QUALITATIVE ASSESSMENT OF PIG HEALTH RISKS RELATED TO THE USES OF FOOD WASTE FOR PIG PRODUCTION IN SUB-URBAN OF HA NOI CAPITAL, VIETNAM

By DUONG TIEU MAI

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Abstract

This study was carried out within the framework of the "Blue Barrels" project with the aim to evaluate the sustainability of collecting and re-using the food waste (FW) for animal production in sub-urban areas in Vietnam and China. Recycling and using FW as animal feed is a common practice in Vietnam. FW collected from different sources such as restaurants, canteens was challenged with potential hazards such as biological, chemical and physical. Temperature can be affected the survival of biological hazards such as virus, bacteria and parasite, but physical and chemical hazards cannot be eliminated by cooking. The aim of this study was to estimate the risk of pigs being affected by physical hazards (PH) via FW. The data were collected by interviewing 41 pig producers in 6 districts of Hanoi using questionnaire including the overall information about FW collection, FW management and re-use at pig holdings. Information about pig health problems related to the risk of FW contaminated was also collected. The results revealed that the risk of FW contaminated with PH such as toothpick was low in pig and it can be eliminated by separation management. The risk of pig stomach damaged by toothpick was higher in pig holders using FW collected from small restaurants. The typical signs of pigs affected with physical hazard were fever, anorexia in a short period of time but the consequences seemed to be low (i.e. no dead pig due to toothpick was mentioned in interviewed pig holdings). Results of this study provide interesting information about risk of pig health problems related to re-using FW for pig production in Vietnam.

Key words: food waste, risk assessment, physical hazards, pig health problems.

Résumé

Cette étude est réalise dans le cadre du projet “Blue Barrels” afin d’évaluer la durabilité de la collection et réutilisation des déchets alimentaires (DA) dans la production animale en zone sous urbaine au Vietnam et en Chine. Les DA recyclés et utilisés comme aliments animal est une pratique connue au Vietnam. Les DA collectés de différentes sources comme restaurants, cantines sont contaminés avec les agents potentiels biologiques, chimiques et physiques. La température peut affectée la survie de agents biologiques tels que virus, bactérie et parasite, mais les agents physiques (AP) et chimiques ne peuvent pas être éliminés par la cuisson. L’objective de cette étude était d’estimer le risque d’être affecté par les agents physiques présentent dans des DA. Les données sont collectées par entretiens avec 41 éleveurs de porc sur 6 districts de Hanoi ville capitale en utilisant un questionnaire portant sur des informations générales sur la collection DA, le management et réutilisation chez leurs animaux. Les informations de problème sanitaire chez le porc reliées avec le risque de DA contaminés sont aussi collectées. Les résultats montrent que le risque de DA contaminé avec des AP comme cure-dents de bois sont moins importants et ils peuvent être éliminés par des pratiques de séparation. Le risque d’endommager l’estomac des porcs étant important chez les éleveurs qui utilisent des DA collectés de petits restaurants. Les signes typiques chez un porc affecté par des AP sont fièvre, anorexie à court terme mais il semble que les conséquences sont moins importantes (i.e. aucun porc mort à cause de cure-dents en bois mentionné lors des entretiens). Les résultats de cette étude nous fournissent des informations intéressantes sur des problèmes sanitaires chez le porc qui sont liées à la pratique de réutilisation des DA dans la production de porc au Vietnam.

Mot clés : déchets alimentaire, de risque, agents physiques, problème sanitaire de porc.

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Contribution of authors

Dr. Marisa Peyre

Dr. Hoa Pham Thi Thanh

Dr. Huyen Le Thi Thanh

Dr. Flavie Goutard

Dr. Jean-Daniel Cesaro

Mr. Timothée CANTARD

Ms. Thuy Dinh Khanh

Dr. Bao Truong Dinh

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Abbreviations

CSFV – Classical Swine Fever virus

DMB - Dry matter basis

E.coli – Escherichia coli

FW – Food Waste

FMD – Foot and Mouth Disease

PH – Physical hazard

PRRS – Porcine reproductive and respiratory syndrome

SI – Swine Influenza

URENCO - Urban Environment Company

Chapter 1 - Introduction

Approximate 1.3 billion tons of food are wasted or uneaten every day around the world (1). According to a research at Cornell university in 2005, 8% meal from human dishes will be scraped (2). The word "food waste" (FW) is used to describe the wasted of table scraps, food leftovers, kitchen wastes, expired foods, etc. (3). FW can be recycled as fertilizer, feed, energy, methane fermentation, oil and fat products (4).

Using FW to feed animals has been starting globally for long time, it can be considered as an effective method to reduce the waste loss (5). In Japan, people started using swill to feed pigs since 1998. Japanese researchers demonstrated a possibility of using FW at the restaurants, canteens for animal feeding (6). They have indicated that pork meat fed by swill became soft and the feeding cost was fewer (7). However, using food waste caused some health problems to pigs (8). In the 1930s, the use of kitchen waste was the reason of parasite infected transmission through the uncooked meat (9). The foot and mouth disease (FMD) outbreak in UK 2001 was linked to untreated FW consumption so many countries had banned using food waste for animal feeding (10). Some diseases as classical swine fever (CSF), porcine reproductive and respiratory syndrome (PRRS), swine influenza can also be transmitted through the untreated FW to feed-pig have been reported (11).

Waste reuse and recycling are common practices in Vietnam. Households routinely separate recyclable wastes such as metals and paper for sale to itinerant buyers or sell it directly to local depots, around 22% of all wastes is produced in Hanoi capital (12). Vietnamese small scale farms make profits by recycling food waste that they collect from the kitchen, restaurant or cafeteria near their houses (13). They can save money by using the food waste and mixing it with rice bran or vegetables as banana root, sweet potato, cassava, etc. to nourish their animals (pig, poultry, and fish). The large number of FW comes from high-density population area. Up to 15%, organic waste is used in compost or feeding animal in Hanoi, which is not segregated at source (14).

The risks of using FW to feed animal in Vietnam have not identified yet, although the food waste in big cities as Hanoi, Danang and Hochiminh city is largely used to feed pigs. The objective of this study was to perform a first qualitative risk assessment for the use of FW for production animal feed in Vietnam. This research has also implemented within the framework of the "Blue Barrels" project (Collection and recycling of urban food waste in peri-urban livestock farms in China and Vietnam) (GloFoods Meta-program INRA).

Objectives of the study

The aim of this study was to focus on the qualitative analysis of the health risks related to the use of food waste to feed animals in sub-urban regions of Hanoi capital, North Vietnam. To achieve this, several specific objectives were set:

- Listing the potential hazards that could contaminate food waste.
- Selecting some hazards for risk assessment and is identified the potential hazards that could be contaiminted food waste for further investigation.

Chapter 2 - Literature Review

2.1 Food waste overview

Waste from hotel, restaurant, resident house used as livestock food was popular in the early of 20th century (36). The amount of FW recyclables as animal food decreased because of the risks of uncooked food waste. FW recycled to animal stuff was banned in EU since 2002 because of concerns about FMD outbreak. The reason for this outbreak occurrence was that UK farmer fed uncooked FW containing infected meat to pigs. EU produced approximately 89-100 million tonnes of FW per year, around 3 million tonnes are reused as animal feed (43). Whereas Japan and South Korea recycled around 35.9% and 42.5% respectively of their FW as feed. In these contries, the regulation of animal industry is very tight includes: heat treatment, storage and transport of FW feed. The heat treatment law of FW containing meats required by food safety for a minimum of 30 minutes at 70^{o}C or 3 minutes at 80^{o}C without destroying nutrients.

Japanese and Korean farmers used swill because of its cost saving and meat quality. Although swill-fed pigs tend to grow more slowly than fed by commercial feed (44). People thought that the recycling of FW can replace conventional animal feed and reduce the environmental impact of meat production. Furthermore, swill can play a role in reducing the land required for meat production. The uncooked food waste to swine feeding caused potential risk outweigh saving cost (37). Wet feed was produced from FW by processed such as sorting, shredding, and heating. The resulting product was supplied to animals and typically contained around 69 % moisture (38).

The nutrients contained in a residual food for animal production purposes should be extensively investigated as alternative sources of feed (15). Some countries started recycling food waste as animal stuffs because of its nutrient value. Food waste collected from the restaurant were more nutrient than from house hold that were high fat, protein. DMB (dry matter basis) reported that the nutrient value includes protein contents 15-23%, 17-24% fat, ash of 3 to 6% in food waste which collected from restaurants, cafeteria (39). Two groups of pigs were fed by FW and corn/soy bean, meal diet which shown that there were no differences growing rate between two groups. Testing flavor and texture of the loin meat between 2 groups were acceptable ($P>0.05$) (15). The limitation factor of using bakery waste to animal feed is meat color, it is paler than feeding by corn, soy diet ($P< 0.05$) (40)

The table 2.1 show the percentage of FW recycled for all purposes, including of Ecofeed, compost and anaerobic digestion in Japan from 2001 to 2009.

Table 2.1 The percentage of FW recycled from 2001 to 2009, in Japan (16)

FW source	2001	2002	2003	2004	2005	2006	2007	2008	2009
Manufacturing (%)	50	60	65	65	76	76	77	93	93
Retail (%)	23.5	26.5	30	29	42	44	45	48	47
Catering and food service (%)	9	8	11	13	14	16	16	13	16

2.2 Processing of FW for animal feed

Pigs feeding by FW must be treated in order to reduce the risk of infectious disease in pigs and eliminate any harmful pathogens. The importance of treatment by heat considered as a risk mitigator.

Some treatment methods have been used to control the biosecurity of FW used as animal feed including boiling, chemical additives, composting, ensiling or heat. Among of that heat treatment seems very useful for small scale farms. Furthermore, farmer prefer recycling food waste was collected from restaurant have been fed to pigs because of its simple processing.

Most of FW research has been conducted with wet FW. New processing technologies to produce a drier product may make it easier to include FW in commercial diets to produce product variability and ultimately to increase the level of FW recycling.

The component of food waste affects its use in balancing diets. Some heat processing methods that utilize excessively high temperature for extended periods of time may destroy some heat- labile vitamin activity. FW is an excellent source of some minerals.

Traditionally, Asians have diverted substantial amounts of waste for use in farming and aquaculture; especially poor farmers in and around cities (17). Japan throws out 20 millions tons of FW a year that about five times as much as world food aid to the needy. However, since 2001 the acts of the government have encouraged the opening of recycling industries where FW are converted to animal feed and fertilizer. The methods of processing FW for animal feed can largely be classified into the following three categories: dehydration, silage and liquid feeding. In Japan, the methods involving in dehydration include: conventional dehydration by heat, fermentation-dehydration and fry cooking. The effect of processing of FW treatment by heated is temperature, ranges from 70-230^{o}C, higher temperature tend to decrease the availability protein. The degeneration of protein during the process of heat treatment is one of the most serious problems in the utilization of FW as animal feed.

Other disease can be introduced by the FW feeding of swine caused by viruses, bacteria, parasite include: CSF, PRRS, Swine Influenza (SI), E.coli, Trichinellosis. The FMD virus is known to survive for up to 48h at 40^{o}C and pH<6 in fresh meat product, up to 6 months in partially cooked, cured and smoked meat products. Based on the research of Sancho, 2004. After treated 65^{o}C for 20 min, E.coli and Salmonella is absence (42).

Porcine reproductive and respiratory syndrome virus (PRRS) can be induced in naïve pigs by the oral, intranasal and intramuscular routes. The virus survives in pork from infected pigs for extended periods at temperatures of -20^{o}C or -70^{o}C.

Swine influenza viruses are enveloped, some of them have been reported to survive for a long period in the environment. Virus is influenced by temperature, pH, salinity and the presence of organic material. Viruses are inactivated by heat of 56^{o}C for a minimum of 60 minutes, low pH (pH=2). Viruses are susceptible to disinfectants including sodium hypochlorite, ethanol, povidone-iodine and lipid solvents.

Most of pathogen bacteria as Salmonella, E.coli are adapted to grow in the tissues or fluids of their host at 37^{o}C (18). FW included oil and fat so it have an unavoidable influence on the microbial (Salmonella, E.coli, molds and yeast) activity and inactivation. Using hydrothermal treatment process of 60-110^{o}C for 10-60 min on the elimination of microbial from FW shown that the 110^{o}C hydrothermal treatment for 60 min was sufficient to disinfect FW as animal feed (19).

2.3 Legislation on food waste to animal feed

In Japan and Korea, the regulation of animal industry is very tight includes: heat treatment, storage and transport of FW feed. The heat treatment law of FW containing meats required by food safety for a minimum of 30 minutes at 70^{o}C or 3 minutes at 80^{o}C without destroying nutrients.

2.4 Vietnam pig production

Pork is the most important source of meat in Vietnam, accounting for approximately 74% of total meat output (20). In 2015, the prices of animal feed was downward and the pork price was increased, remaining beneficial to farmers. The number of farmers tend to expand their herbs or build new farms (21).

Table 2.2 The number of fattening pigs in each categories of farms.

Fatten Pig farms *(They buy only weaned pigs and rasing to finisher)*						**Integrated fatten pig farms**
Farms (50 - 200 pigs)	***Farms (200 - 300 pigs)***	***Farms (300 - 500 pigs)***	***Farms (500 - 1000 pigs)***	***Farms (1000- 1500 pigs)***	***Farms (1500- 2500 pigs)***	***Farms (>2500 pigs)***
3,388	606	241	149	63	24	14
Total fatten pig farms: 4485						

Source: Vietnam General Statistic Office, 2016

The increase in pork consumption has led to increase the pig population. This is linked to the increasing of the threat of large range of pig disease. From 2006-2012, Vietnamese government was reported over 5.000 FMD outbreaks in 62 provinces and more than 3.000 outbreaks of highly pathogenic PRRS. The infectious disease of swine has been caused significant impacts for individual producers and social economic. The PRRS outbreaks in the smallholders could be related to the poor biosecurity such as feeding untreated FW as animal feed, using irrigated water, importing illegal pigs (20).

2.5 FW in Vietnam

In the state of art, the development of the society and the economy, the life style as well, the generation of commercial waste is getting more complicated to control. The quantity and the quality of FW also altered due to the change in lifestyle (7). The situation of FW of commercial waste in different countries are analyzed to evaluate and suggest necessary improvements for the existing waste management system. The activities of recycling food waste as animal feed should be taken into account. FW re-using played an important role to reduce the landfill pollution and environment friendly.

The Vietnamese citizen produces about 42.000 tones MSW per a day, which will be increasing 83.000 tones in 2050. Waste reuse and recycling is a common practice in Vietnam. Households routinely separate recyclable wastes such as metals and paper for sale to itinerant buyers or sell it directly to local depots, around 22% of all wastes produced in Hanoi capital (12). The Urban Environment Company (URENCO) who has the exclusive contract with the local People's Committee of Hanoi supplies the service of collection waste generated in the urban regions of Hanoi. Collects, transports and disposes of municipal solid waste including commercial waste is the main function of the URENCO. Big hotel and restaurant have tightly contract with the URENCO in order to clean and sanitary their kitchen.

Vietnamese small scale farms made profits by recycling food waste that they collected from the kitchen, restaurant or cafeteria near their houses (Le Thanh Luu, 2011). They can save money by using the FW and mixing it with rice bran or vegetables as banana root, sweet potato, cassava, etc. to nourish their animals (pig, poultry, and fish). The large number of FW come from high density population area. Up to 15% organic waste was used in compost or feed animal in Hanoi, which is not segegrated at source (Koc et al, 1999). Swine breeders paid money for either food residue producers or middlemen in exchange for food residue. Food residue can be free of charge if there is a strong human tie between a swine breeder and a food residue producer; however, this is not common (41)

In Vietnam, small scale farms have become more popular during the trend of economic growth. This study investigated the risk pathway of diverting food waste for pigs feed in Hanoi capital. Some districts around the center have conducted a preliminary estimation of the amount of food residue collected by swine household. Mitchell, 2008 started doing the research within the informal waste collecting of people who did their business as waste pickers, junk buyers. At the moment, the research did not focus on the reused FW from restaurant, hotel, and resident house as well. Although it is a common practice in many parts of the world. Danang is one of the biggest city in Vietnam was chosen to conduct the survey of using FW to feed pigs of local farmers. There were 20 small scale farms that feeding FW as animal feed. The FW was collected from the restaurant, hotel, canteens of school or company, etc. The research calculated the total amount of food residue has been collected from each household. It did not mention about the risk of feeding FW as animal feed although it mentioned the hazardous contaminants as separation physical hazards, treatment FW at the farms (41).

There have been an increased interest by piggeries to move to a liquid feeding regime for post weaning stages. The success of liquid feeding systems include: reduction in feed wastage as dust, reduced fighting for feed at the feeding trough.

Figure 2.1 FW transportation in Vietnam (source: Hanoi moi newspaper)

Food waste feeding improves the performance of fattener pigs and the type of food added the increase of nutrient availability. Food waste has long been fed to swine. However, its nutrient components are chemically unstable and putrefactive degradation of the waste can start within a few hours after the waste is discarded. If the waste is not properly processed or preserved, spoilage as well as pathogenic microorganisms can grow in the waste. The waste must be processed to eliminate any pathogens prior to feeding.

The use of FW as pig feed could offer environmental and public health benefit, this will require support from policy makers, the public and the pig industry, as well as investment in separated food waste collection which currently occurs in only a minority of regions.

2.6 Hazard identification

Hazard identification is the process of identifying the pathogenic agents which could potentially be introduced in the commodity considered for importation. The hazards should be identified as a biological, chemical or physical agent in or condition of food with the potential to cause an adverse health effect (Codex Alimentarius Commission) (22).

Hazard identification is the primary step of an official risk assessment. Risk is the likelihood of occurrence and the magnitude of consequences of a specified hazards being realized. The steps of risk analysis were given in the figure 2.1 below.

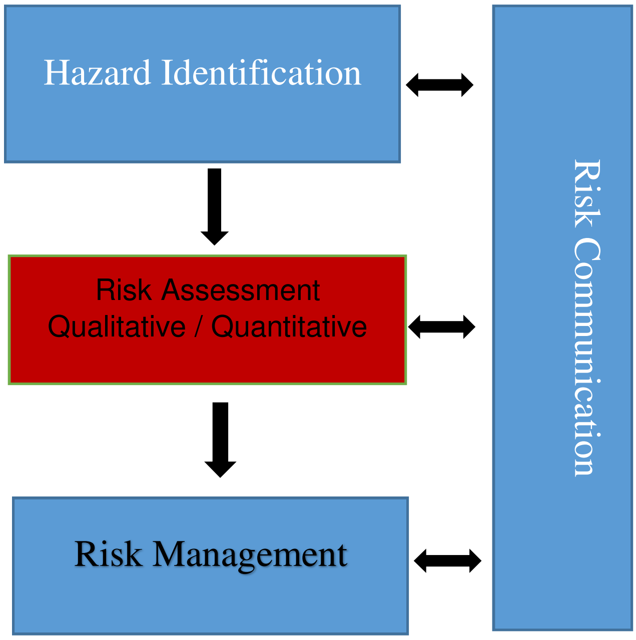

Figure 2.1 The four components of Risk Analysis

Hazards were classified into 3 categories: biological, chemical and physical in order to do the risk assessment of pig health related to the uses of food waste in pig production, hazards identification listed in the table 2.3.

Table 2.3 The list of hazards of using food waste to animals feed

Hazards identification	**Hazards characterization**	**Inactivated pathogen**	**Potential risk**	**Potential consequences**	**Citation**
Biological hazards					
Virus					
CSF	Virus survive on frozen meat for 4 years, chilled fresh meat for 85 days, room temperature (20^{o}C) for 3 weeks, smoked meat on 90 days, salted meat on 313 days	Virus will be destroyed by heating for a minute or less at 90-100^{o}C. Pasteurization process 65^{o}C for 30 mins Clean/disinfection by detergents, phenolics, quaternary ammonium compounds, and aldehydes (formaldehyde, glutaraldehyde)	Transportation Vehicles Human carriage Waste food Un treated FW	Medium (pigs vaccinated) / High (pigs non vaccinated)	(23) (24) (25), (26), (27), (28)
FMD	Virus survive on meat products 48h at 4^{o}C and pH<6; cooked, cured and smoked meat products on 6 months	Virus sensitive to dryness. Meat can be treated with high heat (70 °C internal temp) for at least 30 mins through canning or cooking methods.	Un treated FW Human carriage Human fomite Vehicles	Medium (pigs vaccinated) / High (pigs non vaccinated)	(26), (27) (1), (10), (29)
PRRS	PRRS virus appears in muscle and lymphoid for 24 hours after slaughter, at least 72 hours when chilled at 4^{o}C or frozen at -20^{o}C for one month	Complete inactivation of the virus occurred within 48 hours at 37°C and by 45 mins at 56°C. Low concentrations of detergents and solvents such as chloroform and ether rapidly inactivate PRRSV	FW untreated Aerosol Distance between 2 farms Wildlife Direct contact Human fomite	Medium	(30), (11), (31)
Swine influenza	Virus survive 3-30 days in nature	Inactivated by sunlight and temperature 56^{0}C for 60 mins or to 65^{o}C in 30 mins Disinfectant based on lipid solvents. Low concentrations of soap, detergent	Human contact airborne	High	(32), (33), (34)

		and alkali are potent and efficient for inactivating influenza viruses			
E.coli	Meat, vegetables, fruit, raw milk, dairy products	Treated by heat at 65°C for 20 min	Treatment process contamination	High	(35), (36), (37)
Salmonella	Raw FW	Treated by heat at 80°C for 30 min	Post-treatment storage	Low	(19), (37)
Staphylococcus aureus	Raw FW	Treated by heat at 80°C for 30 min	Post-treatment storage	Low	(19), (37)
Mold and yeast	Raw FW	More than 0.5 log_{10} cfu/g still survived after 60 min treatment at 110°C	Post-treatment storage	Medium	(19)
Parasite					
Trichinellosis	Larvae in the muscle	Cook at least 58.5°C at 10 mins. Freezing meat (-20°C) can kill worm in 3 days	Uncooked garbage containing meat scraps	High	(38)
Chemical hazards					
Pesticide	aldrin, chlordane, DDT, endosulfan, endrin, HCH, hexachlorocyclohexane, heptachlor and hexachlorobenzene	- Dehydration in a rapid high-temperature dryer can remove 60-80% - Food preparation through washing, peeling, cooking reduce levels of pesticides	Uncooked vegetables, vegetables peels	High	(39), (40), (6)
Physical hazards	Broken glass, nails, toothpicks		FW not separated	High	(41)

Chapter 3 - Materials and methods

3.1 Study area and study sample

This study was conducted in 5 districts surrounding the periphery of Hanoi capital (Long Bien, Dan Phuong, Hoai Duc, Gia Lam, Dong Anh) and one district in Hung Yen province (Van Lam) but it is very closed to Hanoi. Selection of study area was based on long traditional practices of collecting and re-using FW for animal production. The FW value chain in pigs was applied in these areas for more than 20 years. Hanoi region and Hung Yen province were selected because of their high pig population and characteristic of pig production linked strictly to FW collection. Hanoi has the highest number of pig population (1.380,1 thousand) among the red river delta regions, with the pig density is 40pigs/km^2 (source: General statistic office of Vietnam, 2013).

Data collection

Data was collected by interviewing pig holders, using questionnaire covered farm general information, the food residue sources, collecting method, the distance from their farm to the collecting point, the FW distribution of the collector, the FW treatment process at the small scale farms and which kind of health problems can be transmitted into the farm link to discard food, taking up to 40 min to complete. Pig holders were randomly selected in each district. The questionnaire was piloted among 3 farmers familiar with producing pigs and modified accordingly to improve clarity prior to undertaking the interviews.

Risk assessment method

The risk assessment are undertaken using the guidelines given in the world Organisation for Animal Health (OIE) Terrestrial Animal Health Code (42). A risk assessment consists of a risk profile based on an analysis and a clear formulation of the problem, a risk characterization and a risk development path containing an estimate of the emission, propagation and consequences. The risk is generally estimated qualitatively. This estimate includes the likelihood of the adverse event occur and the extent of damage it will cause. Step of risk assessment:

- Identify the hazards in small scale household using food waste for feeding animals
- Estimating the flow of contaminated FW into the farm

- Estimating the probability that food waste is contaminated with physical hazard, biological hazard (virus such as: FMD, PRRS, Swine Influenza, CSFV; bacteria as E.coli; parasite) and chemical hazard (pesticide)
- Identifying exposure pathway and estimating the probability and frequency of infection in pigs' household caused by contaminated food waste.

3.2 Hazard selection

Table 3.1 Hazards sensitive to heat (could be destroyed by cooking FW)

Hazards identification	Inactivated pathogen	Citation
Biological hazards		
Virus		
CSF	Virus will be destroyed by heating for a minute or less at 90-100°C. Pasteurization process 65°C for 30 mins	(23) (24) (25), (26), (27), (28)
FMD	Virus sensitive to dryness. Meat can be treated with high heat (70 °C internal temp) for at least 30 mins through canning or cooking methods.	(26), (27) (1), (10), (29)
PRRSV	Complete inactivation of the virus occurred within 48 hours at 37°C and by 45 mins at 56°C.	(30), (11), (31)
Swine influenza	Inactivated by sunlight and temperature 56⁰C for 60 mins or to 65°C in 30 mins	(32), (33), (34)
E.coli	Treated by heat at 65°C for 20 min	(35), (36), (37)
Salmonella	Treated by heat at 80°C for 30 min	(19), (37)
Staphylococcus aureus	Treated by heat at 80°C for 30 min	(19), (37)
Mold and yeast	More than 0.5 log_{10} cfu/g still survived after 60 min treatment at 110°C	(19)
Parasite		
Trichinellosis	Cook at least 58.5°C at 10 mins. Freezing meat (-20°C) can kill worm in 3 days	(38)
Chemical hazards		
Pesticide	- Dehydration in a rapid high-temperature dryer can remove 60-80%	(39), (40), (6)

The hazards considered for this study was FW contaminated with biological (virus: FMD, PRRS, Swine Influenza, CSFV; bacteria; parasite) and chemical and physical. Hazard selection was based on the list of hazard with high consequences as identified by the literature review and confirmed with the farmers during the study. All interviewed farmers treated FW by heat to remove the risk of bacteria, parasite and virus, assuming that the heat treatment was optimum. Physical hazard and chemical hazard cannot remove by cooking.

Due to limited time, the study concentrated on the risk of exposure of pigs to physical hazard (PH) via contaminants FW.

3.3 Risk question

Risk question identification

The study was to estimate the risk of the FW contaminated enter the pigs. The risk questions were as follow:

- Release: What is the probability of introduction of FW contaminated enter the farm?
- Exposure: What is the probability of pigs consumed infected FW after introduction into the farm?
- Consequence: What is the probability of the pig to get sick following consumption of contaminated FW and what would be the impact for the pig health and farmers likelihood?

Risk pathway identification and risk estimation

Pathways were identified for FW contaminated introduction in farms, FW contaminated fed into the pigs. The FW collection and management pathway was required to identify and draw the specific pathway for each hazards considered. The pathways were detailed for the three risk assessment questions. All possible general pathways were represented and considered. Probabilities for each branch of the pathways were estimated for using terms from "negligible" to "very high" (Table 3.2) and uncertainty for each of these estimates was determined using a scale from "low" to "high" (Table 3.3).

Probabilities and uncertainty were estimated for each section of the pathways. When probabilities were based on a proportion such as a probability of separation (i.e. percentage of farms separated FW at each collecting point categories), they are considered roughly and divided in two type of proportion as separation and no separation. For the no separation, very high for the proportions ≥ 90 (i.e. 90% of collector did not separate FW at the collecting point, so the probability for did not separated is very high), high proportions included in the interval [65%-89%], medium for [35%-64%], low for [10%-34%], very low for [1%-9%], and negligible for <1. With the separation, the probability opposite as very high for the proportion ≥ 90 (i.e. 90% of collector divided FW at the collecting point, so the probability for separation is negligible), very low proportion included in the interval [65%-89%], low for [35%-64%], medium for [10%-34%], high for [1%-9%], and very high for <1.

Table 3.2 Categories of probability used for the qualitative risk assessment (22)

Probability category	Interpretation
Negligible	Event is so rare that does not merit to be considered
Very low	Event is very rare but cannot be excluded
Low	Event is rare but does occur
Medium	Event occurs regularly
High	Event occurs very often
Very high	Even occurs almost at certainly

Table 3.3 Qualitative categories for expressing uncertainty in relation to qualitative risk assessment

Uncertainty category	Interpretation
Low	Solid and complete data available; strong evidence provided in ,multiple references; authors report similar conclusions
Medium	Some but no complete data available; evidence provided in small number of references; authors report conclusions that vary from one another
High	Scarce or no data available; evidence is not provided in references but rather in unpublished reports, based on observations, or personal communication; authors report conclusions that vary considerably between them

For the combination of probabilities (probability multiplication) the matrix below was used to combine probabilities in each pathway and to combine the release risk with the exposure risk resulting in the likelihood of disease occurrence (Table 3.4). The next matrix was used to combine the likelihood of disease occurrence with the consequence (Table 3.5).

Table 3.4 Risk categories combine matrix: Release x Exposure

		Parameter 2 Exposure risk category				
		Negligible	**Very low**	**Low**	**Medium**	**Very high**
Release risk category	**Parameter 1**					
	Very high	N	VL	L	M	VH
	High	N	VL	L	M	H
	Medium	N	VL	VL	L	M
	Low	N	N	VL	VL	L
	Very low	N	N	VL	VL	VL
	Negligible	N	N	N	N	N

Table 3.5 Risk combination matrix: likelihood of disease occurrence x Consequence

	Consequence Transmission risk category				
Combine release and exposure risk category	**Negligible**	**Very low**	**Low**	**Medium**	**Very high**
Very high	N	VL	L	M	VH
High	N	VL	L	M	H
Medium	N	VL	VL	L	M
Low	N	N	VL	VL	L
Very low	N	N	VL	VL	VL
Negligible	N	N	N	N	N

3.4 Data management and analysis

Microsoft access version 2013 was used to fill the data then extracted to excel spreadsheet for data analysis. Data on FW management and uses as well as pig health problems related to FW uses were analyzed and summarized as frequencies within different sources of FW, risk of pig health problems was assessed as low, medium, high following risk pathway and based on the proportions of pig holdings applied FW management practices and mentioned about pig health problems related to FW. Draw.io software was used to draw the risk pathway based on the data collected.

Chapter 4 – Results

4.1 Description of the farm sample

Interviewed farm locations shown on the GPS map within the distance of 10 to 15 km from Hanoi center (Figure 4.1). A half of 41 interviewed pig farmers was breeding fattener only (n=21) and half were mixed farms (breeding sows, weaners and fatteners, n=20). Most interviewed farmers are FW collectors and used FW for their pig production (n=36), one farmer was collector, user and distributor the FW to other farms (i.e. sell unused FW to other farmers). Whereas the number of farmers bought FW from the FW collectors was only 4 farmers. These people bought FW at collectors because they did not have the relationship with the food producers and they did not have enough time to do the FW collecting process. The reasons of FW collecting was to make more profit (n=40) in pig production, less investment (n=2) for animal feed and make the environment cleanly and friendly (n=6).

Only fattening pigs and gestation sows were fed by FW whereas farrowing and piglets would not be fed with FW. 35 swine breeders fed FW diet for pigs from 25-30 kg (35/41 farms). They did not feed at the early stage of weaning because pig can have enteric problems. Pigs needed at least 2 weeks or 1 month of being familiar to the feed. Only 1 farmer fed the FW for the weaning pigs. He said that the quality of FW from the hotel where he collected was good and fresh. His pigs did not have any health problems even in the weaning period. 5 farmers thought that pigs at 50kg weight have had the best digestion and immune system, thus FW can be used for pig at that weight.

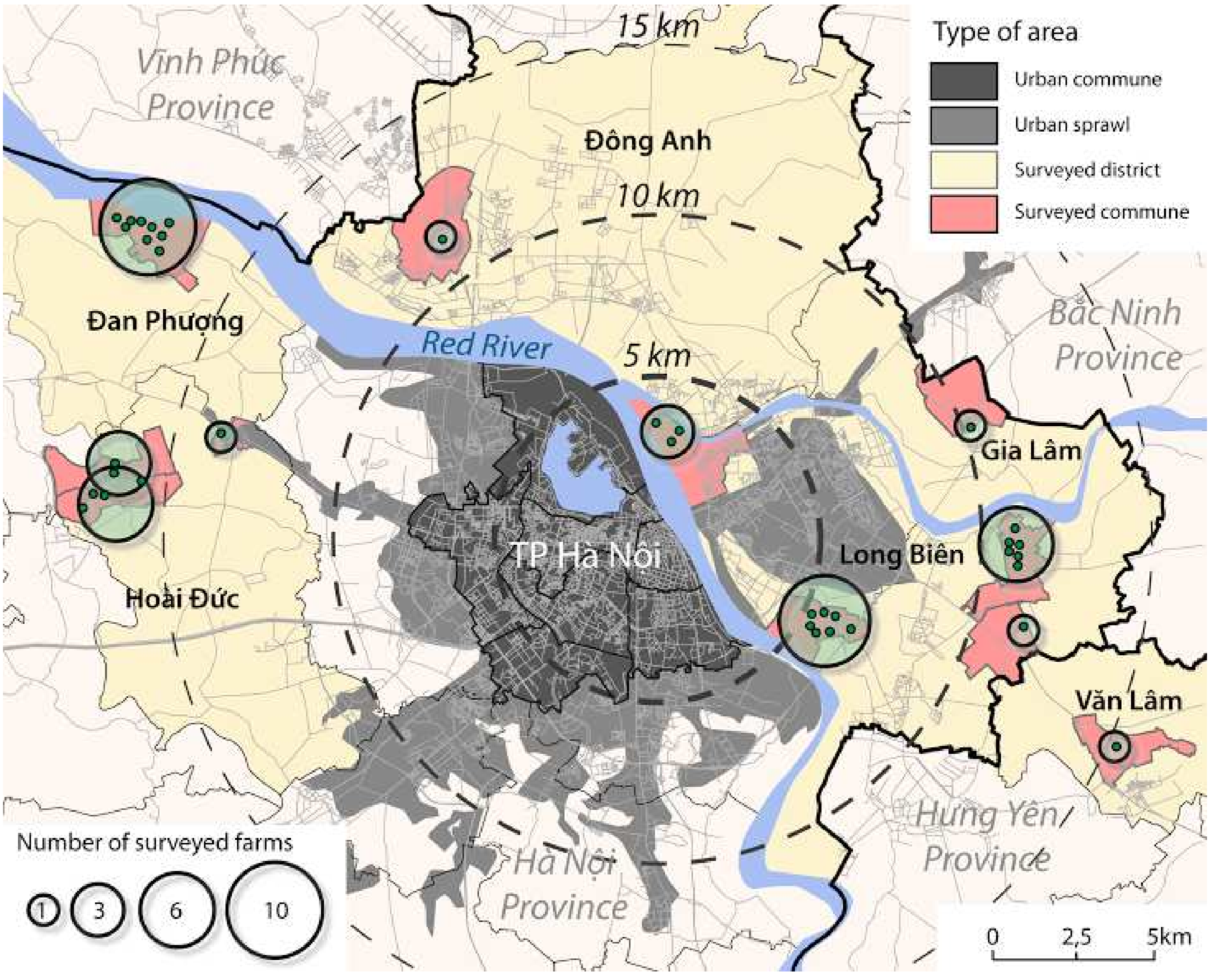

Figure 4.1 GPS mapping with the interviewed farms location

Economic benefits of re-using FW

Most pig farmers mentioned that used of FW to feed animals had economic benefit. First of all, the cost of FW is lower than the cost of commercial feed. Feed cost can be saved from 20% (2 farmers), 30% (3farmers), 40% (4 farmers), 50% (11 farmers) and up to 60% (1 farmer). In addition, farmers can utilize other agriculture products in their house such as tofu residue, wine rice lees, corn in combination with FW to feed pig. Secondly, feeding FW is less investment than feeding by commercial feed (100% farmers mentioned this reason, they have not enough economic budget and land to build an industry farm with automatic trough system to feed pigs by commercial feed). The price of commercial feed is fluctuation and the price of carcass is too, the farmers who fed pigs by commercial feed will be lost more money than farmers fed by FW. Some farmers started to collect the FW over a decade and they would like to maintain it in a long time. This job is strenuous work but it improves the income for their family.

4.2 FW use and management

Collecting point

FW was collected from the different sources. More than half of interviewed pig holders mentioned that FW was collected at the small restaurant (22/41). Other sources of FW were from canteen (8/41), hotel (4/41), residential area (3/41) and collector house (4/41) (Figure 4.2). 14 collectors collected FW in 1 collecting point, 4 collectors collected FW from 2 collecting points, 2 collectors collected FW from 2 collecting points and 17 collectors collected FW from more than 3 collecting points. FW was separated at the collecting points by waiters (n=18) or collectors (n=6) or both (n=2). Only two collectors separated the FW at their farms. The separation types depended on the contract between the collectors and the food producers.

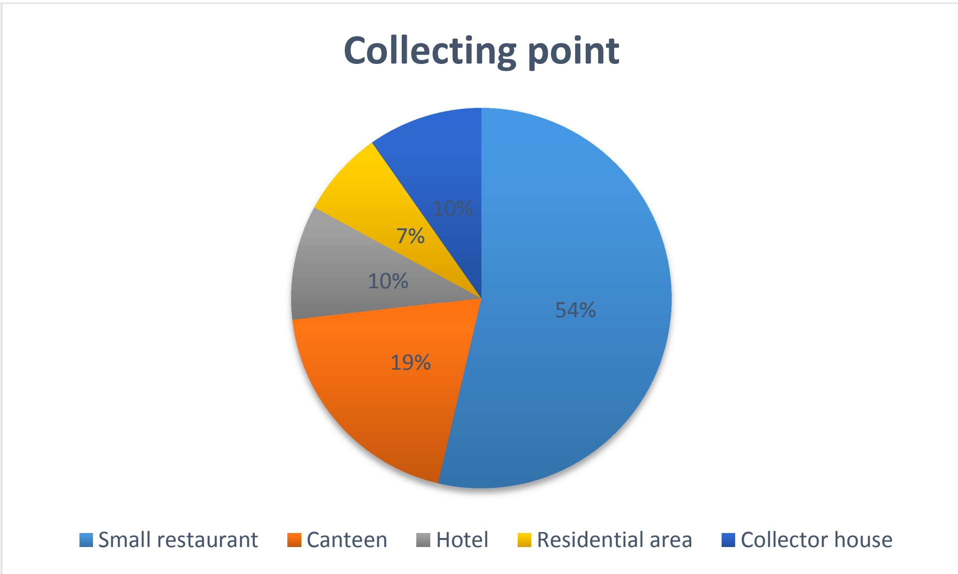

Figure 4.2 FW collecting point categories and percentage of farmers collecting the FW from each category

Usually FW was collected 1 times/day (30/41), 6/41 collectors collected FW 2 times/day, around 5 collectors collected FW every 2 days.

No specific link was observed between types of farm and collecting point, this depended more on the type of relationship between collectors and producers.

FW treatment

All of farmers cooked FW before feeding to pigs. After transported to the farm FW can be stored overnight or cook immediately or just cooked a half and stored the leftover for the next day. Heat treatment was considered as the best FW practice to reduce the risk of pathogen contaminated into the FW. The size of FW cooking container was around 50 to 600 litters, depended on the size of pig farm. It takes 1 -3 hours for FW cooking, farmers stirred the FW to ensure that the FW cooked thoroughly and to kill the bacteria. Then, FW was kept on the stove at least 20 minutes before scooping out to small containers for cooling.

FW components

FW contains rice and noodle (60%), bread (1%), cooked meat (pork, chicken, duck) (7%), fishes (3%), vegetables (17%), and uncooked meat (3%) and fish (3%), and uneaten (3%) (Figure 4.3). It has the foreign objects as chopsticks, toothpicks, spoon and nylon bags. Some collectors said that the FW have been collected, in 2 types: condensed FW (19/41 collectors) and liquid FW (22/41 collectors), the percentage of liquid FW components are 30% of water and 70% of FW). Most of liquid FW has been collected at small restaurants and canteens.

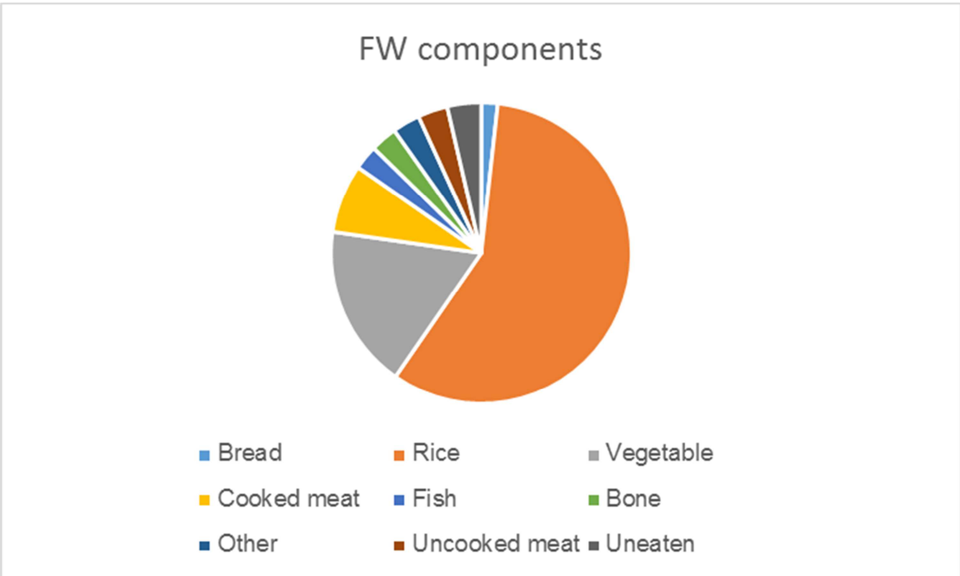

Figure 4.3 FW components and percentage of each component

FW adding during the treatment process

The nutrition values of FW collected was considered as not balance for pig growth, so 39 farmers mentioned that they had to add more food sources such as: tofu residue, corn, wine rice lees, bran and commercial feed (Figure 4.4). Only 3 farmers have not added any type of food into the FW meal for pigs because they thought that supplement sources supplied enough food for their pigs.

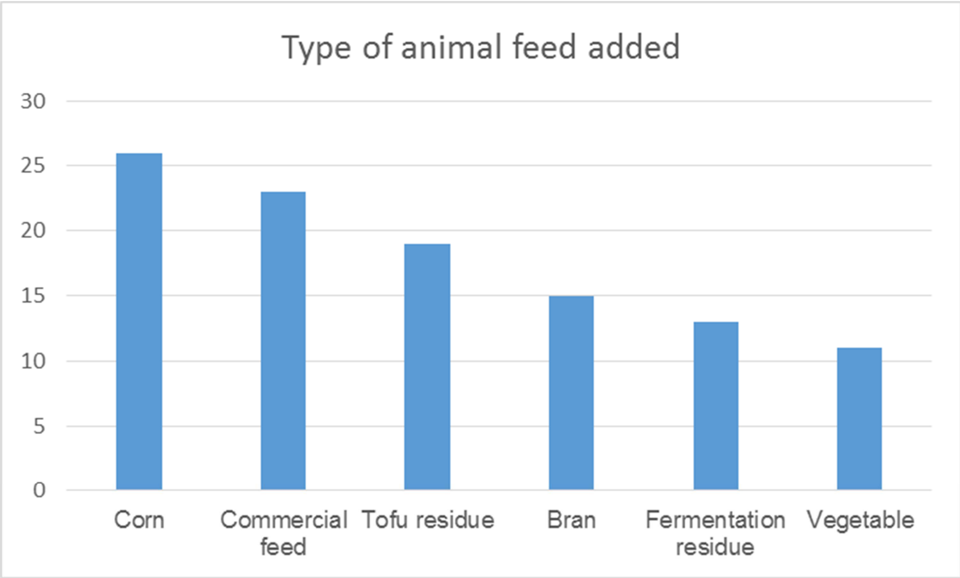

Figure 4.4 Type of animal feed added into the FW before feeding the pigs expressed as a proportion of farmers using this additional feed component in their FW

Corn was mix with FW to make FW more condensed. Tofu residue can reduce the constipation whereas fermentation residues such as wine rice lees, beer residue help pigs to improve the digestion system. Vegetables, tofu residues improve the appetite of pigs. Commercial feeds usually add at the fattening stage to gain more weight and produce more lean meat (per farmer's perceptions).

Farm biosecurity

Most of the farms located at the residential area with the high population and house density, with very poor biosecurity. Access to the farm had no control in more than half of farms visited (26/41), no vehicle disinfection sink was at farm gate. Farmers did not like to work with the boot or gloves except in winter.

4.3 Health problems in the sampled farms (and potential link with FW use)

Table 4.1 The list of health problems mentioned by the farmers in the interviewed farms

Health problems	Number of farm affected	Farmers perception	Link with FW use
Bacteria			
Pasteurelosis	3	Seasonal, outbreak	No
Salmonellosis	1	Weather	No
Edema disease	5	Pigs eat more food, the biggest pigs in batch	No
Virus			
Pneumonia enzootic	22	Seasonal, weather, no vaccination, breeder, swill has water, cold, pigs care	No
Erysipelas suis	1	Weather	No
FMD	2	Winter and outbreak	No
CSF	5	Weather change, vaccination did not protect well,	No
Swine influenza	2	Weather, no vaccination	No
Physical hazard			
Physical hazard	18	FW contaminated toothpicks, pigs did not die but have fever, eat loss, gain weight were not equal than normal pigs, the number of pigs inffected 1-4/100/year	Yes
Parasite			
Parasite	9	Larvae in liver, intestine, round worm	No
Other symptom			
Diarrhea	34	Outbreak, FW has fat, weather change, FW contaminated dishwashing dishes	Yes

Figure 4.5 show that the frequency of pig health problems mentioned by the farmers interviewed. The 3 most important problems mentioned were diarrhea (83%); enzootic pneumonia (54%) and physical hazard (44%).

The common reasons mentioned for contagious disease occurring at the farms were weather change, outbreak around their farms, vaccination, use of breeders. Famers only mentioned that diarrhea and physical hazard might be linked with the FW used in farm (Table 4.1). Following the farmer's perception, the reason for FW to cause diarrhea was because it was contaminated with dishwashing liquid (n=4), FW had more fat (n=5), the change of diet (n=11), FW had smell (n=1). Nine farmers mention parasite infestation in their pigs were larvae of fluke worm in liver (n=1), intestine (n=2), the larvae in liver and intestine (n=1) and round worm (n=5).

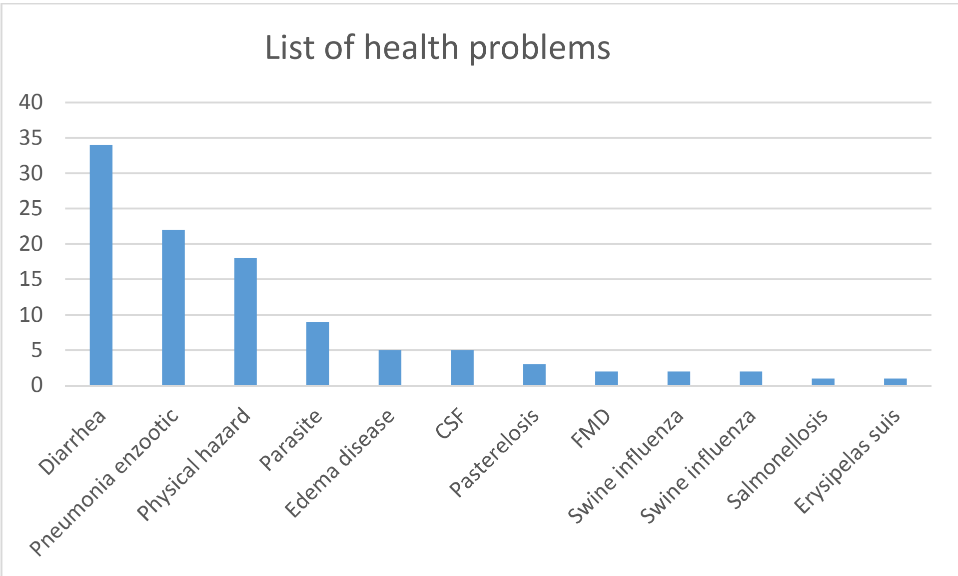

Figure 4.5 Type and proportion of farmers mentioning health problems in their pigs at the interviewed farms

4.4 General risk pathway for pig health risks due to FW consumption (risk of introduction and exposure)

Based on the information from the interviewed farmers, the general pathway was drawn with 4 types of FW sources as small restaurant, canteen, hotel and residential area. At the collecting point, FW can be contaminated due to the storage time, type of FW components, FW separation management and mixing FW from the different collecting points. FW which has also contaminated during the transportation, the routes of release FW contaminated into the farm were identified, including FW segregation management, storage time, clean and disinfection containers, vehicles, FW distribution. The exposure pathways considered were taking into account the FW processing at farm such as FW segregation management, FW treatment, FW storage and the biosecurity. The consequence pathways considered were the pig health problems related to the consumption of FW contaminated (Figure 4.6).

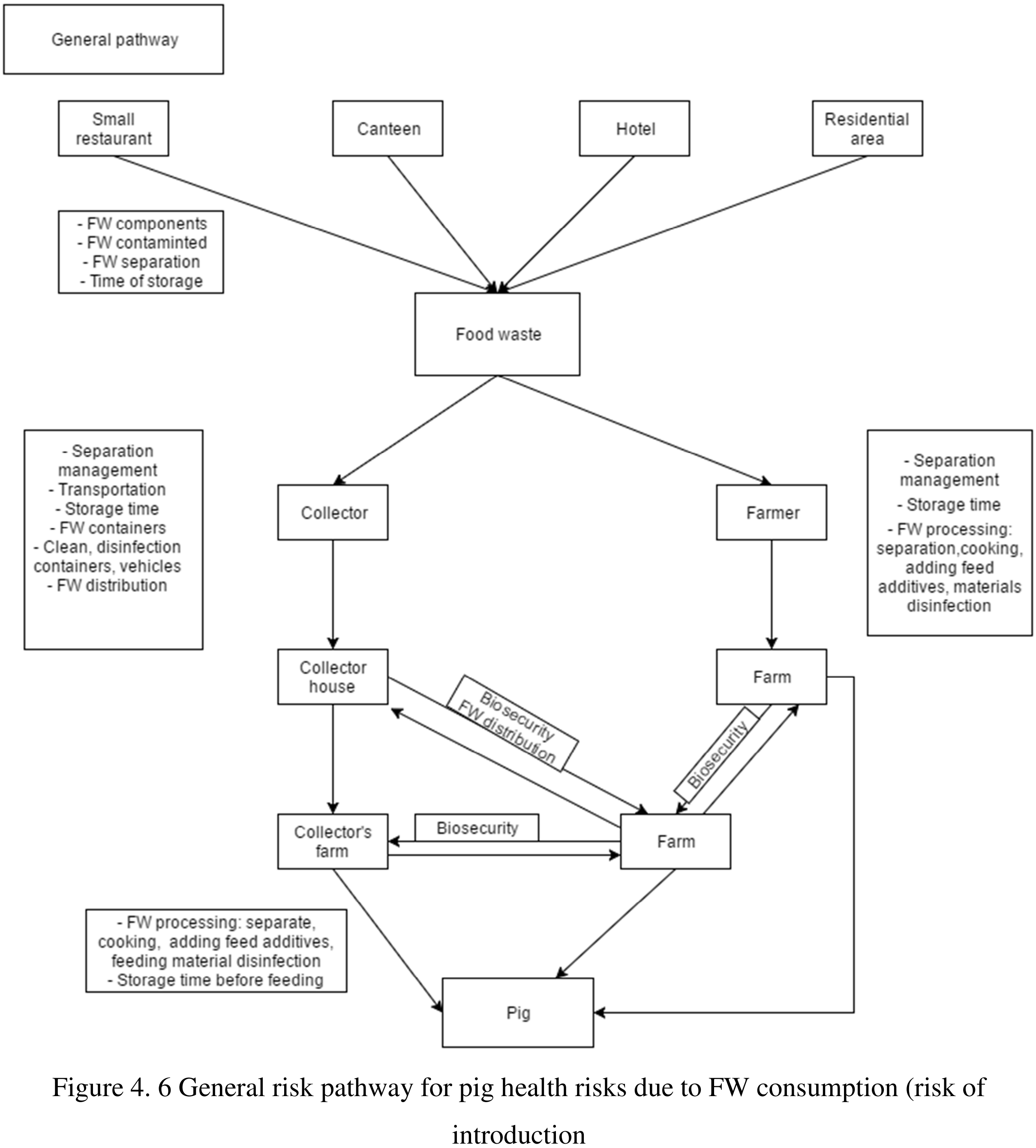

Figure 4. 6 General risk pathway for pig health risks due to FW consumption (risk of introduction

4.5 Qualitative assessment of physicial hazard (PH) pig health risk from FW consumption

4.5.1 PH risk of introduction in the farm and exposure to the pigs via FW

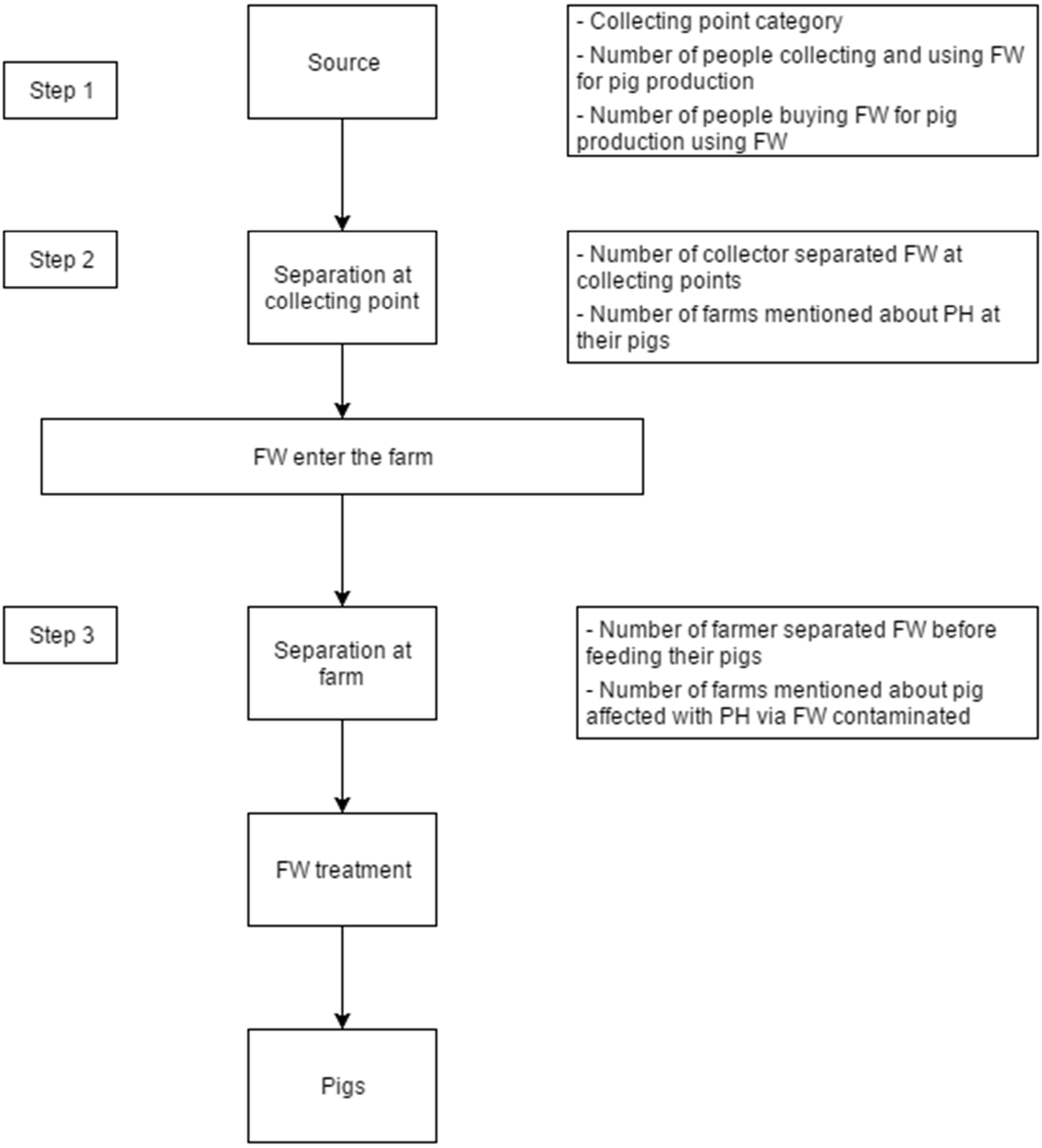

Figure 4.7 Pathway of risk of PH consumption by the pigs via FW use

In the general pathway, we considered 4 type of collecting points, including small restaurant, canteen, hotel and residential house. For the risk of PH in FW contamination we focused on 5 type of sources: small restaurant, canteen, hotel, residential house and collector house (farmer go to the collector house to buy FW). The different type of PH mentioned to contaminate the FW were toothpicks, chopsticks, spoon, and napkin from the customers at the restaurant. Nylon bags, big bone, seashell can be contaminated into the FW containers from the kitchen. Rock and nails can contaminate FW during the time collectors transferred or stored the FW. It is easy to separate and discard the big foreign objects during separation step or if not, farmers mentioned that the pigs do not eat the hard PH such as rock, nails. Toothpicks are small and hard to separate, so more farmers mentioned this kind of PH as a threat for their pigs. Furthermore, PH cannot be removed by boiling so small PH such as toothpicks cannot be eliminated from the FW contaminated (Figure 4.7).

Based on the list of health problems of the interviewed farms, 18 farmers confirmed that their pigs had exposure with the PH (toothpicks) via FW contaminated. The list included 11 farmers collecting the FW from the small restaurants, 4 farmers from the canteen, 2 farmers at the hotel and only 1 farmer bought the FW from the collector house.

PH can be enter farms through FW which did not go through a separation step before. Some farmers separate the PH before doing the FW treatment process. The probability of PH to remain in the FW which did not go through any separation steps neither at the collector house or farm was high.

Table 4.2 Data need to estimate the risk of PH contaminated FW introduced into the farms and pig consumption of PH via FW

	Risk pathway step and data available					
Source	Separate PH at collecting point	Separate PH at farm	Farms have pigs eat FW contaminated with PH	Missing data	Risk category	Risk uncertainty
Small restaurant (n=22)	Yes: 15 (68%)	Yes:12 (80%)	n= 4 (33%)	-Medium scale farmers sold the live pigs, they have not information of the slaughtered pigs - The farmers buy FW from collector house, they unknow the FW source	N	L
		No: 3 (20%)	n= 2 (67%)		L	L
	No: 7 (32%)	Yes: 3 (43%)	n= 2 (67%)		L	M
		No: 4 (57%)	n= 3 (75%)		L	H
Canteen (n=8)	Yes: 8 (100%)	Yes: 2 (25%)	n= 0		N	L
		No: 6 (75%)	n=4 (67%)		N	L
	No:0		n=0			
Hotel (n=4)	Yes: 3 (75%)	Yes: 1 (33%)	n=1 (100%)		M	L
		No: 2 (67%)	n=1 (50%)		VL	L
	No: 1 (25%)	Yes: 1 (100%)	n=0		N	L
		No:0				
Residential area (n=3)	Yes:1 (33%)	Yes: 1 (100%)	n=0 (0%)		N	L
		No: 0				
	No:2 (67%)	Yes: 1 (50%)	n=0		N	L
		No:1 (50%)	n=0		N	L
Collector house (n=4)	No data	Yes: 1 (25%)	n=0		N	L
		No: 3 (75%)	n=1 (33%)		L	H

*N: negligible; VL: very low, L: low; M: medium; H: high

4.5.2 Scenario tree

A scenario tree was used to assess the risk of PH via FW contaminated at different source categories (Figure 4.8; 4.9; 4.10; 4.11; 4.12)

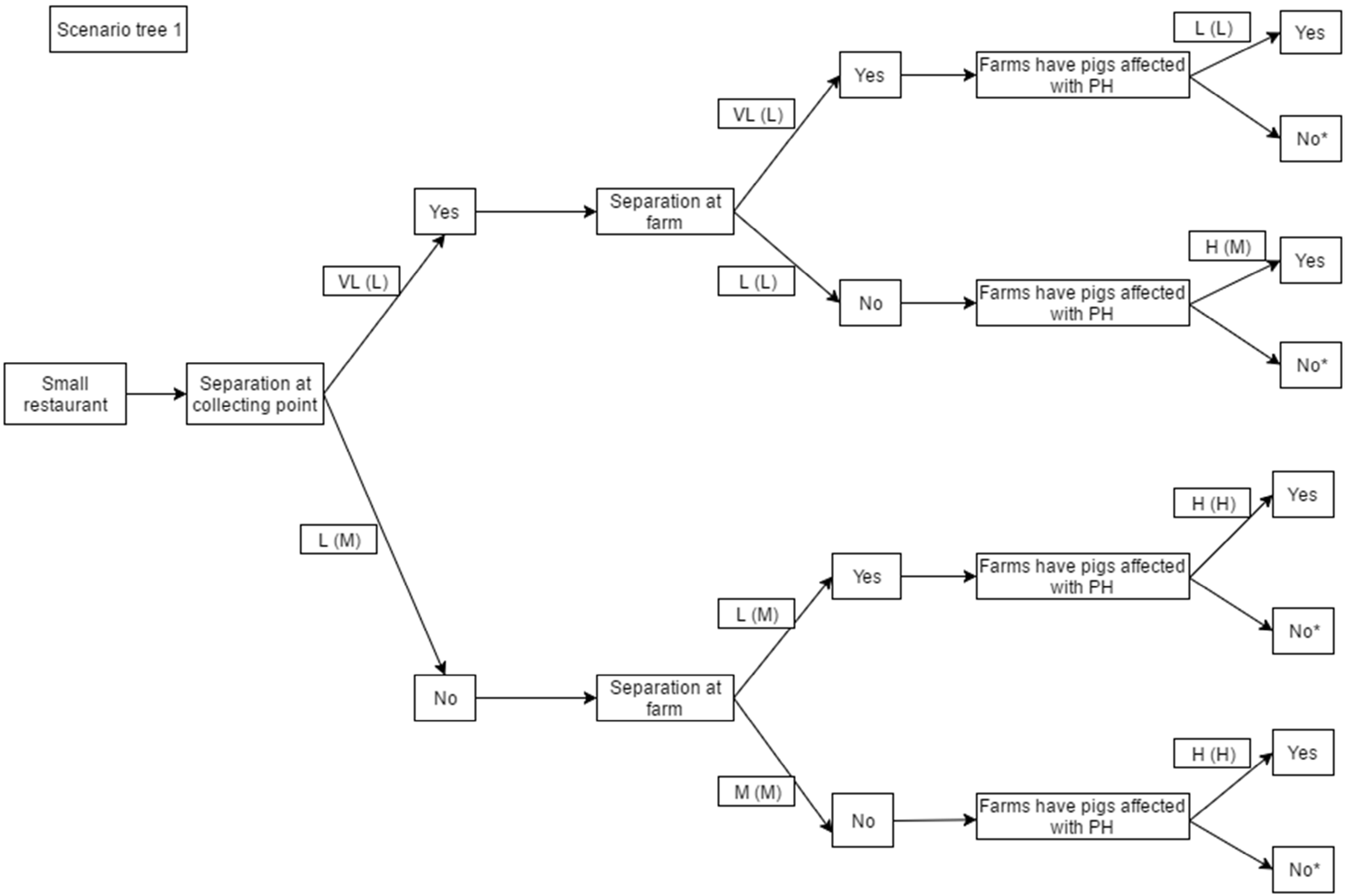

Figure 4.8 Scenario tree for the probability of pigs affected with PH via FW contaminated at small restaurant source

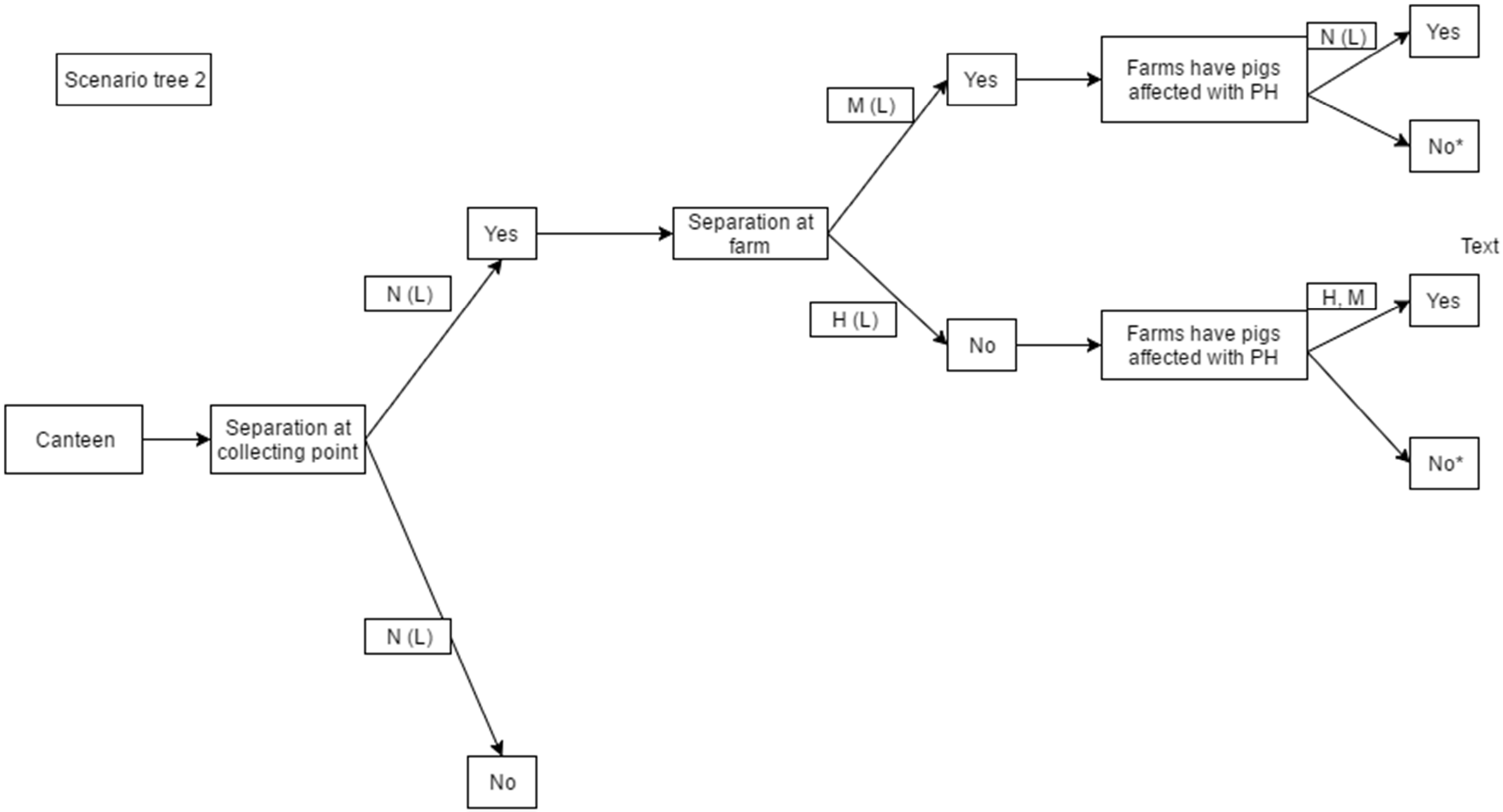

Figure 4.9 Scenario tree for the probability of pigs affected with PH via FW contaminated at canteen source

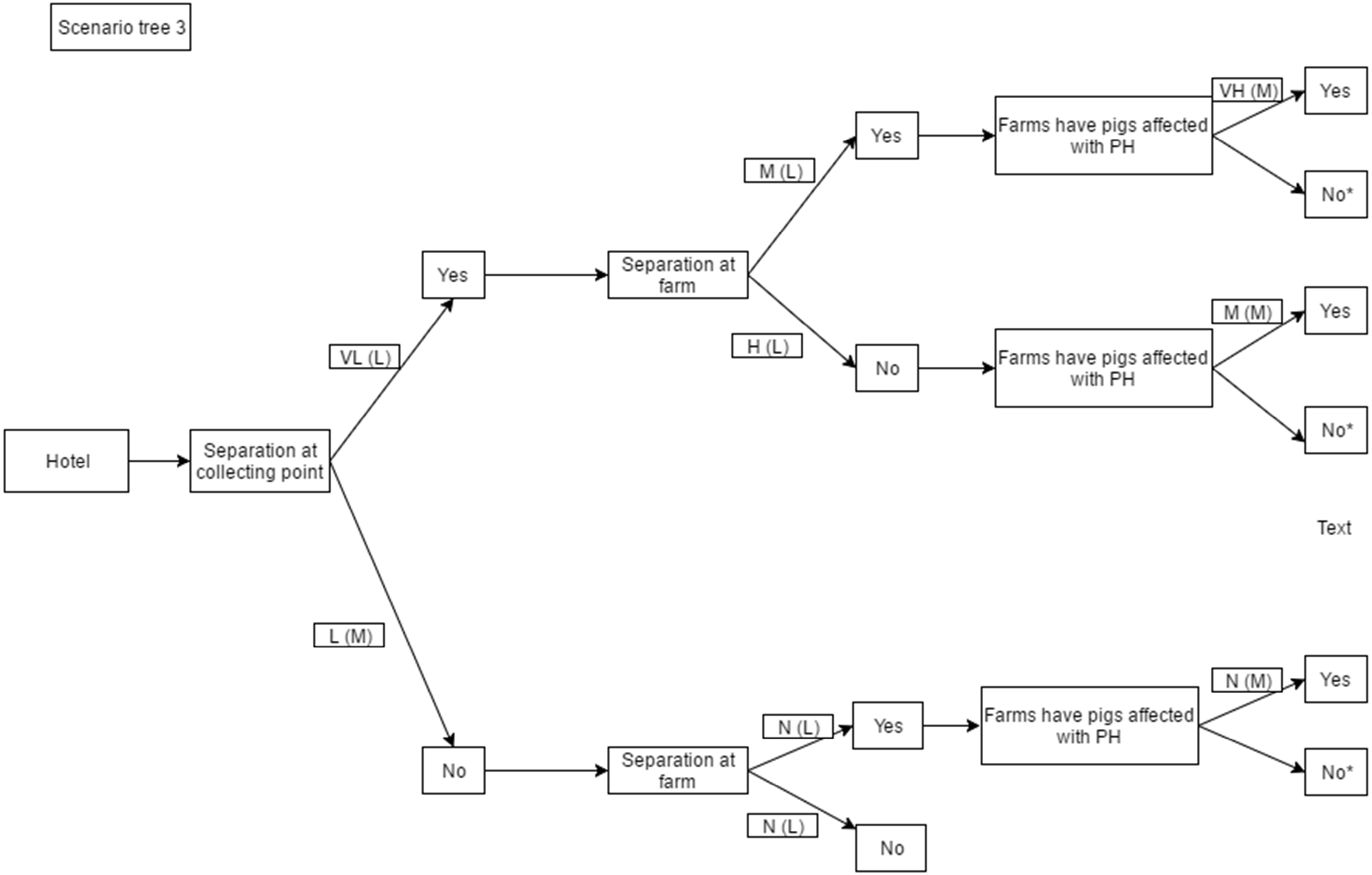

Figure 4.10 Scenario tree for the probability of pigs affected with PH via FW contaminated at hotel source

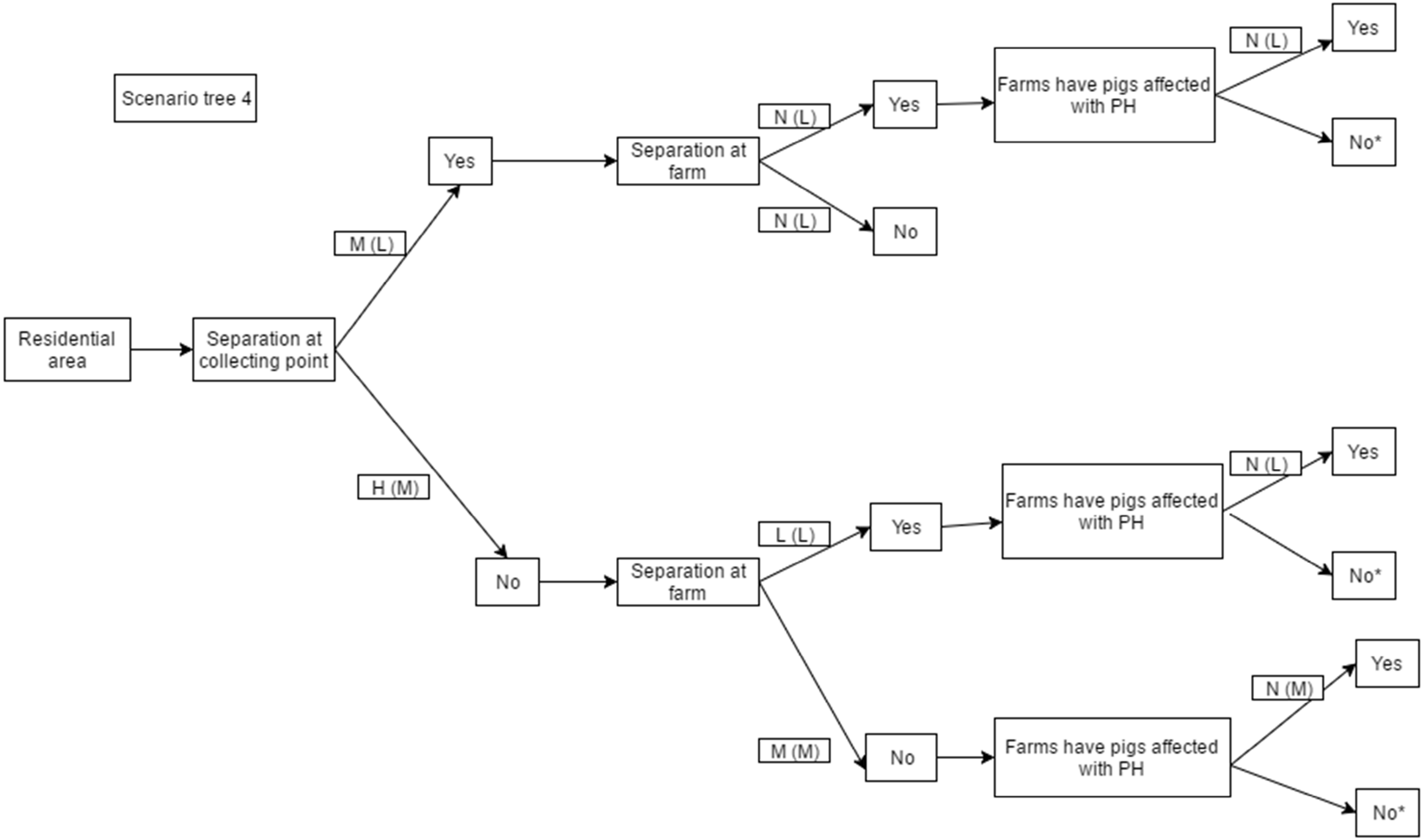

Figure 4.11 Scenario tree for the probability of pigs affected with PH via FW contaminated at residential source

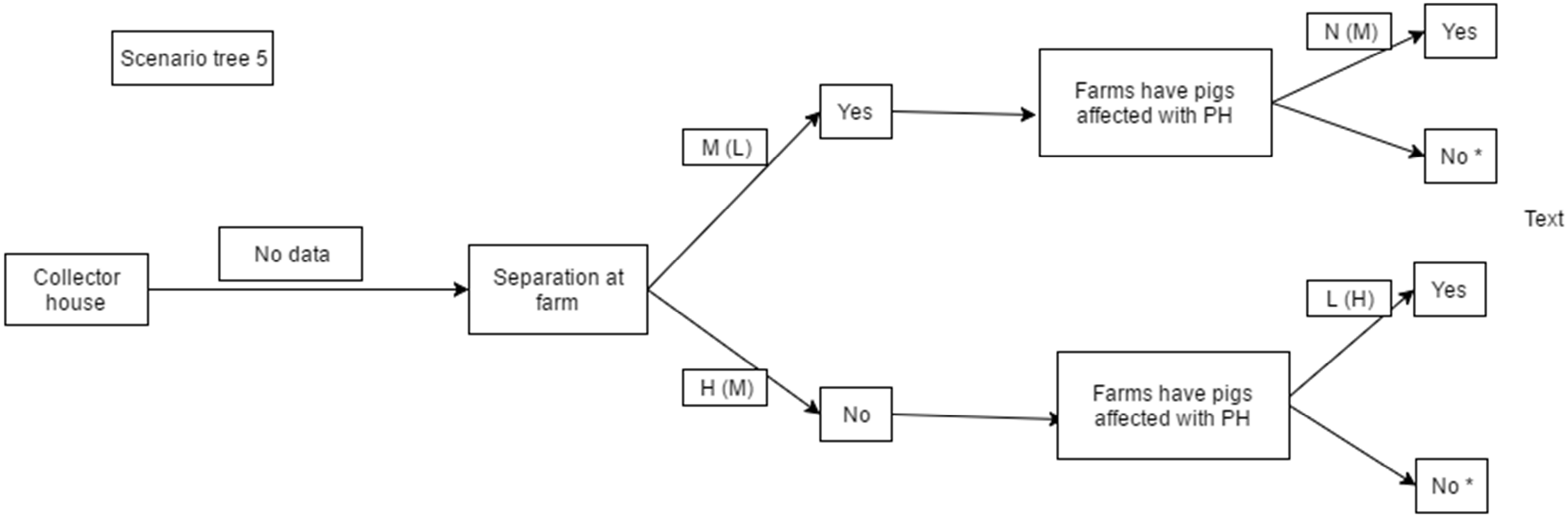

Figure 4.12 Scenario tree for the probability of pigs affected with PH via FW contaminated at collector house source

4.5.3 Likelihood of PH in FW contaminated

We estimated the likelihood of pig eating PH contaminated FW for the 5 collecting point categories using the combination matrix for release and exposure probabilities (Table 4.3)

Table 4.3 Estimation of the likelihood of PH in FW contaminated in the different collecting points

Collecting point categories	Separation practices	Release		Exposure		Likelihood of FW contaminated with PH	
		Risk	Uncert.	Risk	Uncert.	Risk	Uncert.
Small restaurant (n=22)	Collecting point and farm	VL	L	VL	L	N	L
	Collecting point only	VL	L	L	L	VL	L
	Farm only	L	M	L	M	VL	L
	None	L	M	M	M	VL	M
Canteen (n=8)	Collecting point and farm	N	L	M	L	N	L
	Collecting point only	N	L	H	L	N	L
Hotel (n=4)	Collecting point and farm	VL	L	M	L	VL	L
	Collecting point only	VL	L	H	L	VL	M
	Farm only	L	M	N	L	N	M
Residential area (n=3)	Collecting point and farm	M	L	N	L	N	L
	Farm only	H	M	L	L	L	L
	None	H	M	M	M	M	M
Collector house (n=4)	Farm only			M	L	M	M
	None			H	M	H	M

*N: negligible; VL: very low, L: low; M: medium; H: high

4.5.4 Consequences of PH contaminated FW fed to the pigs

If the pig would eat PH from FW, they can experience some symptoms like fever, eating loss but this will be only for a short period and then the pig can recover. 18 farmers confirmed that toothpicks were present inside the pig’s stomach when they slaughtered (43.9%). Every year they have around 100 pigs to slaughter at farms, among of that 1-4 pigs have toothpicks on their stomach. The number of farms have pigs affected with PH depended on the separation management and the type of FW sources. Only pigs have slaughtered at farms were confirmed this information. For the other farm, they do not receive the feedback from the trader, so we missed some data here. PH can caused fever, eating loss, but it did not make the pigs death. The probability was considered as mentioned in the table 4.4.

Table 4.4 Estimation of the risk of consequence PH in FW contaminated in the different collecting points

Collecting point categories	Separation practices	Risk level of consequence	
		Consequence	Uncertainty
Small restaurant (n=22)	Collecting point and farm	L	L
	Collecting point only	H	M
	Farm only	H	H
	None	H	H
Canteen (n=8)	Collecting point and farm	N	L
	Collecting point only	H	M
Hotel (n=4)	Collecting point and farm	VH	M
	Collecting point only	M	M
	Farm only	N	M
Residential area (n=3)	Collecting point and farm	N	L
	Farm only	N	L
	None	N	M
Collector house (n=4)	Farm only	N	M
	None	L	H

*N: negligible; L: low; M: medium; H: high; VH: very high

4.5.5 Overall risk estimation of pigs affected with PH via FW contamination

The likelihood of PH in FW contaminated and the probability of PH related pig infection were combined using the combination matrix in Table 3.4, giving an overall risk estimate for pigs eaten PH via FW contamination (Table 4.5):

- At small restaurant:
    - Separation at collecting point and farm: negligible with low uncertainty
    - Separation at collecting point: low with low uncertainty
    - Separation at farm: low with medium uncertainty
    - No separation: low with high uncertainty
- At canteen:
    - Separation at collecting point and farm: negligible with low uncertainty
    - Separation at collecting point: negligible with low uncertainty

- At hotel:
    - Separation at collecting point and farm: medium with low uncertainty
    - Separation at collecting point: very low with low uncertainty
    - Separation at farm: negligible with low uncertainty
- At residential area:
    - Separation at collecting point and farm: negligible with very low uncertainty
    - Separation at farm: negligible with low uncertainty
    - None separation: negligible with low uncertainty
- At collector:
    - Separation at farm: negligible with low uncertainty
    - Not separation at farm: low with high uncertainty

Table 4.5 Estimation of the overall risk of pigs affected with PH via FW contamination

Collecting point categories	Likelihood of FW contaminated with PH		Consequence persistence		Overall risk estimate	
	Risk	Uncertainty	Consequence	Uncertainty	Risk	Uncertainty
Small restaurant (n=22)	N	L	L	L	N	L
	VL	L	H	M	L	L
	VL	L	H	H	L	M
	VL	M	H	H	L	H
Canteen (n=8)	N	L	N	L	N	L
	N	L	H	M	N	L
Hotel (n=4)	VL	L	VH	M	M	L
	VL	M	M	M	VL	L
	N	M	N	M	N	L
Residential area (n=3)	N	L	N	L	N	L
	L	L	N	L	N	L
	M	M	N	M	N	L
Collector house (n=4)	M	M	N	M	N	L
	H	M	L	H	L	H

*N: negligible; VL : very low; L: low; M: medium; H: high; VH: very high

Chapter 5 – Discussion

In this study, a risk assessment framework was developed to estimate the risk of pigs being affected by PH via FW contaminated, based on the information provided by farmers and from the literature review. For this study it was assumed that other hazards such as bacteria, virus or parasite would be eliminated by cooking and all the farmers interviewed cooked the FW before feeding the pigs.

The risk of pigs eating PH contaminated FW varied according to the different collecting point and the sequences in terms of separation management. The study showed that the risk was higher when it was collected from small restaurants where the FW is mixed with multiple collecting points. Farmers need to collect from different collecting points because of the amount of FW from small restaurant was not enough to supply for their pigs. The study highlighted that the risk of PH such as toothpick was high under some circumstances however the consequences seemed to be low. Some farmers thought it is not important whereas some farmers noticed that pigs had a short period of time getting fever, eating loss but they unknown the reason.

FW can be contaminated with biological hazards during the transportation, storage and treatment process, storage before feed to release the heat. Bacteria can incubate during the transportation and storage time. All of farmers interviewed were cooking FW before feeding the pigs, but practices varied according to the farmers: different types of containers; different cooking time and different material supplements to FW after cooking (i.e. feed as tofu, vegetables, corn and commercial feed); therefore the temperature of cooked FW varied and it might have impact on the survival of biological hazards. In addition, time of cooked FW storage before feeding pig can have influence on the growth of bacteria, virus contaminated in cooked FW etc. so it can have effects on the pig health. Therefore, it would be interesting for further studies to look into the risk pathways for bacterial and viral diseases in pig holdings using FW for pig production.

Small holders have still raised the pigs by the traditional method, recycling the food surplus in order to make more profit because of feed cost. Using FW as animal breeding with an appropriate heat treatment was perceived as appropriated way to reduce the risk of microbial hazards.

Based on preliminary data from this study the risk of viral/bacterial infection in pig holdings from FW would be considered not only due to FW but also poor bio-security. Pathogen transmission between households can be linked to contaminated mechanical transportation between pig holdings and FW collection points. Raw meat is a component of the FW (even if very low) and it can be contaminated to containers and vehicles during transporting and can be potential risk of pig infection at farms.

Based on the result of this study, diarrhea seemed to be a big concern in the interviewed farms, it can cause important economic impacts. The diarrhea symptom linked to chemical hazards (such as dishwashing liquid) was mentioned by pig holders so this should be an interesting issue for further investigation.

Food safety is increasingly concerned by Vietnam government in this year. Therefore food practices at restaurant, canteen are sensitive topics. Farmers did not want to share the information about the collecting points and FW collecting process (i.e. how they separated FW). Moreover, regarding the health problems, this was based on the farmer perception, not on laboratory confirmation. Furthermore, the number of interviewed pig farmers of this study is quite small (41 farmers) compare to the required size of a risk assessment (n= 200 – 300). Results of this study would be more interesting if increasing the sample size and collecting additional data to perform the risk assessment for other the hazards identified in this study.

Chapter 6 - Conclusion

This is the first study showing the potential animal health risk of using FW for pig production in Vietnam. Different types of hazard were identified and the risk of PH was assessed. The study demonstrated that the risk for pig health was dependent on the FW source and management. Separation and cooking FW were essential steps to reduce the risk of physical and biological hazards affecting the pigs. However, these practices were shown to be different between the farms. The use of FW would also imply the risk for mechanical transmission of pathogens between pig holdings due to poor biosecurity. Further work should be done to qualitatively assess the risk of microbiological hazards (bacteria, virus and parasite) but also chemical hazards present into the FW to pig health.

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