

Artificial Digestion Surveillance for *Trichinella* in Slaughtered Pigs and Farm Management Practices: A One Health Investigation of Zoonotic Risk in Kumasi, Ghana

Richard Kusi Boateng¹, Kwame Antwi Darkwa¹, Prince Oduro Kwarteng¹ & Bright Arthur²

¹School of Veterinary Medicine, College of Health Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

²School of Medical Sciences, College of Health Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Corresponding Author: Richard Kusi Boateng

School of Veterinary Medicine,
 College of Health Sciences, Kwame
 Nkrumah University of Science and
 Technology, Kumasi, Ghana

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Abstract:

Background. *Trichinella* infection is a foodborne zoonosis acquired mainly through undercooked pork. Direct evidence of infective larvae in pigs is scarce in Ghana, where earlier work relied largely on serology.

Methods. In a cross-sectional study (April–September 2025), muscle from the tongue, diaphragm and masseter of 100 pigs slaughtered at three facilities in the Kumasi metropolis was pooled (10 g per pig) and examined for larvae by pepsin–HCl artificial digestion followed by stereomicroscopy. Management practices on 25 farms in five source communities were assessed with a semi-structured questionnaire and a direct-observation checklist.

Results. *Trichinella* larvae were not detected in any of the 100 pigs (0/100; exact 95% CI 0–3.6%). The pigs were 62 females and 38 males of five breeds. Of the 25 farms, 23 (92%) used intensive and two (8%) semi-intensive systems; none was free-range. Environmental hygiene was rated best or better on 15 farms, good on nine and poor on one, and 23 farms (92%) reported regular deworming.

Conclusions. No larvae were detected in pigs from predominantly confined, peri-urban production in Kumasi. With 100 pigs, the study can exclude only a prevalence above about 3.6%, and individual pigs were not traced to farms, so the husbandry findings are descriptive and do not explain the negative result. Targeted, larger surveillance of free-range pigs, where serological exposure has been reported, is the priority for Ghana.

Keywords: *Trichinella*; trichinellosis; zoonosis; One Health; artificial digestion; pigs; slaughterhouse surveillance; Ghana.

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Introduction

Trichinellosis is a foodborne zoonosis caused by nematodes of the genus *Trichinella*. People become infected by eating raw or inadequately cooked meat that contains infective larvae, most often from domestic pigs, wild boar and other game (Dupouy-Camet, 2000; Gottstein et al., 2009). Infection in pigs is usually subclinical, so infected animals cannot be recognised without laboratory testing, and testing at slaughter is the main safeguard for consumers (WOAH, 2023). In humans the disease ranges from enteric symptoms to fever, muscle pain and periorbital oedema, and severe cases may involve myocarditis or encephalitis (Gottstein et al., 2009).

Pork trade and consumption in Ghana have expanded, and zoonoses linked to pigs along the pork value chain have raised public health concern (Majekodunmi et al., 2019). Evidence on *Trichinella* in the country is limited. A parasitological survey of crossbred pigs in the Upper East Region found no *Trichinella* larvae (Permin et al., 1999). Later serological surveys reported antibodies in 4.5% of pigs, all of them from free-range herds, and

in 0.31% of people (Addo et al., 2021), and in 8% of pigs in the Upper East Region (Majekodunmi et al., 2019). Antibodies show exposure but not the presence of viable larvae in meat. Direct detection by artificial digestion is the reference method for that purpose (WOAH, 2023), and to our knowledge it has not been reported for pigs slaughtered in Kumasi, the capital of the Ashanti Region.

Whether pigs are exposed to *Trichinella* depends largely on how they are kept, particularly contact with wildlife and rodents and access to meat-containing waste (Gamble et al., 2024). We therefore paired laboratory surveillance at slaughter with a description of management on the farms that supply the slaughter facilities, in line with a One Health approach that links animal production, food safety and human health (Grace et al., 2012). The objectives were (i) to detect *Trichinella* larvae in the muscle of pigs slaughtered at three facilities in the Kumasi metropolis by artificial digestion, and (ii) to describe housing, hygiene and anthelmintic practices on pig farms in five source communities.

Materials and methods

Study design, sites and ethics

A cross-sectional study was conducted from April to September 2025. Sampling took place at the Kumasi Abattoir Company Limited (KACL), which handles about 30 pigs per day alongside other species, and at the Krofrom and Dakodwom Slaughter Slabs, which slaughter only pigs (about 10 and 25 pigs per day, respectively) (Figure 1). Pigs slaughtered at Krofrom

come from Darbaa, Obuasi and Barekese, with some from the northern regions and Techiman. Farm visits took place in five towns, Barekese, Boadi, Darbaa, Ejisu and New Ntensere, which facility managers identified as the main source communities for slaughtered pigs (Figure 2). Ethical clearance was granted by the KNUST Committee on Human Research, Publication and Ethics (KNUST/CHRPE/AP/2025/567). Facility managers gave permission for sampling, and all farmers gave informed consent. Tissue was taken only from pigs slaughtered for commercial purposes; no live animals were handled.

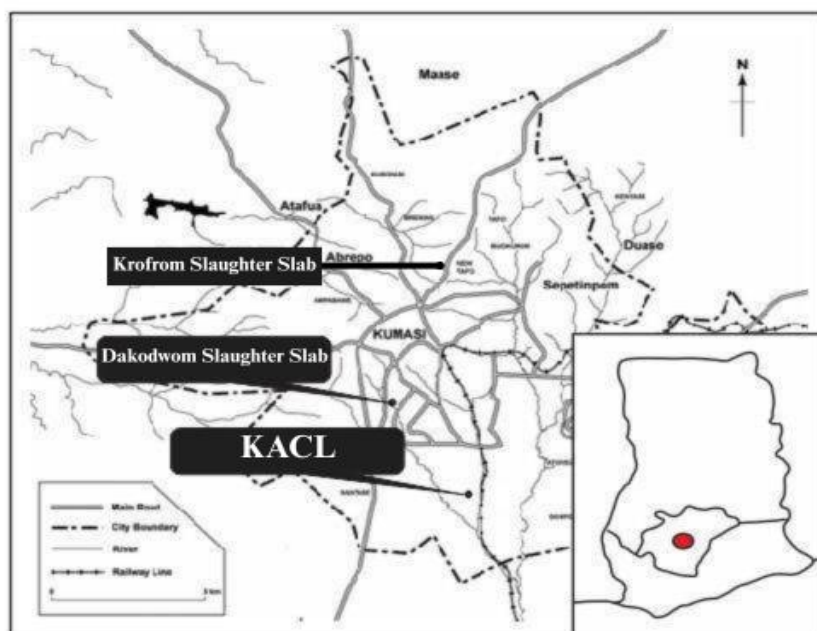


Figure 1. Locations of the three slaughter facilities sampled in the Kumasi metropolis.

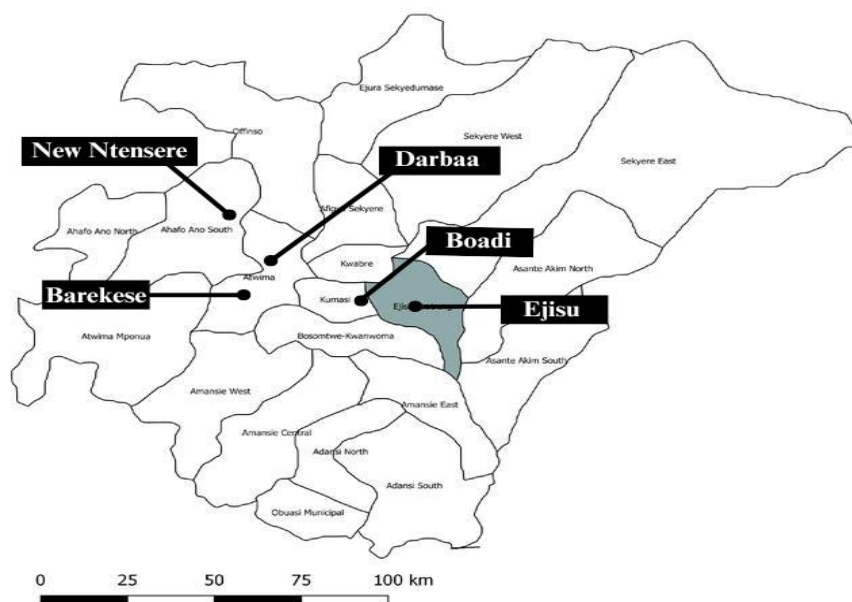


Figure 2. Locations of the five source communities visited for the husbandry assessment.

Pigs and sample collection

One hundred pigs were randomly selected from those slaughtered at the three facilities during the study period. All were market-weight finishers (about 80–100 kg), with an age of roughly 4–9 months estimated from live weight and stage of growth, not

from dentition or records. Sex was recorded by external examination of the genitalia after slaughter. Breed was assigned from coat colour, ear shape and body conformation as Large White, Landrace, Hampshire, Pietrain crossbred or Ashanti Dwarf (indigenous). Immediately after slaughter, about 2–3 g of muscle was taken from each of three predilection sites (tongue, diaphragm

and masseter), pooled and made up to 10 g per pig, held on ice and processed in the laboratory the same day, within about 6–8 hours of collection.

Artificial digestion

Each 10 g composite sample was digested by the pepsin–hydrochloric acid magnetic stirrer method of the WOAHH Terrestrial Manual (2023, Chapter 3.1.22), applied at one-tenth of the reference quantities (100 g of tissue in 2 L of water with 16 mL of 25% HCl and 10 g of pepsin; European Commission, 2015; WOAHH, 2023). The composite sample from each pig was digested individually, without pooling across animals. Digestion fluid consisted of 200 mL of water at 45 °C, 1.1 mL of 37% HCl (about 0.55% v/v, approximately equivalent in acid content to 1.6 mL of 25% HCl) and 1 g of pepsin (0.5% w/v). The sample was homogenised in a blender with part of the fluid, transferred to a beaker and stirred at 45 ± 2 °C for 30 minutes. The digest was passed through a 180–200 µm sieve and left to sediment for 30 minutes. Forty millilitres were then drained into a conical tube and allowed to stand for 10 minutes, 30 mL of supernatant were removed, and the remaining 10 mL were examined in a Petri dish under a stereomicroscope at 10–20×, with 40× used for suspect structures. Larvae were identified by size, coiled shape and the anterior and posterior ends as described in the WOAHH manual. A blank digest (fluid without tissue) was run on every day of analysis. A positive control (a sample containing larvae or tissue spiked with larvae) was processed in parallel on days when one was available, and it consistently yielded larvae.

Farm survey and scoring

A semi-structured questionnaire was developed by the research team, reviewed by two epidemiologists and ten veterinarians of the Ashanti Regional Veterinary Office, and pre-tested with five farmers in Kwadaso, outside the study towns. Its biosecurity items follow the FAO good-practice guidance for the pig sector (FAO, WOAHH and World Bank, 2010). It was translated into Twi, back-translated into English by a linguist who had not

seen the original, and administered face to face on tablets with KoBo Collect. It covered socio-demographic characteristics, breeds kept, housing system, feeding, water source, anthelmintic use, rodent control, veterinary access and disease history. A structured observation checklist (housing, cleanliness, manure management, rodents or scavengers, feed and water storage) was completed during the same visit. Farmers were recruited by snowball sampling: the first farmer identified in each town recommended others who regularly supplied the same slaughter facilities. All 25 farmers approached took part. Practices were scored with an algorithm adapted from Ekakoro et al. (2023): each item carried a value, each response a weight (0 to 1, in steps of 0.25 for Likert items), and the item score was the product of the two. Item values were based on FAO (2010) guidance and, where the guidance was silent, set by the modal value proposed by the ten veterinarians. Environmental hygiene was classified as poor, good, better or best.

Data analysis

Data were summarised as frequencies and percentages in Microsoft Excel 2016 and SPSS version 27. Prevalence is given with an exact (Clopper–Pearson) 95% confidence interval. When no positives are found, the upper limit is $1 - 0.025^{1/n}$. Assuming perfect test sensitivity, a sample of 100 pigs has a 95% chance of finding at least one positive if the true prevalence is about 3% or higher. No inferential tests were performed, because there were no positive animals to compare.

Results

Pigs sampled and detection of larvae

Of the 100 pigs, 45 came from the Dakodwom Slab, 31 from the Krofrom Slab and 24 from KACL (Table 1). Sixty-two were female and 38 male. Landrace (37), Large White (31) and Ashanti Dwarf (25) predominated, followed by Pietrain crossbreds (5) and Hampshire (2). *Trichinella* larvae were not detected in any pig (0/100; 95% CI 0–3.6%; Table 2). Representative digests are shown in Figure 3.

Table 1. Characteristics of the 100 pigs sampled.

Characteristic	n	%
Slaughter facility		
Dakodwom Slaughter Slab	45	45
Krofrom Slaughter Slab	31	31
Kumasi Abattoir Company Ltd (KACL)	24	24
Sex		
Female	62	62
Male	38	38
Breed		
Landrace	37	37
Large White	31	31
Ashanti Dwarf (indigenous)	25	25
Pietrain crossbred	5	5
Hampshire	2	2

Table 2. Detection of *Trichinella* larvae by artificial digestion, by slaughter facility.

Facility	Pigs examined	Positive	Prevalence (exact 95% CI)
Dakodwom	45	0	0% (0–7.9%)
Krofrom	31	0	0% (0–11.2%)
KACL	24	0	0% (0–14.2%)
All facilities	100	0	0% (0–3.6%)

**Figure 3.** Stereomicroscope views of digests from samples 12 (left) and 78 (right). No larvae were present.

Farmers and farm practices

Twenty-three of the 25 farmers (92%) were men. Nineteen (76%) were aged 40 years or older, four (16%) were 30–39 and two (8%) were 20–29. Eighteen (72%) had completed secondary education, four (16%) tertiary education and three (12%) had no formal education (Table 3).

Table 3. Characteristics of the 25 farmers interviewed.

Characteristic	n	%
Sex		
Male	23	92
Female	2	8
Age group (years)		
20–29	2	8
30–39	4	16
40 and above	19	76
Education		
No formal education	3	12
Secondary	18	72
Tertiary	4	16

Twenty-three farms (92%) used intensive systems and two (8%) semi-intensive systems, one each in Barekese and Ejisu. No farm kept pigs free-range (Table 4). On environmental hygiene, two farms were rated best, 13 better, nine good and one poor; the poor rating was at Barekese. Twenty-three farms (92%) reported a regular deworming schedule; the two irregular schedules were at Barekese and Ejisu (one each).

Table 4. Housing system, environmental hygiene rating and deworming schedule by town (number of farms).

Town	Farms	Intensive	Semi-intensive	Best	Better	Good	Poor	Regular deworming
Barekese	9	8	1	1	5	2	1	8
Boadi	1	1	0	0	1	0	0	1
Darbaa	6	6	0	1	3	2	0	6
Ejisu	6	5	1	0	3	3	0	5
New Ntensere	3	3	0	0	1	2	0	3
Total	25	23	2	2	13	9	1	23

Counts are derived from the percentages reported per town. Hygiene ratings: best, better, good or poor.

Discussion

This study found no *Trichinella* larvae in the muscle of 100 pigs slaughtered in Kumasi, using the reference digestion method on three predilection sites. To our knowledge it is the first direct-detection survey of pigs at slaughter in the city. The result must be read with its statistical limits in mind. With 100 pigs, the upper 95% confidence limit for prevalence is 3.6%, and the study could reliably have found infection only if it were present at about 3% or higher. The finding therefore shows that infection is not common in this sample of pigs, not that it is absent from the supply chain.

The result fits the pattern reported from Ghana. No larvae were found in crossbred pigs in the Upper East Region (Permin et al., 1999), while serological exposure was documented in free-range pigs there and elsewhere: all the seropositive pigs in the national serosurvey of Addo et al. (2021) were free-range, and Majekodunmi et al. (2019) found 8% seropositivity in the Upper East Region. The pigs we sampled came mainly from confined farms, and none of the 25 farms was free-range. Contact with wildlife and rodents and access to meat-containing waste are the recognised routes of exposure for pigs, and controlled, confined production that excludes them is considered to carry negligible risk (Gamble et al., 2024). Our data are compatible with that view, but they cannot support it directly. We did not test any husbandry factor against infection status, individual pigs were not traced to a farm of origin, and some pigs at Krofrom came from the northern regions and Techiman, where management is likely to differ. The 25 farms are best read as a description of the supply area, not as the origin of the sampled animals.

The scale of the evidence also differs greatly from that of Gamble et al. (2024), who found no positives in more than three million samples from pigs raised under controlled management in the United States. That study supports the principle that controlled management lowers risk. Ours is a small local survey and does not offer comparable assurance.

Regular deworming was reported by 92% of farmers, but this should not be interpreted as protection against *Trichinella*. Routine deworming mainly targets gastrointestinal nematodes, and the key control for *Trichinella* is preventing exposure to infected meat, rodents and wildlife. Deworming is better seen here as a marker of general husbandry standards. Likewise, 15 of 25 farms were rated better or best for hygiene and only one poor, which is reassuring but is a snapshot from a non-random sample recruited by snowballing.

From a One Health perspective, the results are reassuring for pork from this peri-urban supply but leave open the risk in free-range systems, where exposure is plausible and where inspection is least likely. Human exposure was not measured. Serology has detected antibodies in people in Ghana (Addo et al., 2021), so the public health relevance rests on pork cooking and handling practices that this study did not examine.

Limitations

First, 100 pigs give limited power to detect low prevalence. Second, sampling was restricted to three facilities in one metropolis over six months, so seasonal variation and pigs from the north are poorly represented, and the number sampled per facility was not proportional to daily throughput. Third, the digestion protocol used proportions equivalent to one-tenth of the reference method but was not separately validated for sensitivity at that scale, and a positive control was not available on every day of analysis. Fourth, breed was assigned by phenotype and age was estimated. Fifth, the farm data rely partly on self-report, farmers were recruited by snowball sampling, and the variables most relevant to *Trichinella* exposure, such as feeding of meat-containing waste and rodent control, are not analysed here. Sixth, pigs could not be linked to specific farms.

Conclusions and recommendations

Trichinella larvae were not detected in 100 pigs slaughtered in Kumasi, and the farms supplying them were predominantly intensive, with generally satisfactory hygiene. These findings are consistent with low exposure in confined peri-urban production but do not explain it. We recommend (i) larger and risk-based surveillance, with pooled-sample digestion and recording of each pig's farm of origin, focused on free-range pigs in the northern regions and on pigs of unknown origin; (ii) risk-based *Trichinella* testing at slaughter facilities, consistent with WOA (2023) and European Commission (2015) standards, to be considered by the national veterinary authority; (iii) farmer education on exclusion of rodents and wildlife and on not feeding raw meat waste to pigs; and (iv) public messaging on thorough cooking of pork.

Declarations

Ethics approval. Approved by the KNUST Committee on Human Research, Publication and Ethics (KNUST/CHRPE/AP/2025/567). Informed consent was obtained from all farmers. Tissue was collected from pigs already slaughtered for commercial purposes, and no live-animal experimentation was undertaken.

Consent for publication. Not applicable.

Availability of data and materials. The datasets generated and analysed during the study are available from the corresponding author on reasonable request.

Competing interests. The authors declare that they have no competing interests.

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Authors' contributions. R. Kusi Boateng: conceptualisation, study design, sample and data collection, laboratory analysis, and writing of the original draft. K. Antwi Darkwa: sample and data collection, data analysis, and review and editing. P. Oduro Kwarteng: sample and data collection, and review and editing. B. Arthur: sample and data collection, data analysis, and review and editing. All authors read and approved the final manuscript.

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