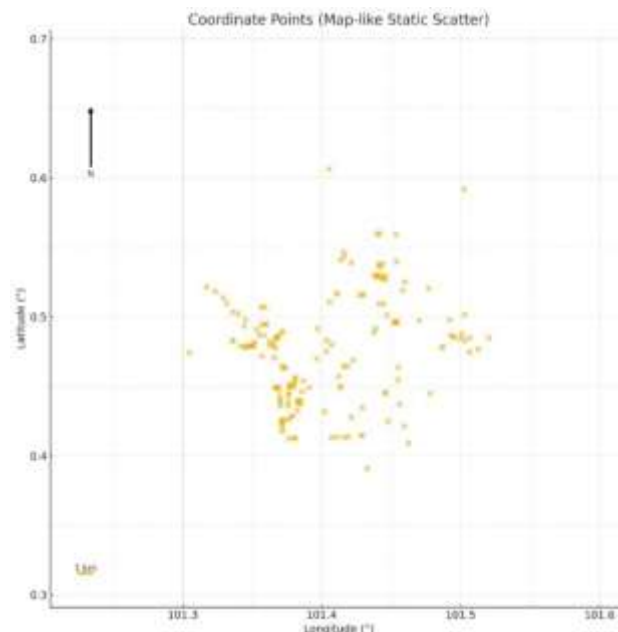

Figure 2. Scatter plot coordinates of meat sales sampling locations in Pekanbaru and surrounding areas

Risk Index

The results of calculating the risk index score for *T. gondii* contamination in chicken, beef and goat meat sold traditionally in Pekanbaru City and its surroundings are shown in Table 1.

Tabel 1. Risk index score of *T. gondii* contamination in various types of meat sold traditionally in Pekanbaru City and its surroundings

No	Variable Components	Risk Index Score of Meat		
		Chicken (n=278)	Beef (n=104)	Lamb (n=105)
1	Sanitation of facilities	49.53	54.42	65.52
2	Seller hygiene	44.06	47.31	59.14
3	Handling and storage	49.46	46.63	60.86
4	Environment and pests	41.49	38.78	54.44
5	Tool cleanliness	44.72	49.04	60.63
	Average	45.85	47.24	60.12
	Risk index category*	Moderate	Moderate	Moderate

*score 0-33 (low), score 34-66 (moderate), score 67-100 (high)

Of the five parameters, the facility sanitation component received the highest contamination risk score for all three types of meat, although the risk index was still classified as moderate. Meanwhile, the environment and pests component had the lowest contamination risk score for all three types of meat, falling within the moderate risk index.

Goat meat has the highest index score compared to chicken and beef. Several field studies in Indonesia have reported a relatively high prevalence of *T. gondii* in small ruminants (goats/sheep), so goat meat biologically has the potential to carry a greater tissue cyst burden than beef under similar conditions. Furthermore, goat carcass handling practices in many traditional markets often involve longer exposure (whole carcasses, on-site slaughter, direct contact with the floor/environment), which increases the risk of cross-contamination from the environment and reservoir animals. Several previous

studies using molecular detection such as PCR have reported the discovery of positive *T. gondii* samples in chicken, goat, and ruminant products (Adrianto et al., 2024).

The facility sanitation component obtained the highest relative scores for all three types of meat (49.53 for chicken; 54.42 for beef; 65.52 for lamb), especially for goat meat. These results indicate that the physical aspects of market facilities (floors, drainage, clean water) are one of the main weaknesses. Research (Marin Garcia et al., 2022) states that environmental hygiene control for meat production and processing is a key factor in reducing *T. gondii* contamination in meat products. The role of market infrastructure and processing/sales facilities in the risk of foodborne pathogens, including *T. gondii*, is well understood; improving physical sanitation can directly reduce the opportunity for cross-contamination and vector exposure (e.g., cats) to fresh food. Therefore, improving the physical condition of markets, sales facilities, and improving market infrastructure are priority interventions in reducing zoonotic risks (Rossi et al., 2024).

Vendor hygiene at meat stalls in traditional markets in Pekanbaru City and its surrounding areas appears low to moderate (44.06-59.14), indicating inadequate personal hygiene and handling practices and potentially increasing meat contamination (Girma et al. 2024). The most significant contributing factors are limited handwashing facilities, inconsistent use of personal protective equipment, and irregular equipment cleaning (Sparaciari et al., 2025). Therefore, providing adequate handwashing facilities, ongoing hygiene training for vendors, and strengthening market sanitation supervision are crucial. These measures have been shown to be effective in reducing microbiological contamination of meat (GAIN, 2025).

Meat handling and storage parameters showed relatively high scores for goat (60.86) compared to beef (46.63) and chicken (49.46). This suggests that goat meat is handled or stored less optimally than the other two types of meat. This factor is crucial because poor handling and storage, such as exposure to heat and exposed meat, can increase the number of cysts or *T. gondii* contamination (Garcia et al., 2022).

In terms of environmental cleanliness and pest presence, the scores were the lowest among the five parameters for the three types of meat (41.49 for chicken; 38.78 for beef; and 54.44 for goat). Although numerically, this appears better than the other parameters (lower scores mean lower risk), it is still in the moderate risk category. These results indicate that pest management (including cats and rats) and environmental conditions in traditional markets are far from ideal. This is in line with reports that traditional markets in middle- to low-income countries often exhibit inadequate sanitation practices, leading to the risk of zoonoses, including *T. gondii* (Leahy et al., 2022).

The equipment hygiene component in this study showed a moderate risk score for all types of meat, namely 44.72 for chicken, 49.04 for beef, and 60.63 for goat. This score reflects that equipment cleaning practices such as knives, cutting boards, cutting tables, and meat containers are still suboptimal in traditional markets in Pekanbaru City and its surroundings. Equipment cleanliness is a crucial factor in preventing *T. gondii* contamination, given that this parasite can be transmitted through indirect contact between meat tissue and contaminated surfaces or equipment (Opsteegh et al., 2024). When equipment is used repeatedly on meat from different animals without thorough cleaning, the risk of cross-contamination increases significantly.

Furthermore, several studies have reported that porous, worn, or long-term use of equipment can trap dirt and micro-meat tissue that can potentially carry *T. gondii* cysts or other pathogenic organisms (Lai et al., 2024). Therefore, equipment cleanliness is influenced not only by the frequency of washing, but also by the quality of the equipment material, traders' access to clean water, and the availability of adequate sanitation facilities in the market area. The quality of equipment material, traders' access to clean water, and the availability of adequate sanitation facilities in the market area (Alves et al., 2024).

CONCLUSION

The risk index for *T. gondii* contamination in meat sold in traditional markets in Pekanbaru City and its surrounding areas is classified as moderate. These findings indicate that hygiene and sanitation practices at stalls, including market facilities, equipment cleanliness, handling/storage, and vendor hygiene, still need improvement. Therefore, integrated mitigation measures are recommended, including increasing access to clean water and washing facilities, hygiene training for vendors, implementing proper equipment cleaning and storage protocols, pest control, and targeted

microbiological surveillance (especially for goat commodities) to validate and reduce the risk of transmission to consumers.

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REFERENCES

Adrianto, H., Silitonga, H. T. H., Suwanti, L. T., Bravimasta, B. D., Firmanto, I. A., & Nidom, R. V. (2024). Investigation of *Toxoplasma gondii* in raw meat from Surabaya, Indonesia based on molecular detection: a cross-sectional study*. Afr. J. Biomed. Res.*, 27(4s), 10027-10032. https://doi.org/10.53555/AJBR.v27i4S.4993

Alves, V. F., Pires, A. C. M., Pereira, M. G., Bersot, L. S., & De Martinis, E. C. P. (2024). Hidden places for foodborne bacterial pathogens and novel approaches to control biofilms in the meat industry. *Foods, 13*(24), 3994. https://doi.org/10.3390/foods13243994

Costa, G. T., de Souza, I. S. R., de Oliveira, D. W., de Jesus Souza, O. M., Afonso, C. M. C., de Carvalho, G. O. A. M., Seabra, S. H., & de Azevedo Fortes, F. S., (2025). *Toxoplasma gondii*: cellular aspects of parasite. *Research Society and Development*, 14(1), e7714148052. https://doi.org/10.33448/rsd-v14i1.48052

GAIN (Global Alliance for Improved Nutrition). (2025). *Guidelines for food hygiene in traditional markets* (Discussion Paper). GAIN.

Hamie, M., Najm, R., Deleuze-Masquefa, C., Bonnet, P. A., Dubremetz, J. F., El Sabban, M., & El Hajj, H. (2021). Imiquimod Targets Toxoplasmosis Through Modulating Host Toll-Like Receptor-MyD88 Signaling. *Frontiers in immunology*, 12, 629917. https://doi.org/10.3389/fimmu.2021.629917

Hussain, M. A., Stitt, V., Szabo, E. A., & Nelan, B. (2017). Toxoplasma gondii in the Food Supply. *Pathogens (Basel, Switzerland)*, *6*(2), 21. https://doi.org/10.3390/pathogens6020021

Lai, H., Tang, Y., Ren, F., Jiao, X. A., & Huang, J. (2023). Evaluation of Hygiene Practice for Reducing *Campylobacter* Contamination on Cutting Boards and Risks Associated with Chicken Handling in Kitchen Environment. *Foods (Basel, Switzerland)*, *12*(17), 3245. https://doi.org/10.3390/foods12173245

Latifah, K. T., Rafli, M., & Prihanani, N. I. (2025). Contamination of Coliform bacteria in chicken and fish meat in traditional market. *Buletin Veteriner Udayana*, 17(1), 131–141. https://doi.org/10.24843/bulvet.2025.v17.i01.p14

Leahy, E., Mutua, F., Grace, D., Lambertini, E., & Thomas, L. F., (2022). Foodborne zoonoses control in low- and middle-income countries: Identifying aspects of interventions relevant to traditional markets which act as hurdles when mitigating disease transmission. *Front. Sustain. Food Syst.* 6, 913560. https://doi.org/10.3389/fsufs.2022.913560

Leal, S., Pieper, A., Oliveira, M., Cardozo, R., & Carvalhai, J. F. (2025). Condições Higiênico-Sanitárias No Comércio De Carnes E Derivados Em Feiras Livres Em Colatina, Espírito Santo. *Pubvet*, *19*(03), e1738. https://doi.org/10.31533/pubvet.v19n03e1738

Marín-García, P. J., Planas, N., & Llobat, L. (2022). *Toxoplasma gondii in foods: Prevalence, control, and safety*. Foods, 11(16), 2542. https://doi.org/10.3390/foods11162542

Nanfuka, A., Mewa, E. A., & Rachuonyo, H. A. (2025). Hygiene and Safety Measures Practised by Roadside Meat Vendors of Namawojjolo and Lukaya Food Markets, Uganda. *East African Journal of Health and Science*, 8(2), 71–82. https://doi.org/10.37284/eajhs.8.2.3266

Ollong, A. R., Palulungan, J. A., & Arizona, R. (2020). Analisis Jumlah Coliform Dan Faecal Coli (MPN) Pada Daging Sapi Dan Ayam Di Kota Manokwari. *Jurnal Ilmu Peternakan Dan Veteriner Tropis (Journal of Tropical Animal and Veterinary Science)*, *10*(2), 113. https://doi.org/10.46549/jipvet.v10i2.124

Opsteegh, M., Cuperus, T., van Buuren, C., Dam-Deisz, C., van Solt-Smits, C., Verhaegen, B., Joeres, M., Schares, G., Koudela, B., Egberts, F., Verkleij, T., van der Giessen, J., & Wisselink, H. J. (2024). In vitro assay to determine inactivation of Toxoplasma gondii in meat samples. *International journal of food microbiology*, 416, 110643. https://doi.org/10.1016/j.ijfoodmicro.2024.110643

Paredes-Núñez, D., Barragán-Peña, A. E., Rodríguez-Pazmiño, Á. S., Vélez, A., Cruz, M., Salas-Rueda, M. X., Narváez, A., Orlando, S. A., & García-Bereguiain, M. Á. (2025). High Prevalence

of Toxoplasma Gondii Infection in Free-Roaming Dogs From Ecuador: A Proxy for Sentinel Surveillance of Zoonotic Threats in Low- And Middle-Income Countries. *Frontiers in Veterinary Science*, *12*. https://doi.org/10.3389/fvets.2025.1672769

Pinto-Ferreira, F., Caldart, E. T., Pasquali, A. K. S., Mitsuka-Breganó, R., Freire, R. L., & Navarro, I. T. (2019). Patterns of Transmission and Sources of Infection in Outbreaks of Human Toxoplasmosis. *Emerging infectious diseases*, *25*(12), 2177–2182. https://doi.org/10.3201/eid2512.181565

Sleda, M. A., Pitafi, Z. F., Song, W., Oldfield, E., & Moreno, S. N. J. (2024). Lipophilic bisphosphonates reduced cyst burden and ameliorated hyperactivity of mice chronically infected with *Toxoplasma gondii*. *mBio*, *15*(11), e0175624. https://doi.org/10.1128/mbio.01756-24

Sparaciari, F. E., Firth, C., Karlsson, E. A., & Horwood, P. F. (2025). Zoonotic disease risk at traditional food markets. *Journal of virology*, *99*(8), e0071825. https://doi.org/10.1128/jvi.00718-25

Symeonidou, I., Sioutas, G., Lazou, T., Gelasakis, A. I., & Papadopoulos, E. (2023). A Review of *Toxoplasma gondii* in Animals in Greece: A FoodBorne Pathogen of Public Health Importance. *Animals : an open access journal from MDPI*, *13*(15), 2530. https://doi.org/10.3390/ani13152530

Sumiarto, B., & Budiharta, S., (2021). Epidemiologi veteriner. Yogyakarta: Gadjah Mada University Press

Wati, D., Wandadaya, W. M., Kurniawati, N., Yunihasto, E. B., Edithya, E., Fredik, W. I., & Nisa, M. (2021). Pedoman pengawasan inspeksi higiene sanitasi pangan berbasis risiko. Jakarta: Kementerian Kesehatan Republik Indonesia