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RESEARCH ARTICLE

PIG BRAIN CONSUMPTION HABITS AND ITS POTENTIAL FOR TRANSMISSION OF PORK TAPEWORM TO HUMANS IN PORCINE CYSTICERCOSIS ENDEMIC AREAS

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ABSTRACT

Porcine *Taenia solium* cysticercosis causes taeniasis in humans, the source of neurocysticercosis that causes life-threatening epileptic seizures. The current drug of choice cannot kill parasite larvae in the brain of pig. In addition, meat inspection in most countries does not include inspection of the brain. A questionnaire was administered to 74 smallholder pig farming households in porcine cysticercosis endemic villages of Mbulu district, northern Tanzania, to explore about pig brain consumption habits as compared to those of pork. While approximately 89.2% (95% CI: 79.8, 95.2; n = 74) of households consumed pork, only about 29.7% (95% CI: 18.9, 42.4; n = 64) admitted that they consumed pig brains. Nevertheless, 40.6% (95% CI: 28.5, 53.6; n = 64) of the households indicated that pig brains were consumed in the village. Males were approximately two times more likely to indicate that pig brains were consumed than females. While frying was the preferred method of cooking pork, boiling in water was the preferred method of cooking the brain. More studies are needed to ascertain local perceptions, adequacy of cooking methods in destroying *T. solium* larvae as well as the need for routine inspection of pig brains in porcine cysticercosis endemic areas.

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INTRODUCTION

Brains of meat animals, including pigs, are edible and provide nutrition to the humans. However, like other parts of meat animals, the brain needs to be free from health hazards, particularly diseases transmissible to humans. Hazards related to consumption of animal brains have mainly been associated with the potential for transmission of prion diseases, mostly transmissible neurodegenerative conditions that include Creutzfeldt-Jakob disease (CJD) in humans and bovine spongiform encephalopathy (BSE) and scrapie in animals (Collinge, 2001). These diseases are characterized by serious, usually fatal conditions. To date, little has been reported on the potential of animal brains transmitting other infectious diseases, including those caused by parasites. Furthermore, little is known on the extent of consumption of animal brains, including those of pigs in communities. *Taenia solium* is a parasite, which causes intestinal infection (taeniasis) in humans and tissue infection (cysticercosis) in pigs, humans and a few other animal hosts. Neurocysticercosis is the dangerous form of human cysticercosis, characterized by life-threatening epileptic seizures because of invasion by the parasite larvae in the central nervous tissues, commonly the brain. The human is the sole natural definitive host who harbours the adult *T. solium* in the small intestine. Thus human is the only source of cysticercosis in humans and other intermediate hosts. Poor personal hygiene and environmental contamination with human faeces facilitate transmission of *T. solium* eggs from infected humans to the intermediate hosts through ingestion, leading to cysticercosis. In most endemic areas, pigs are the most common intermediate hosts that harbour *T. solium* larvae in striated muscles and brain. Thus pigs are the most common source of human taeniasis, especially in areas where pork consumption is common. The human acquires taeniasis through ingestion of viable larvae with infected tissues of pig, commonly pork. The larvae develop into an adult parasite in the small intestine of human to complete its life cycle. Because human taeniasis and porcine cysticercosis are the primary two components of the lifecycle of *T. solium*, control programmes need to focus on these infections when seeking to control or eliminate the parasite in an endemic situation. The idea is to interrupt the lifecycle in order to prevent taeniasis in humans and cysticercosis in pigs. Certainly, combined strategies that prevent both, porcine cysticercosis and human taeniasis would provide better results and should be promoted where possible.

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Three major approaches can be considered for prevention of pigs from acquiring cysticercosis, each of which has some limitations. Vaccination of pigs before they are infected provides an opportunity for long-term control of porcine cysticercosis (Lightowlers, 2003). To date there is no vaccine in routine use in the field, though some vaccine candidates such as TSOL18 have shown good results in experimental studies. Another option for preventing porcine cysticrcosis is total confinement of pigs to prevent them from eating human faeces that may be found on the environment. This strategy combined with environmental sanitation enabled the elimination of porcine cysticercosis in Europe and the United States of America (Schantz *et al*., 1993). However, pig confinement is impractical in many *T. solium* endemic areas because of poverty, which hinders investments required to raise intensively reared pigs. Environmental sanitation is another best strategy to prevent pigs from acquiring cysticercosis. This strategy focuses on assuring availability and proper use of sanitary facilities, primarily latrines to avoid environmental contamination with human faeces caused by open defaecation. Nevertheless, its implementation in some rural areas is hindered by poverty and cultural beliefs (Flisser *et al*., 2003). Therefore, while promotion of pig confinement and use of latrines cannot be neglected, their potential limitations should be considered. *Taenia solium* life cycle can also be interrupted by preventing transmission of the parasite from infected pigs to humans through prevention of humans from eating viable larvae in pig products. Treating infected pigs provides one of such options. Oxfendazole is currently the drug of choice and has proven to be safe in pigs (Mkupasi *et al*., 2013). Nevertheless, the drug is unable to kill larvae located in the brain of pig, leaving the consumer at risk of acquiring taeniasis from infected pig brains. Another option in this aspect would be to prohibit consumption of infected pig meat unless the larvae are rendered sterile. Various guidelines exist in different countries regarding handling of pig carcasses infected with cysticercosis detected during meat inspection. Some countries allow freezing the carcass for a specified period of time before consumption of the meat while others (including Tanzania) require total condemnation of the carcass whatever the level of infection (URT, 1962).

Previous studies in Tanzania have revealed high consumption of pork infected with cysticercosis. This is facilitated by high prevalence of clandestine pork markets, which bypass official meat inspections (Ngowi *et al*., 2004a,b; Ngowi *et al*., 2008). The clandestine pork trade and consumption of infected pork is presumably caused by poverty and ignorance on the human health hazards associated with consumption of infected pork. A previous randomized health education intervention trial in 42 villages of Mbulu district revealed significant reduction of reported consumption of infected pig meat by the intervention with no significant improvement in the use of latrines or pig confinement (Ngowi *et al*., 2008). While changing poverty related behaviours may take time as alleviating poverty itself, it is important to determine the risks of humans acquiring taeniasis from infected pig products to devise strategies to minimize the risks in order to contribute to the national and international efforts towards parasite control. This study explored the extent and habits of human consuming pig brains as compared to pork, and hence, highlighting the risk of acquiring taeniasis from cysticercosis infected pig brains in Mbulu district, northern Tanzania.

MATERIALS AND METHODS

Study area

This study was carried out in three villages of Kainam ward in Mbulu district. The district is located in the northern highlands of Tanzania and it is one of the districts with high incidence of porcine cysticercosis and confirmed cases of human neurocysticercosis (Ngowi *et al*., 2008; Winkler *et al*., 2009). A previous study identified Kainam as the ward with the highest risk of porcine cysticercosis in Mbulu district based on antigen enzyme-linked immunosorbent assay (Ag-ELISA) (Ngowi *et al*., 2010). The three studied villages (Kainam, Hareabi, Tsaayo) were originally one but later on split because of population expansion. Therefore, apparently these villages are closely related.

Sample size and sampling design

This survey was incorporated in an epidemiological and sociological study that aimed at validating a rapid diagnostic test for porcine cysticercosis. In that study, 74 smallholder pig farming households were visited for collection of pig blood samples for the study. Village leaders guided in the identification of pig-keeping households as the households were haphazardly distributed and there were no village household registers to enable random selection of the households. The current questionnaire survey included all the 74 households.

Data collection procedure

A door-to-door visit was made to the 74 pig farming households where a total of 74 respondents were interviewed one-to-one to assess pig meat and brain consumption and their cooking methods. The respondent was preferably the pig owner. However, when this was not possible, any family member living in the household and able to respond to the questionnaire was interviewed. The question on pig brain consumption habits was asked indirectly to encourage compliance as the researcher presumed that consumption of pig brain could be perceived as a stigma. Therefore, the respondent was asked how the household prepared pig brain before consumption in the household, instead of directly questioning on whether the household was consuming the pig brain. A similar approach was used for questions related to consumption of pork.

Data analysis

Data in this survey were entered in Microsoft Excel spreadsheet and analysed in Stata statistical software. Because of the non-random sampling procedure used, only percentages of variables of interest were computed and compared where necessary without analyzing for statistical associations. Because of unstructured nature of some responses, especially those related to pig brain consumption, both quantitative and qualitative approaches were used to analyse the data. For

quantitative analysis, any response suggesting that pig brain was consumed in the community was considered an indication of such consumption regardless of whether the respondent's household was consuming it or not. On the other hand, a specific admission of consumption of pig brain in the household was analysed separately to quantify household level consumption of pig brain. The qualitative analysis was carried out manually by highlighting important responses raised when answering this question. The combined quantitative and qualitative analysis of the data enabled identification and quantification of important practices related to consumption of pork and pig brain in the study area. The qualitative analysis specifically helped to reveal some perceptions related to consumption of pig brains.

Ethical consideration

Permission to carry out this research was obtained from Sokoine University of Agriculture and relevant authorities in Mbulu district. Questionnaire respondents were anonymised and their private information kept confidential.

RESULTS

General results

A total of 74 smallholder pig farming households were visited in three villages of Kainam ward in Mbulu district, northern Tanzania. Approximately, 63.9% of the respondents were females and their age ranged from 15 to 90 (median 40) years. Approximately, 24.3% of the respondents had no formal education, 67.6% completed primary school education and 8.1% had college education.

Pork consumption and preparation methods

Out of the 74 households interviewed, 89.2% (95% CI: 79.8, 95.2) consumed pork, 98.5% (95% CI: 92.0, 100; n = 67) of which was obtained from butcher shops rather than home slaughter. Sixty percent (95% CI: 47.1, 72.0; n = 65) of the households consuming pork consumed it at least once a month. About 92.1% (95% CI: 82.4, 97.4; n = 63) of consumers preferred fried pork. Only a few other pork consumers preferred boiled or barbequed pork.

Pig brain consumption and preparation methods

A total of 64 households responded to the question on how they prepared pig brains for consumption. Of these, 40.6% (95% CI: 28.5, 53.6) indicated that pig brains were consumed in the Mbulu community. More males (59.1%, n = 22) than females (30.0%, n = 40) admitted that pig brains were consumed by humans in the community, indicating that males were approximately two times more likely to indicate that brains of pig were being consumed by humans. One of the female respondents informed further that the pig brains were mostly prepared and consumed in local brew clubs, which were located nearby pig slaughter places. With regard to home consumption of pig brains, only 29.7% (95% CI: 18.9, 42.4; n = 64) households admitted to be consuming pig brains in their homes and explained how they prepared such brains before consumption. There was no much difference between sexes in reporting home consumption of pig brains. About 68.4% of pig brain consumers preferred boiling the brain in water, 42.1% preferred frying and 5.3% preferred barbequing.

DISCUSSION

The present study has confirmed that consumption of pig brain is common in a pig-keeping community of Mbulu district, northern Tanzania, although not as common as consumption of pork in general. This can be explained based on the relative quantities of brains to that of pork, which limit the availability of brains to consumers. The present study also gave some indication that consumption of pig brain was perceived as a stigma since several respondents were only free to say that others than themselves were consuming it. This was not the case with information on consumption of pork in general. This potential misperception may have led to underestimation of the true prevalence of households consuming pig brains in the study area. Routine meat inspection, especially in developing countries is confined to examination of few designated sites of the carcass as described in the government meat inspection guidelines, which normally exclude the brain (URT, 1962). Thus making the brain consumed based on judgment of fitness of other parts of the animal. For example, in Tanzania despite the presence of specific guidelines for inspection of a pig carcass suspected of porcine cysticercosis, examination of the pig brain is not a requirement (URT, 1962). This could be due to lack of necessary facilities to enable exposure of the brain for inspection in most pig slaughter slabs. It could also be due to lack of knowledge by health authority on the potential for animal brains transmitting infections to consumers. Despite available literature on the edibility of brains of meat animals, this information is lacking in some areas, leading limited motivation for inspecting the brains. Consumption of inadequately cooked brain of pig in areas endemic for porcine cysticercosis may be a risk for acquiring taeniasis even though the pig meat may have been found free from infection. Absence of larvae in pig meat does not rule out presence of larvae in the brain. For example, when pigs infected with cysticercosis are treated with oxfendazole, larvae located in the muscles die and disappear eight to over twelve weeks after treatment depending on the severity of infection while larvae located in the brain remain viable (Mkupasi *et al*., 2013). Thus routine postmortem inspection of effectively treated pigs will pass the carcasses for human consumption, some of which might be harbouring viable larvae in their brains. This poses a risk of taeniasis to the consumers of the brain. There is a need for revising the meat inspection guidelines in porcine cysticercosis endemic countries to include a requirement for routine inspection of pig brains to reduce the risk of transmitting taeniasis to humans. This study showed that males were more likely than females to inform that pig brains were consumed by humans in the community. In addition, one female respondent informed that brains of pigs were mostly consumed in local brew clubs, which were commonly located nearby pig slaughter places. These two responses suggest that men were probably the most common consumers of pig brain as in this rural setting they were the one most attending to the local brew clubs while women stayed at homes to take care of children and animals. Being consumed possibly mostly in

local brew clubs also queries the adequacy of cooking of the pig brain as when people are drunk they might be impatient waiting for thorough cooking of the brain.

More research is needed to ascertain the adequacy of cooking methods in destroying *T. solium* larvae in pig meat and brain to guide appropriate measures to prevent ingestion of viable larvae by humans. *T. solium* larvae can be killed by exposing them to irradiation, cooking or freezing. A minimum temperature of 60ºC is required for inactivation (Krauss *et al*., 2003). Freezing at a temperature of -10ºC for 4 days will inactivate larvae (Fan *et al*., 1998). Larvae can survive up to 30 days in the carcass of pigs at 4ºC (Fan *et al*., 1998). Long-term strategies should find effective treatment of infected pigs to eliminate larvae, including those located in the brain. There were differences between the cooking of pork and that of brains for human consumption, with pork commonly fried while the brain was mostly boiled in water. These different cooking methods may be due to the differences in the textures of the tissues as well as local perceptions of the cuisines. Nevertheless, studies are needed to confirm the adequacy of the cooking methods in destroying *T. solium* larvae to safeguard consumers from taeniasis.

Conclusion

Brains of pigs are frequently consumed in Mbulu district, a porcine *T. solium* cysticercosis endemic area of Tanzania. The preferred preparation of pig brain for human consumption is boiling it in water as opposed to frying in the case of pork. There is an indication of brains consumed mostly in local brew clubs and the consumers possibly stigmatized. Studies are needed to ascertain local perceptions, adequacy of cooking methods and need for routine inspection of pig brains in porcine cysticercosis endemic countries to safeguard consumers from taeniasis.

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