THE STATUS OF HYGIENIC PRACTICES OF SMALL SCALE POULTRY SLAUGHTERHOUSE IN THAILAND: AN ECOHEALTH APPROACH

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DOCTOR OF PHILOSOPHY

(VETERINARY SCIENCES)

THE GRADUATE SCHOOL

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A THESIS SUBMITTED TO THE GRADUATE SCHOOL IN

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Title thesis The Status of Hygienic Practices of Small Scale Poultry Slaughter House in Thailand; an EcoHealth approach

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ABSTRACT

Salmonella is pathogen of many mammalian species and it is one of the most important bacteria that cause food borne illness worldwide. Salmonella spp. can be commonly found in raw poultry and meat. Eggs, agricultural products, processed foods, raw milk and raw milk products and contaminated water also have been implicated in human salmonellosis. In Thailand, *Salmonella* was found to be the second largest cause of food poisoning, following rotavirus. Furthermore, antimicrobial-resistant strains of *Salmonella* spp. has been reported in many parts of the world. The importance of the resistance is that the bacteria acquire their resistance in the animal host before being transmitted to human through food chain. This may result treatment failures in human when applying antimicrobial agents to treat human salmonellosis. This study aimed to elucidate

the status of small scale poultry slaughterhouses and their affect to ecological and health in the community in order to sustainably enhance hygiene and functioning of small scale poultry slaughterhouses in Northern Thailand.

Initial steps included the identification of key stakeholders associated with the meat production chain, development of a research framework, and design of a methodology based on stakeholder consultations. The framework and methodology combine issues in five major areas: (1) public health, (2) socioeconomics, (3) policy, (4) veterinary medicine, and (5) communities and the environment. Consequently, a total of 41 small-scale poultry slaughterhouses were visited during the period from July 2011 to May 2012. Data on the current status of the slaughterhouses regarding productivity, economic status, hygienic management, and opportunities and challenges faced in improving the plants and following the DLD slaughterhouse regulations, were collected using a structured questionnaire and interviews. In addition, a checklist, which was developed based on the DLD regulations, was used for triangulation. In addition, a microbiological risk assessment approach was employed to detect Salmonella contamination in meat processing facilities. The microbial risk assessment was combined with stakeholder perceptions to provide an overview of the existing situation, as well as to identify opportunities for upgrading slaughterhouses in order to more effectively address matters of food safety, processing, and government licensing.

The results of this study demonstrated that the developed conceptual framework could elucidate the complex factors limiting small-scale slaughterhouse improvement including a lack of appropriate enabling policies and an apparent absence of feasible interventions for improvement. Unhygienic slaughterhouse management was reflected in the incidence of *Salmonella* contamination. The prevalence of *Salmonella* spp. in live poultry, carcasses, waste water, and soil around processing plants were 3.17%, 7.32%, 21.27% and 29.27%, respectively. Moreover, the bacteria could be isolated from each point of slaughter lines. Eighteen different serotypes were identified, the most common being Corvallis (15.19%), followed by Rissen (13.92%), Hadar (12.66%), Enteritidis (10.13%), [I. 4,5,12 : i : -], Stanley, and Weltevreden (8.86%). Tests revealed that 68.35% of the

Salmonella spp. were resistant to at least one antimicrobial while 50.63% showed multiple drug resistance (MDR). Specifically, 44.30% of Salmonella was resistant to nalidixic acid, followed by streptomycin (41.77%), ampicillin (34.18%), tetracycline (34.18%), and sulfamethoxazole/trimethoprim (20.25%).

Policy advocacy was implemented through meeting with policy-level DLD officer responsible for slaughterhouse control in Thailand. The instruction including blueprint and feasible criteria of good practice of small scale poultry slaughterhouse was developed and then tested of microbiological quality of the meat. The results showed that Coliform bacteria and total bacteria count in meat after implementation was lower than that before implementation. It could be concluded that there is potential for the use of an Ecohealth approach to address critical problems and it's solving at the interface of rural development and public health. The findings of this study could serve as a model for transdisciplinary studies and interventions related to other similar complex challenges.

ชื่อเรื่องวิทยานิพนธ์ การจัดการด้านสุขศาสตร์ของโรงเชือดสัตว์ปีกขนาดเล็กในประเทศไทย; การศึกษาโดยใช้แนวทาง EcoHealth

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บทคัดย่อ

เชื้อซัลโมเนลลา เป็นเชื้อสาเหตุหลักของโรคเกี่ยวกับระบบทางเดินอาหารที่มากับอาหารในสัตว์เลี้ยงลูกด้วยนมหลายชนิดทั่วโลก เชื้อนี้สามารถพบได้ในเนื้อสัตว์และผลิตภัณฑ์จากเนื้อสัตว์ ไข่ และสินค้าทางการเกษตรหลายชนิด และมีความเกี่ยวข้องกับโรคติดเชื้อซัลโมเนลลาในมนุษย์ในประเทศไทย เชื้อแบคทีเรียนี้เป็นสาเหตุอันดับสองของโรคอาหารเป็นพิษในผู้ป่วยรองจากเชื้อไวรัสโรตา นอกจากนี้ ปัญหาเชื้อแบคทีเรียซัลโมเนลลาที่ดื้อต่อยาต้านจุลชีพก็เป็นปัญหาวิกฤตทางสุขภาพที่สำคัญและมีรายงานทั่วโลก ความสำคัญของปัญหาเชื้อดื้อยาที่สำคัญได้แก่ เชื้อซัลโมเนลลาที่พบในสัตว์สามารถส่งผ่านคุณสมบัติของการดื้อยาไปยังเชื้อซัลโมเนลลาที่ก่อโรคในมนุษย์ผ่านทางห่วงโซ่การผลิตอาหารจากเนื้อสัตว์ได้ ซึ่งส่งผลกระทบที่สำคัญคือ ทำให้เชื้อแบคทีเรียซัลโมเนลลาที่เป็นสาเหตุของการติดเชื้อในผู้ป่วยดื้อต่อยาต้านจุลชีพที่ใช้รักษา จุดประสงค์ของการศึกษานี้คือเพื่อศึกษาระบบการจัดการด้านสุขศาสตร์ในโรงฆ่าสัตว์ปีกขนาดเล็ก และผลกระทบต่อสาธารณสุขและสิ่งแวดล้อม และพัฒนาแนวทางการพัฒนาระบบการจัดการด้านสุขศาสตร์ของโรงฆ่าสัตว์ปีกขนาดเล็กที่ตั้งอยู่ในเขตภาคเหนือของประเทศไทย

ทำการวิเคราะห์ผู้มีส่วนได้ส่วนเสียของระบบการผลิตเนื้อสัตว์ปีกและเชิญเข้ามามีส่วนร่วมในการวิจัยตั้งแต่ช่วงแรกของการดำเนินการ ทำการพัฒนากรอบแนวคิดงานวิจัย และการพัฒนาวิธีการศึกษาวิจัยร่วมกับผู้มีส่วนได้ส่วนเสีย กรอบการศึกษาวิจัยครอบคลุมสาขาวิชาที่เกี่ยวข้องได้แก่ 1) สาธารณสุข 2) สังคมและเศรษฐศาสตร์ 3) นโยบาย 4) สัตวแพทยศาสตร์ และ 5) ชุมชนและสิ่งแวดล้อม

ข้อมูลที่จำเป็นสำหรับการศึกษาเก็บรวบรวมได้จากฆ่าสัตว์ปีกจำนวน 41 แห่งในจังหวัดเชียงใหม่ในช่วงเดือน กรกฎาคม 2554-พฤษภาคม 2555 โดยข้อมูลที่ต้องการประกอบด้วยปริมาณการผลิตต่อวัน สถานภาพทางด้านเศรษฐศาสตร์ การจัดการด้านสุขศาสตร์และสุขอนามัยในโรงฆ่าสัตว์ แนวทางในการพัฒนาและปัญหาในการพัฒนาโรงฆ่าสัตว์ตามข้อกำหนดมาตรฐานโรงฆ่าสัตว์ปีกของประเทศไทย เครื่องมือที่ใช้เก็บข้อมูลประกอบด้วยแบบสอบถามและแบบสัมภาษณ์ และใช้แบบสังเกตและแบบบันทึกตรวจสอบในการสอบเทียบข้อมูล ทำการเก็บตัวอย่างจากสัตว์ปีกมีชีวิต ขั้นตอนการฆ่า ซากสัตว์และตัวอย่างจากสิ่งแวดล้อม เพื่อทดสอบการปนเปื้อนของเชื้อซัลโมเนลลา ข้อมูลการจัดการดังกล่าวและทัศนคติของเจ้าของโรงฆ่า ถูกนำมาวิเคราะห์ถึงสถานภาพการจัดการของโรงฆ่าสัตว์ปีก และโอกาสในการพัฒนาโรงฆ่าตามข้อกำหนดมาตรฐานโรงฆ่าสัตว์ปีกที่มีอยู่เพื่อให้เกิดความปลอดภัยทางอาหาร

ผลการศึกษาแสดงให้เห็นถึงความซับซ้อนของหน่วยงานและปัจจัยที่มีผลต่อการพัฒนาโรงฆ่าสัตว์ปีกขนาดเล็ก เช่น นโยบายที่ยังไม่ชัดเจนในการเข้าไปช่วยเหลือ ให้คำแนะนำในการพัฒนาโรงฆ่า ส่งผลให้โรงฆ่าสัตว์ปีกขนาดเล็กมีการจัดการสุขศาสตร์ที่ไม่เหมาะสม และทำให้เกิดการปนเปื้อนของเชื้อซัลโมเนลลา ทั้งนี้ ความชุกของเชื้อซัลโมเนลลาในสัตว์ปีกมีชีวิตก่อนการฆ่า ซากสัตว์ปีกหลังการฆ่าและชำแหละ น้ำเสีย และดินบริเวณรอบโรงฆ่าเท่ากับ 3.17%, 7.32%, 21.27% และ 29.27% ตามลำดับ นอกจากนี้ ยังแยกเชื้อได้ในขั้นตอนต่างๆ ของกระบวนการฆ่าชำแหละ ซีโรไทป์ที่แยกได้ส่วนใหญ่คือ Corvallis (15.19%), รองลงมาคือ Rissen (13.92%), Hadar (12.66%), Enteritidis (10.13%), [I. 4,5,12 : i : -], Stanley, และ Weltevreden (8.86%) ตามลำดับ 68.35% ของเชื้อที่แยกได้นั้นดื้อต่อยาต้านจุลชีพอย่างน้อย 1 ชนิด และ 50.63% ของเชื้อดื้อต่อยาต้านจุลชีพหลายชนิด 44.30% ของเชื้อดื้อต่อ nalidixic acid, รองลงมาคือ streptomycin (41.77%), ampicillin (34.18%), tetracycline (34.18%), sulfamethoxazole/trimethoprim (20.25%) tetracycline (34.18%), และ sulfamethoxazole/trimethoprim (20.25%).

ดำเนินการประชุมร่วมกับเจ้าหน้าที่ระดับนโยบายของกรมปศุสัตว์ที่ทำหน้าที่ควบคุมโรงฆ่าสัตว์ของประเทศของกรมปศุสัตว์ และได้พัฒนารูปแบบและข้อกำหนดที่ปฏิบัติได้จริงของแนวทางการปฏิบัติที่ดีของโรงฆ่าสัตว์ปีกขนาดเล็ก หลังจากนั้นได้ทำการทดสอบผลของการพัฒนาต่อคุณภาพเนื้อสัตว์ทางด้านจุลชีววิทยา ผลการทดสอบพบว่าสามารถลดการปนเปื้อนของเชื้อโคลิฟอร์มและเชื้อแบคทีเรียรวมที่ปนเปื้อนในเนื้อสัตว์ปีกหลังการชำแหละลงได้ การศึกษานี้สามารถสรุปได้ว่า การศึกษาโดยใช้แนวทาง Ecohealth มีประสิทธิภาพในการแสดงความซับซ้อนและความเชื่อมโยงอย่างครอบคลุมของปัญหาและแนวทางการแก้ไขปัญหาที่ครอบคลุมในทุกๆ ด้าน ผลการศึกษานี้เป็นแนวทางต้นแบบของการดำเนินการแบบสหสาขาวิชาและการแก้ไขปัญหาที่มีลักษณะซับซ้อนได้เป็นอย่างดี

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ABBREVIATIONS

AD	Anno Domini
AIFST	The Australian Institute of Food Science Technology
AMP	Ampicillin
BLQS	Bureau of Laboratory Quality Standard
C	Chloramphenicol
^{o}C	The degree Celsius
cfu	Colony forming units
CIP	Ciprofloxacin
CTX	Cefotaxime
CDC	Center for Disease Control
CO_2	Carbon Dioxide
DLD	Department of Livestock Development
EFSA	European Food Safety Authority
EU	European Union
FDG	Focus group discussions

g	Gram
GMPs	Good manufacturing practices
h	Hour
IDRC	International Development Research Center
ISO	International Organization for Standardization
HPAI	Highly pathogenic avian influenza
ml	Milliliter
N	Number
NA	Nalidixic acid
NOR	Norfloxacin
OIE	Office International des Epizooties
pH	Potential of Hydrogen ion
S	Streptomycin
SARS	Severe acute respiratory syndrome
SXT	Sulfamethoxazole/trimethoprim
TE	Tetracycline
USA	The United States of America
USD	United States Dollar

CHAPTER 1
INTRODUCTION

2.1 Background and description of the problem

Early in 2004, the highly pathogenic avian influenza virus H5N1 (HPAI H5N1) has emerged in many countries in Asia including Vietnam, Cambodia, China, Indonesia, Japan, Laos, Republic of Korea, and Thailand (1). In order to control the disease, the governments of each country initiated many programs for the control, eradication and establishment of a national campaign and control measures to contain and prevent avian influenza from spreading by following OIE guidelines. Result from combating with HPAI was a massive slaughter of many millions poultry. Unfortunately, there still have been reports of HPAI in many countries such as Cambodia, Vietnam and Indonesia. However, the disease triggered the awareness of zoonotic diseases in the region including food borne diseases.

Salmonella is pathogen of many mammalian species and it is one of the most important bacteria that cause food borne illness worldwide. *Salmonella* spp. can be commonly found in raw poultry and meat (2). Eggs, agricultural products, processed foods, raw milk and raw milk products and contaminated water also have been implicated in human salmonellosis. In European Union (EU), approximately 100,000 human cases were registered each year (3). In the United stated, 2 million human cases are reported annually. The disease causes enormous economic impact. There is report on estimated the cost for the disease in the United States and reported that the cost for the disease was USD 3.3 million annually for medical care and lost productivity (4). The disease is not only recognized as an economic loss, but it is considered as a public health concerns in terms of drug resistance.

Antimicrobial-resistant strains of *Salmonella* spp. has been reported in many parts of the world. The prevalence of resistant isolates in intensive animal production countries is between 10-30% and when focusing strains isolated from the food-producing animals that are held under intensive use of antimicrobial in animal production the prevalence might up to 60-90%. The importance of resistance to antimicrobial agents of *Salmonella* spp. originated from animal is that the bacteria acquire their resistance in the animal host before being transmitted to human through food chain (5,6) It is able to lead treatment failure when treatment human salmonellosis with antimicrobial agents.

Some reports indicated that poultry processing at the slaughterhouse might be the potential source of *Salmonella* contamination in meat. Rasschaert et al. reported that the improper slaughtering processes could higher bacterial contamination in meat (7). Padungtod and Kanenee studied the prevalence of *Salmonella* spp. in chicken at the farms and at the slaughterhouses in Northern Thailand and reported that the prevalence were 4% and 9% respectively (8). It could be noted that the slaughterhouses play important role of the source of *Salmonella* contamination in meat.

In Thailand, there are not many reports of *Salmonella* contamination in poultry meat in poultry slaughterhouses. The associated research regarding disease control and prevention was reported by Rojanasthien et al. that most of poultry slaughterhouses in northern Thailand were small scale (9). They also reported that the slaughterhouse owners lack the knowledge concerning the sanitation and disease control. Therefore, the sanitation and hygienic practices management ware poor and it need to be improved.

EcoHealth is an emerging field of study focusing how changes in the ecosystems affect human health. It has many disciplines. EcoHealth examines changes in the biological, physical, social and economic environments and relates these changes to human health. EcoHealth study differs from traditional study, single discipline studies. The researcher identifies the problems and seeks solutions for those problems. The result is that sometimes the direction for solving a problem does not actually result in a solution when it is implemented due to a lack of participation on the part of the group affected by the problem. Meanwhile, an Ecohealth study uses a different approach. It brings the multiple specialist disciplines together with members of the affected community since the study begins. This approach could lead to creative and novel approaches and can lead to a strong social solution.

Because there are many disciplines involving to operating a small scale poultry slaughterhouse including veterinary sciences, public health, social, economics, and environment. Therefore, how to improve the disease control and hygienic management in the small scale poultry slaughterhouses are multifaceted. These disciplines are needed to include to the study.

2. The objectives of this study

1. To determine the prevalence of *Salmonella* contamination in chicken meat in the small scale poultry slaughterhouses in Northern Thailand
2. To determine the level of antimicrobial-resistant *Salmonella* spp. presented in the slaughterhouses
3. To develop a pilot model or renovate the existing small scale poultry slaughterhouses through Ecohealth concept in order to make “sustainably enhance hygiene and functioning of the slaughterhouses”

CHAPTER 2
LITERATURE REVIEW

1. *Salmonella*

1.1 Taxonomy and characteristics of *Salmonella*

Salmonella bacteria are gram-negative rods that measure 0.7-1.5 by 2.0-5.0 μm. They are usually motile with peritrichous flagella and facultative anaerobic. Most species reduce nitrates to nitrites and they ferment glucose mostly with the formation of gas. The growth of *Salmonella* spp. depends on several factors including temperature, pH, water activity and levels of nutrients present. In general, *Salmonella* grows at temperatures between about 5°C and 46°C, with an optimum growth at approximately 37°C. *Salmonella* spp. decline during freezing, though the organism can survive for long time on frozen foods. *Salmonella* are killed by heat treatment. The pH for its growth ranges from 3.8 to 9.5 with an optimal pH between 7 and 7.5 (10).

The *Salmonella* serovars can be divided into 3 groups based on their association with particular host populations. *Salmonella* serotypes which are almost exclusively associated with one particular host species are called the host-restricted serotypes (e.g. human *Salmonella* Typhi and poultry *Salmonella* Pullorum). Serotypes which are prevalent in one particular host species but can cause disease in other host species are the host-adapted serotypes (e.g. *Salmonella* Dublin causes disease in cattle but can also infrequently cause disease in other mammalian hosts). The last group of serotypes are the unrestricted or broad-host-range serotypes, capable of inducing disease in a broad range of unrelated host species (e.g. *Salmonella* Typhimurium and *Salmonella* Enteritidis) (11).

Salmonella Typhi is the cause of typhoid fever with symptoms, such as sustained fever, headache, malaise, abdominal pain, and enlargement of the liver and spleen and systemic infections. It is transmitted by ingestion of food or water contaminated with feces from an infected person. Therefore, typhoid fever is a problem in parts of the world with poor sanitation practices (10).

Other *Salmonella* serotypes are non-typhoid and cause less severe symptoms in humans. Symptoms of gastroenteritis occur between a few hours and five days following ingestion of the pathogen. The symptoms are diarrhea, abdominal pain, headache, nausea, mild fever and sometimes vomiting. The diarrhea is non-bloody and varies from a few, thin stools to massive evacuation with accompanying dehydration. The disease is usually self-limiting and recovery occurs after a few days to a week. In some rare cases, the infection is followed by more serious complications especially in immunocompromised people, pregnant women, elderly and children. Approximately 5% of individuals with gastrointestinal illness caused by non-typhoidal *Salmonella* will develop bacteremia which is often accompanied with focal infections such as meningitis, septic arthritis, osteomyelitis, pneumonia and arteritis (12). According to the Center for Disease Control and Prevention (CDC) in the US, 0.04% of the estimated number of non-typhoidal *Salmonella* cases has a lethal outcome (13,14).

1.2 Temperature effects

Salmonella can grow in the presence or absence of air. The growth rate on beef muscle stored at 20 ^{o} C under nitrogen is only slightly less than that obtained when stored under air. At high concentrations of CO_2 (50-60%), growth is strongly inhibited on crab meat, beef steak and ground beef at a temperature of 10 to 11 ^{o} C, but at 20 ^{0}C there is little inhibition (15).

Salmonella can survive for 28 days on the surfaces of vegetables under refrigeration. Some foods, including meat, appear to be protective of *Salmonella* during freezing and frozen storage (16). AIFST reported that rapid freezing promotes survival and that lower storage temperature and less fluctuation in temperature give greater survival (15). Storage temperatures near the freezing point result in most death or injury. In chicken breast meat (pH 5.8), 60-83% of *Salmonella* cells survived storage at -20 ºC for 126 days, whereas at -2 ºC and -5 ºC only 1.3% to 5.8% were still viable after 5 days.

1.3 Epidemiology

Many reports revealed the study of *Salmonella* in poultry especially in European countries. In the European Union, wide baseline study of *Salmonella* in commercial broiler flock was done by European Food Safety Authority (EFSA) during 2005-2006. The prevalence of positive flocks varied from 0.0 to 68.2 %. A total of 11.0% of the broiler flocks were estimated to be positive for *Salmonella* Enteritidis and/or *Salmonella* Typhimurium (17). The summary of *Salmonella* prevalence in broiler flock in different countries is showed in table 1.

Table 1: Prevalence of *Salmonella* in broiler flock in different countries (percentage)

Country	Prevalence		Reference
	S. spp	***S.* Enteritidis and *S.* Typhimurium**	
Austria	5.4	1.3	EFSA 2007
Belgium	12.4 2.0	-	EFSA 2007
Cyprus	9.1 1.7	-	EFSA 2007
Czech Republic	19.3	9.6	EFSA 2007
Denmark	1.6	0.3	EFSA 2007
Estonia	2.0	1.7	EFSA 2007
EU	23.7	11.0	EFSA 2007
Finland	0.1	0.0	EFSA 2007
France	6.2	0.5	EFSA 2007
Germany	15.0	1.6	EFSA 2007
Greece	24.0	3.2	EFSA 2007
Hungary	68.2	5.1	EFSA 2007
Ireland	27.6	0.0	EFSA 2007
Italy	28.3	2.3	EFSA 2007
Latvia	6.2	5.1	EFSA 2007
Lithuania	2.9	3.3	EFSA 2007
Norway	0.1	0.2	EFSA 2007
Poland	58.2	32.4	EFSA 2007
Portugal	43.5	39.3	EFSA 2007
Slovakia	5.7	3.3	EFSA 2007
Slovenia	1.6	1.6	EFSA 2007

Spain	41.2	28.4	EFSA 2007
Sweden	0.0	0.0	EFSA 2007
The Netherlands	7.5	1	EFSA 2007
United Kingdom	8.2	0.2	EFSA 2007
Thailand	4	-	Padungtod and Kaneene, 2006
USA	11.4	-	USDA-FSIS, 2007

There are some reports regarding the prevalence of *Salmonella* in animal production in Thailand. During the period from 1993 to 1996, Boonmar et al. studied the predominant serovar isolated from 27,497 *Salmonella* isolates from human, chicken meat, ready-to-eat Thai foods and shrimps. They reported that the most common serovar isolated from human specimen were *S*. Weltevreden, *S*. Darby, *S*. Enteritidis, and *S*. Typhimurium. The common *Salmonella* serovar isolated from chicken meat were *S* Enteritidis, *S*. Hadar, *S*. Blockery, and *S*. Paratyphi B, they concluded that the foods were significant as a vehicle for human salmonellosis (18). They also studied the contamination of *Salmonella* in chicken meat production and reported that the prevalence of *Salmonella* contamination in retail chicken meat, chicken meat from slaughterhouses, and chicken feces samples were 28%, 4.5%, and 6.6% respectively and the major serovar was *S*. Enteritidis (19). Moreover, report from Hanson et al. showed the prevalence of *Salmonella* in pig and chicken varied from 2-25% (20). Padungtod and Kanenee also study the prevalence of *Salmonella* in food animal in Northern Thailand and they reported that the prevalence of *Salmonella* in chickens at the farm, slaughterhouse and chicken meat at the market were 4%, 9% and 57%, respectively (8). From the previous studies, it might reflex that the slaughterhouse play important role in *Salmonella* contamination in meat products.

1.4 The Public health importance of *Salmonella*

Salmonella is well known as one of the most common organisms causing infections diarrheal diseases worldwide. Each year, approximately 40,000 *Salmonella* infections are reported to the United States Centers for Disease Control and Prevention (CDC), which estimates an annual rate of 1.4 million cases, 16,430 hospitalizations, and 582 deaths in the United States alone (14). Of total cases, 95% are estimated to be caused by foods.

In the European Union 192,703 cases of salmonellosis were reported in 2004 which represents an incidence of 42.2 per 100,000 people. Incidence ranged from 6.6/100,000 people in Portugal to300.9/100,000 in the Czech Republic (17). The salmonellosis notification rate in Australia for 2002 was 40.3 cases per 100,000 Population. Children less than five years of age had the highest notification rate, with a rate of 210.6 cases per 100,000 people reported for 2002 (21).

It is clear that there is association between *Salmonella* in food animal and Salmonellosis in human. According to Mead et al, more than 95% of all *Salmonella* infections are foodborne (14). In the Netherlands, eggs and poultry meat are responsible for 39% and 21% of human salmonellosis cases, respectively, whereas human salmonellosis is caused by pork in 25% of the cases and by beef in about10% of the cases (22). Eggs are the most important source of salmonellosis, especially in outbreaks where the serotype Enteritidis is involved (23-26). Poultry meat also contributes to the transmission of *Salmonella* to humans.

It was shown in a study of the US that eating chicken outside of the home was the only significant risk factor for sporadic *Salmonella* Enteritidis infections. In Spain, there was a *Salmonella* outbreak with more than 2,000 cases due to consumption of pre-cooked chicken (27).

1.5 Antimicrobial resistance of *Salmonella*

Antimicrobial- resistant strains of *Salmonella* spp. are now widespread all over the world and are causing great concern due to the spread of multi-drug-resistant strains. In developed countries it is becoming more accepted that a majority of resistant strains are of zoonotic origin and have acquired their resistance in an animal host before being transmitted to humans through the food chain (5,28).

In animal production, antimicrobial drugs are used for therapy, prophylaxis, and growth promotion. The use of such drugs causes a selective pressure to be imposed on bacterial populations and antimicrobial resistances are selected. The pool of resistance genes is thus spread in the environment (29). Antibiotic resistance determinants are usually encoded on plasmids but can also be presented on the *Salmonella* chromosome. Resistance can be achieved through mutations and acquisition of resistance encoding genes. Co-integrates of resistance and virulence plasmids in *Salmonella* have been observed. This means that antibiotic pressure may select for these plasmids and that both resistance and virulence traits are obtained simultaneously. This may lead to more antibiotic-resistant and virulent *Salmonella* strains (30). Data suggesting that disease caused by resistant strains can be more severe than disease caused by susceptible strains have been published (31-33). The prevalence of resistant isolates in different countries where intensive animal production are 10 -30%. When concentrating on strains isolated from food-producing animals that are held under strong antibiotic selective pressures the prevalence of resistant strains can be very high, up to 60-90% (34). In the year 1999, total of 8,508 *Salmonella* isolates of animal origin were tested against 17 antimicrobial drugs in the USA. The results indicated that many *Salmonella* serotypes were resistant to some of the antibiotics commonly used in human and animal health and as growth promoters in the animal production industry (35,36)

In 2004 in the EU, human isolates of the two dominating serotypes, *Salmonella* Typhimurium and *Salmonella* Enteritidis, showed a considerable variation in the prevalence of resistant isolates between reporting countries. For *Salmonella* Enteritidis the prevalence of resistant isolates was generally low but for *Salmonella* Typhimurium resistance to commonly used antimicrobials was high in some countries. *Salmonella* Typhimurium strains resistant to 2 or more antimicrobials varied from7.8 to 56.4%. In the Netherlands 21% of human isolates of *Salmonella* Typhimurium were resistant to more than 4 antimicrobials. In broiler meat the prevalence of resistant isolates of *Salmonella* spp. also showed great variation with a relatively high level of resistance to several antimicrobials reported from some countries. The percentage of strains resistant to 4 or more of the 11 tested antimicrobials varied between 0 and 36% among reporting countries (17).

1.6 *Salmonella* contamination in the slaughterhouses

There have been reports indicating *Salmonella* contaminations in meat at the slaughterhouses. Hue et al. reported the prevalence of *Salmonella* contamination in chicken meat at the slaughterhouses in France was 7.5% (37). Cortez et al. assessed the occurrence of *Salmonella* in chicken slaughterhouses in Sao Paulo state, Brazil and reported that the 10% (29/288) of the samples were positive to *Salmonella* spp. (38). Bohaychuk et al. studied microbiological baseline study of poultry slaughtered in provincially inspected abattoirs in Alberta, Canada and reported that *Salmonella* spp. was isolated only 0.015% (2/1296) of the samples (39). In Thailand, Padungtod and Kenenee studied the prevalence of *Salmonella* in food animal in Northern Thailand and reported that the prevalence of *Salmonella* of chickens at the farm and slaughterhouse were 4% and 9% respectively (8).

Berends et al. identified and quantified the risk factors of *Salmonella* on pork carcasses at Dutch pig slaughterhouses and reported that there was the strong relation between the number of live animals that carry the *Salmonella* spp. in their feces and the number of contaminated carcasses at the end of slaughterline (40). Live animals that carry *Salmonella* were 3-4 times more likely to end up as a positive carcass than *Salmonella*-free animals. The risk factors of *Salmonella* spp. contamination in chicken carcasses in slaughterhouses were also reported. Arsenault et al. reported that the risk factors of *Salmonella* contamination in chicken carcasses in slaughterhouses located in Quibec, Cannada were a higher proportion of positive carcasses within lots, *Salmonella*-positive cecal culture, low rainfall during transportation to the slaughterhouse, temperature of ≥0°C during transportation to the slaughterhouse, and a ≥4-h waiting period in shipping crates before slaughtering (41). Moreover, the effect of processing on *Salmonella* contamination on chicken carcasses was determined and reported by Cardinale et al. that using scalding water for plucking increased the risk of contamination (42). Food Standards Australia New Zealand (17) concluded the effect of the processing on the *Salmonella* contamination which is showed in table 2.

Table 2 shows the effect of processing stage on *Salmonella* contamination

Process stage	Comment	Reduce	Minimal	Increase
Stun/Skill			√	
Scald – low temperature	Survival of *salmonella* in scald water-cross contamination			√
Scald – high temperature	Kill step	√		
De-feathering	Cross-contamination			√
Effective Washing	Physical removal of bacteria	√		
Evisceration	Contamination with faeces, main source of carcass contamination			√
Effective Washing	Physical removal of bacteria	√		
Chilling – immersion suboptimal	Cross-contamination			√
hilling – immersion effective	Requiresconstant monitoring of water temp., flow rates and chlorine levels		√	
Chilling – air	Slight reduction due to desiccation ofthe carcass surface		√	

Portioning	Possible growth/cross contamination	√

It could be concluded that there are two main sources of *Salmonella* contamination in the processing plant. (1) the birds themselves and (2) cross-contamination from other birds or the environment. However the table above shows the risk of *Salmonella* contamination in modern slaughterhouses, it might be different from traditional slaughterhouses which are commonly found in Thailand. There is the report in Malaysia that the contamination rates of food-borne pathogen (*Campylobacter* spp.) in traditional slaughterhouses were intensely higher than modern slaughterhouses (43). Therefore, the risk factors of *Salmonella* contamination in chicken meat processed from small scale poultry slaughterhouses, which are traditional slaughterhouses, should be studied.

1.7 Poultry slaughterhouses in Thailand

According to the report by Department of Livestock Development, Thailand has 2,380 poultry slaughterhouses. Only 119 plants (5%) have the license for operating the plant (44). It could reflex that most of the slaughterhouses do not address the standard slaughterhouse certification. Since food safety is the policy of Thailand, DLD has policy to encourage all poultry slaughterhouses in Thailand to meet the standard regulation (45). However, the main problem is that most of those slaughterhouses are small scale and the owners could not invest to improve their plants because lack of investment funds (46).

2. Ecohealth

2.1 Definition

The definition of Ecohealth is given by Waltner-Toews that "Ecohealth can be defined as systemic, participatory approaches to understanding and promoting health and well-being in the context of social and ecological interaction" (47). It is the study of changes in the biological, physical, social, and economic environment and of the relations of these changes to human health. Ecohealth addresses the links between human health, animal health, and the environmental health including social, cultural, and economic factors. This is a change from the traditional approach, where research is conducted by experts from within the single discipline. Ecohealth strives to overcome the traditional compartmentalized thinking by promoting transdisciplinary research. The Ecohealth approach integrates different type of knowledge to develop strategies for improving the health of humans, animal, and other associated disciplines. The concept of Ecohealth approach is showed in the figure 1.

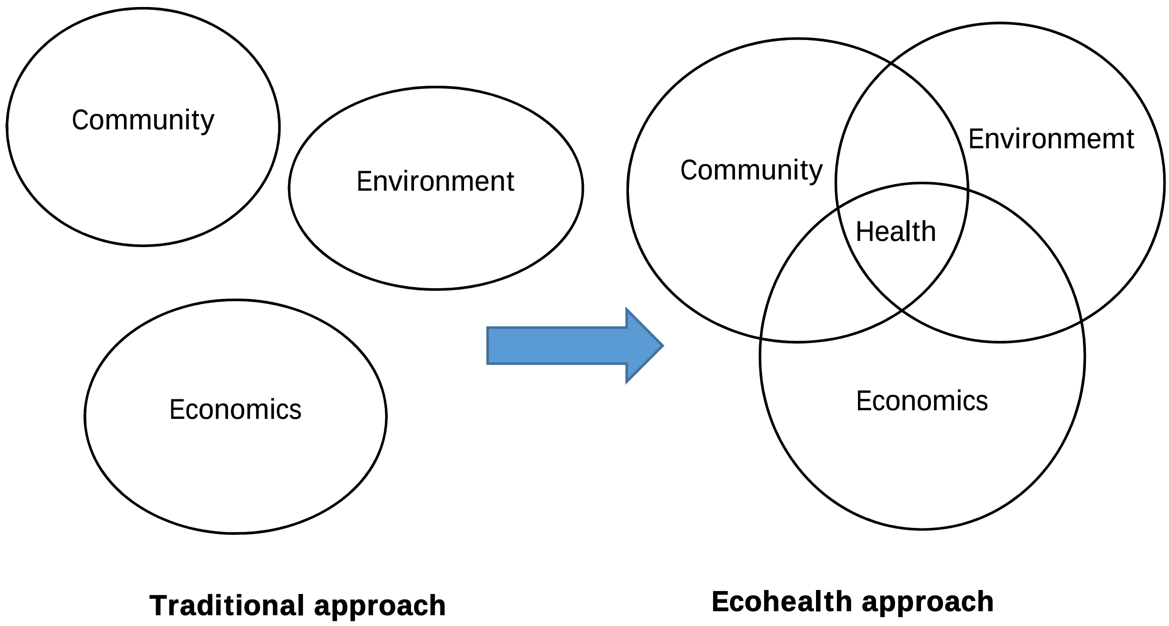

Figure 1: Comparison between traditional research and transdisciplinary research (Adapted from Handcock (48))

2.2 History of Ecohealth approach

It is difficult to indicate the exact time and place where Ecohealth concept was first launched. Hanlon staged regarding the terms related with Ecohealth that, “The human ecologic approach, of necessary and by definition, calls for an interdisciplinary effort wherein the natural, physical, and social sciences, in company with engineering, combine to study the adaptive response of man and specially the effect of unsuccessful adaptation of his health” (49). He also stated for calling on action that “we must call for man and woman with the foresight and courage to accept the new and broader philosophic base of human ecology, as applied to human welfare, and , on accepting it, it act upon it. Only then may we as a profession make our true potential contribution to the development of a new society and a better world.” These states are parallel with Schwabe’s statement that “the critical need of man includes the combating the disease, ensuring enough food, adequate environmental quality, and a society in with humane value prevail” (50). Furthermore, he stated that “between human and animal medicine there is no dividing lines-nor should that be”. It could be concluded that integrative approach among the disciplines is an effective means to use in the study in order to improve the health.

The term Ecohealth has been adopted recently and widely used by several organizations. The major organization who use the terms Ecohealth is International Development Research Center (IDRC). This organization also hosted the international Ecohealth conference. The first conference was held at the University of Wisconsin-Madison, in the USA in 2006 and then the event has been set up every two years.

2.3 The principle of Ecohealth

The principle of Ecohealth is descripted by Charon (51) that there are 5 main principles including system thinking, transdisciplinary, participation, sustainability, equity, and knowledge to action. Since the Ecohealth research is difficult to do because it relies on imperial approaches and flexible. The set of principle is only the guideline for the research “how to” conduct the Ecohealth research. The briefly explanation of these principles is showed in the table 3.

Table 3: The explanation of Ecohealth principle

Principle of Ecohealth	Explanation
System thinking	• Understanding the whole and its parts (issues, interaction, key actors, components, and interrelationship); includes system sciences
Transdisciplinary	• Collaboration between researchers and practitioners from complimentary disciplines/sectors and/or other stakeholders on a problem; use multiple methods/tools that facilitate the generation of new frameworks, concepts, methods, institutions, etc, from the knowledge sharing and interaction
Participation	• From the beginning, stakeholders(including affected population) collaborate on various research stages using local knowledge and addressing some of their priorities; also refers to participatory action research
Sustainability	• Meeting the needs of current generation without compromising the needs of future generations; the outcome or goal of ecohealth also refers to sustainability of the environment and/or of interventions/projects
Equity	• Address differences between groups affected by research problem; gender (roles, responsibility), power (decision making, access to the resources), and trade-off (who benefit)

Knowledge to action	• Result in something done to solve or mitigate the research problem under study

2.4 The importance of Ecohealth approach

Ecohealth takes different approaches to research and to traditional problem solving. It can be indicated that it discards traditional research methods. It represents a new approach to research which mobilizes various disciplines to work together from the outset of a project and gathers together relevant individuals both from upper levels, e.g., policy makers, and the owners of the problem, e.g., people from a community which is having a problem. All work together in all facets including evaluation of the problem, evaluation of the desired objective, specifying the method of solving the problem, and carrying out problem-solving activities.

Using the Ecohealth approach to achieve results requires that the acquisition of knowledge must follow the important directions of Ecohealth including thinking of the overall picture, systems thinking, and viewing problems from a collective perspective, seeing the connections between various components in the systems, integrating work efforts, working across disciplinal boundaries from the beginning, relevant stakeholders having a role with all stakeholders being afforded equal importance. The research is not done exclusively to understand a problem. It must also lead to a solution of the problem through application of the newly acquired knowledge. The problem solution should focus on sustainability, that is, through truly applying the combined important aspects of the Ecohealth approach.

With traditional research methods, the researcher identifies the problems and seeks solutions for those problems. The result is that sometimes the direction for solving a problem does not actually result in a solution when it is implemented due to a lack of participation on the part of the group affected by the problem. In using the Ecohealth approach, it is necessary to remove and discard the traditional methods of research. That is, individuals from many disciplines must work together. Stakeholders must have a role, especially those directly affected by the problem. Thus those who have a role in the activity must be open-minded about learning about academic areas which are different from their own area of expertise. They must be ready to learn together, to look at the same problem, and to work together with the community and government officials

CHAPTER 3

MATERIALS AND METHODS

1. Hypothesis of this study

The hypothesis of the study is "systemic approach shall improve and sustain the slaughterhouses more hygienic and viable".

2. The framework of this study

This study was conducted during March 2011 – September 2014. The Ecohealth concept was used as a guideline for this study, including system thinking, transdisciplinary, participation, sustainability, equity, and knowledge to action. The stakeholders regarding the slaughterhouses were identified and participated in the beginning.

The food safety policies, standard poultry slaughterhouse law, regulation, and the implementation were systemically reviewed.

The hygienic status of the small scale poultry slaughterhouses was determined as well as *Salmonella* contamination in meat, slaughter line, and the environment. The socio-economic situation of those slaughterhouses were also investigated. The results were used to explore for the reason that why the small scale slaughterhouse owners could not address the standard regulation. The research findings were advocated to the policy-level officers of the Department of Livestock Development (DLD). The feasible guideline for slaughterhouse improvement in order to address the standard poultry slaughterhouse regulations were developed and then pilot tested.

3. Study site selection

Chiang Mai province is located in the northern part of Thailand and is characterized as having dense areas of poultry production. In 2010, more than three million chickens were produced in this province (52). Furthermore, according to data from Rojanasthien et al. (9), the most slaughterhouses in Northern Thailand were located in Chiang Mai, therefore, the study were conducted in Chiang Mai province.

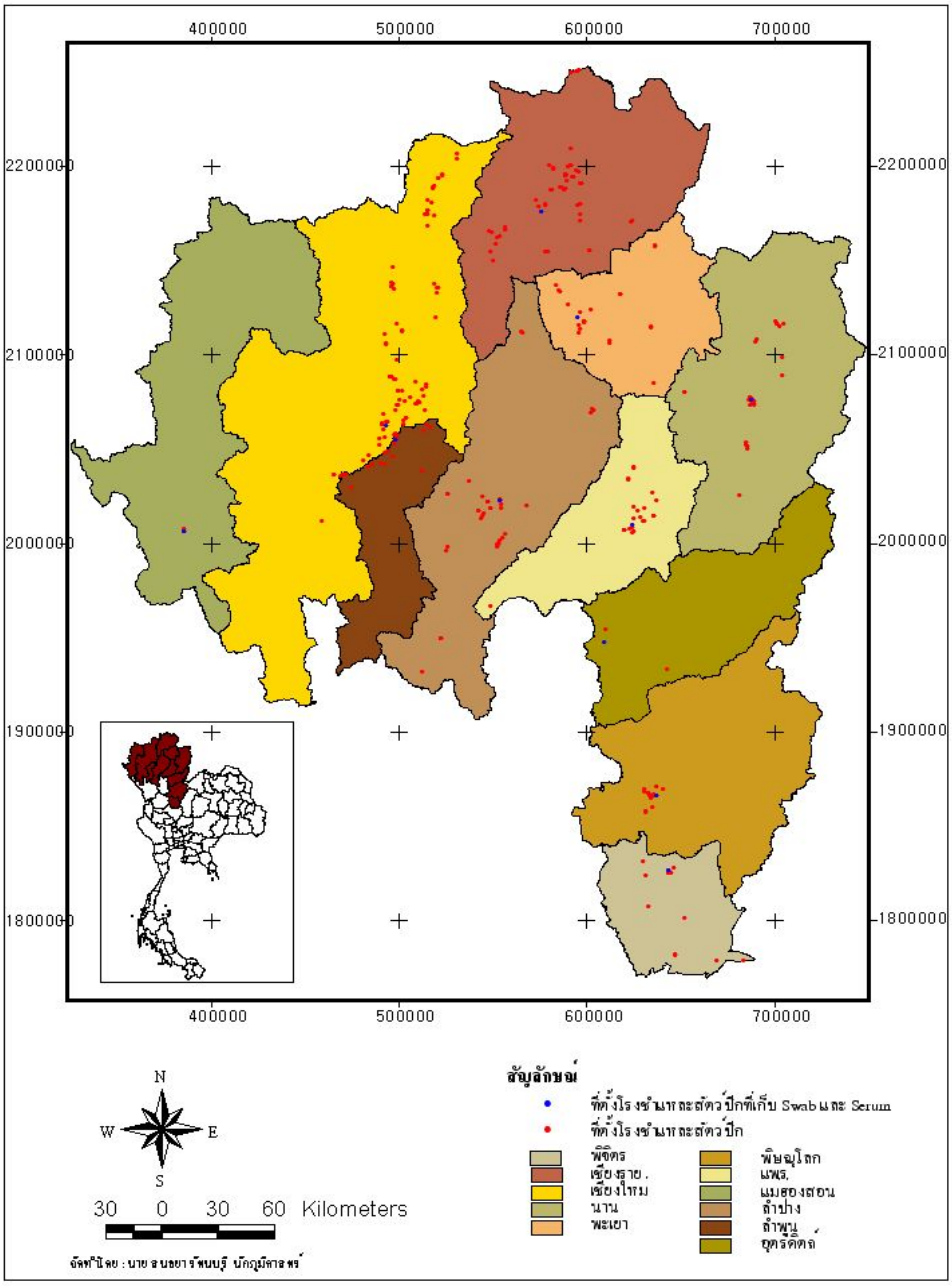

Figure 2: The poultry slaughterhouses located in Northern Thailand

Table 4: the poultry census in Upper Northern Thailand

Province	Native chicken		Broiler		Layer		Broiler breeder		Layer breeder	
	birds	farmers	birds	farmers	birds	farmers	birds	farmers	birds	farmers
Chiang Mai	2,654,640	76,973	755,153	933	1,655,302	977	264,646	292	93,025	160
Lamphun	937,589	19,103	661,277	383	394,407	352	13,024	27	5,095	36
Lampang	1,733,940	58,591	528,886	561	33,174	408	61,587	362	16,506	29
Phrae	961,040	29,123	227,057	292	88,680	497	68	4	395	8
Nan	1,763,288	48,956	72,315	524	68,975	1,075	25,341	77	2,218	80
Payao	1,379,397	45,130	70,091	474	69,365	472	205	17	11	2
Chiagrai	2,761,637	75,711	462,457	519	458,449	441	79,881	171	26,760	98
Maehongson	372,538	17,796	1,784	92	1,689	145	996	38	361	39

4. The required data, target population, and data collection tools

Ecohealth concept was used as a guideline for this study, including transdisciplinary and participatory approach. Therefore, the stakeholders were identified and participated from the beginning of the study.

Table 5: the required data and target population of the study

Required data	Target population
• Conceptual framework of the study	• Identified stakeholders
• The food safety policies • The existing standard slaughterhouse regulations • The implementation of those regulations	• Government officers (policy making and practitioner level)
• *Salmonella* spp. prevalence along the slaughtering processes and environments	• Slaughterhouses
• Slaughterhouse management • Socio-economic status • Knowledge, attitude and practices concerning food safety • The need for slaughterhouse improvement	• Slaughterhouse owners

5. Conceptual framework development

Since food safety, especially in rural areas of Thailand, is a complex challenge and involves many sectors, an integrated approach was applied in this study. The main stakeholders were identified in the early stages of the project, using participatory methods, for instance, researchers meeting with key stakeholders, including slaughterhouse owners, as well as DLD officers at the national and regional levels, to identify problems. The information obtained from discussions with stakeholders was then reviewed by experts in veterinary science, socioeconomic, and public health before being used as the basis for developing a conceptual framework

6. Review of policies, law, and regulation regarding poultry slaughterhouse control in Thailand

Policies, laws, and regulations which include the key phrases "food safety," "slaughterhouse standards," "current situation of poultry slaughterhouses," or "foodborne diseases in Thailand" were collected from published and unpublished sources, including the Royal Thai Government Gazette, the Eleventh National Economic and Social Development Plan of Thailand (2012–3016) (53), the DLD strategic plan (54), as well as domestic and international research reports on poultry slaughterhouses.

7. Implementation of laws and regulations

Perceptions regarding the implementation of existing regulations were obtained through focus group discussions (FGDs) with DLD regional officers. The principle investigator and co-principle investigator led the FGDs. Purposive sampling was used to identify participants using the criteria: (1) DLD provincial officers; (2) heads of DLD district offices; and (3) individuals having responsibility for slaughterhouse control. Two FGDs were conducted with a total of 22 participants between May and June 2012.

8. Data collection on hygienic management of poultry slaughterhouses

A total of 41 small-scale poultry slaughterhouses were visited during the period from July 2011 to May 2012. Data on the current status of the slaughterhouses, especially data regarding productivity, economic status, hygienic management, and opportunities and challenges faced in improving the plants and following the DLD slaughterhouse regulations, were collected using a structured questionnaire and interviews. In addition, a checklist, which was developed based on the DLD regulations, was used for triangulation.

9. Sample collection and *Salmonella* identification

A preliminary survey found that, in 2010, Chiang Mai had 55 small-scale poultry slaughterhouses with approximately 25,000 poultry being sent to these slaughterhouses each day. Samples were collected from slaughterhouses located within 100 kilometres of the laboratory at Chiang Mai University to ensure that samples could arrive the laboratory center within three hours. A total of 410 meat samples from 41 slaughterhouses were collected. Each carcass was placed in a large bag with 250 ml of sterile peptone water, which was then shaken inside the bag for one minute, the rinse water was then poured into a sterile bottle and used for identification of *Salmonella* spp. In addition, samples were also collected from each point of slaughter line and environment (table 6). The total of number of samples for each slaughterhouse was shown in table 6. Sample collection was conducted between July 2011 to May 2012.

Meat samples were collected in the morning immediately after completion of the slaughtering process, put into single use zip lock plastic bags, kept on ice in an ice chest, and sent within three hours of collection to the Diagnostic Center, Faculty of Veterinary Medicine, Chiang Mai University, for testing for the presence of *Salmonella* spp. The cold chain was not broken during sample collection and transport to the Diagnostic Center. Scientists used a standard Diagnostic Center form to record information on each ice chest, including the number of the ice chest, the owner of the slaughterhouse, the sender of the sample, and individual sample identification information. Samples were then stored in a refrigerator at 4°C prior to individual sample testing, which were conducted the following morning. After each use, each ice chest was washed with dishwashing liquid and water and then dried in a plate dryer. To further preclude possible contamination, each ice chest was withdrawn from use for between five and seven days after delivering the samples. The Diagnostic Center is certified by the Bureau of Laboratory Quality Standard (BLQS), Department of Medical Sciences, Ministry of Public Health.

The bacteria were isolated according to standard method (ISO 6579:2002) (55). Initially, the samples were aseptically added to 225 ml of preenrishment medium, Buffer Peptone Water, and incubated for 18 hours at 37 ^{o}C. The preenrished culture, 0.1 and 1 ml, respectively, were then transferred to Rappaport-Vassiladis broth and Selenite broth and incubated at 42 and 37 ^{o}C, respectively. After 24 and 48 hours of incubation, a loopful from each of the enriched broth was streaked onto plates of *Salmonella Shigella* agar and XLD agar, and incubated at 37 ^{o}C for 24 hours. The plates were examined for the presence of typical colonies of *Salmonella*, for example, transparent colonies with black centers on SS agar and red colonies with black centers on XLD agar. Suspected colonies (Maximum 5) were randomly selected from each plate and confirmed by biochemical tests including fermentation of glucose, lactose and sucrose, hydrogen sulfide production, urease activity, phenylalanine deamination, lysine decarboxylation, citrate, methyl red and indole tests. One of isolate per sample with the typical biochemical profile of *Salmonella* was confirmed using API 32 GN system. The presence of *Salmonella* was tested at Faculty of Veterinary Medicine, Chiang Mai University. Then the bacteria were sent for serotyping and testing for antimicrobial susceptibility at The National Institute of Health, Department of Medical Sciences, Ministry of Public Health.

Antimicrobial susceptibility testing was performed using the disk diffusion method of the National Committee for Clinical Laboratory Standard (NCLSS). Nine antimicrobial agents in the form of disks were employed for susceptibility testing of 79 *Salmonella* isolates. The concentrations of the antimicrobial agents were as follows: ampicillin (AMP) 10 µg, chloramphenicol © 30 µg, cefotaxime (CTX) 20 µg, ciprofloxacin (CIP) 5 µg, nalidixic acid (NA) 30 µg, norfloxacin (NOR) 10 µg, streptomycin (S) 30 µg, Sulfamethoxazole – trimethoprim (SXT) 25 µg, and tetracycline (T) 30 µg. In the test, Escherichia coli ATCC 25922 was used as the quality control stain.

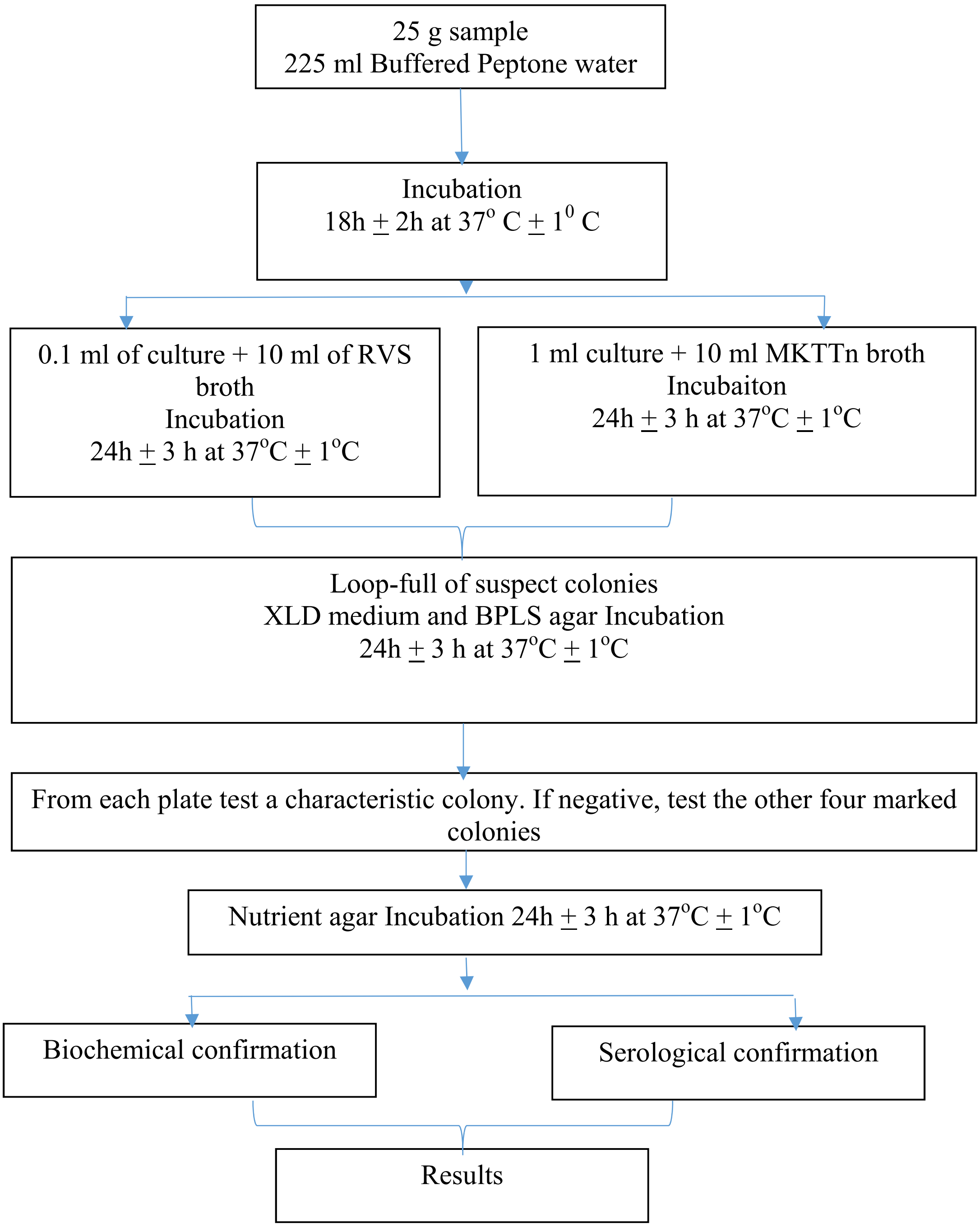

Figure 3: Flow diagram of procedure for isolation of *Salmonella* spp. (ISO 6579:2002)

Table 6: Source of samples and number of samples per slaughterhouse for bacteria identification

Source of samples	Number of samples per slaughterhouse per time	Remark
1. Holding pen	1	Pool sample
2. Live poultry	10	
3. Equipment used in slaughtering process;		Pool sample
- Knife	1	
- Table	1	
- Cutting board	1	
- Container	1	
4. Ground of slaughtering area	1	Pool sample
5. Water supply	1	Pool sample
6. Carcasses	10	
7. Environment		
- Soil	5	
- Waste water	5	
8. Worker's hands	3	
Total	**40**	

9. Data analysis

9.1 Qualitative data

Data regarding the review of the literatures of food safety policies, existing standard poultry slaughterhouse regulations were analyzed by using the technique of content analysis.

Data from FDGs was also qualitative content analyzed using the five-step process as described by Agus et al. (56): (1) Following transcription of the interviews, summaries of the discussions were compiled; (2) All interviews were coded and categorized, outlined, then grouped under appropriate headings; (3) Similar headings were combined and categories were generated to reflect the study aims; (4) Analysis of the trustworthiness of the results was performed by asking a colleague to generate a theme list; and (5) Each transcript was coded by theme.

9.2 Quantitative data

9.2.1 Slaughterhouse management

The data from structured questionnaire and checklist was coded and recorded. Descriptive statistics was used to analyze the data by the application of Microsoft Excel 2010 program (Microsoft Corp.). To describe the slaughterhouse status, the combination of the data from questionnaire, observation, and checklist was done and these results were compared with the criteria of the slaughterhouse regulations.

9.2.2 Prevalence of *Salmonella* contamination on carcasses, facilities, and environment

The prevalence of *Salmonella* contamination in carcasses, each point of slaughter line, soil, and wastewater was calculated by dividing the number of samples positive for *Salmonella* by the total number of samples processed.

10. Policy advocacy and development of the feasibility of good practices to enhance hygienic management in small scale poultry slaughterhouses

To advocate the findings to policy, the meeting with policy-level DLD officers was set up. The knowledge translation and brainstorm were implemented in order to develop the guideline encouraging the hygienic improvement of the small scale slaughterhouse to address food safety and to achieve a license.

The cost-effective blueprint of the small scale slaughterhouse and the minimum requirement of the improvement criteria was developed and then pilot test was implemented to developed model of good practice small scale slaughterhouse. To evaluate the effectiveness of the implementation, meat samples were collected before and after implementation for testing of Coliform bacteria and total bacteria count in meat.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Conceptual framework and problem identification

Over the last 30 years, several successful attempts have been made to control various infectious diseases in countries all over the world, especially in developed nations. However, threats still exist, such as antimicrobial resistant bacteria and unsafe farming and food production practices, as well as threats created by the impact of urbanization and agricultural intensification (57). In addition, traditional methods of controlling infectious diseases using conventional biomedical strategies have often failed, resulting in the emergence and outbreak of diseases such as SARS, H5N1 and H7N1 avian influenza, malaria, tuberculosis (58). In order to address these challenges and to achieve improvements in overall health—not just human health—the crucial roles of social, economic, and cultural factors must also be considered. Thus, it is imperative that non-medical sciences be involved in the process of developing disease control strategies.

In this study, the main stakeholders were the slaughterhouse owners, DLD officers at the national and regional levels, regional public health officers, and local administration officers. Brainstorming meetings and interviews confirmed the stakeholders' views on the importance of food safety and food policies in Thailand. They realized that poultry slaughterhouses are an important link in the poultry meat production chain, that the standard regulations should be followed, and that there are many factors affecting the improvement of slaughterhouses. They concurred that the main problems to be addressed are the inability of most small-scale slaughterhouses to comply with the current standard regulations and a lack of appropriate strategies to motivate and assist small-scale slaughterhouses to comply with these regulations.

The conceptual framework of this study (Figure 4) reveals the complex interactions related to achieving slaughterhouse improvements. For example, there are three main government agencies responsible for the control of slaughterhouses: (1) the DLD, which is primarily responsible for animal health and disease control on livestock farms plus improvement and updating of regulations governing slaughterhouses; (2) The Ministry of Public Health, which is responsible for setting food safety standards for meat products; and (3) Local administrative organizations, which are responsible for giving permission to slaughter animals and to distribute meat, as well as appointing meat inspectors. To effectively assist slaughterhouse owners to improve their slaughterhouses and to follow regulations, government officers from these agencies must work together in an integrative model.

To more effectively identify avenues for enhancing safe processing in small-scale poultry slaughterhouses, practitioners of veterinary and human medicine, social scientists, and economists cooperatively followed an integrative approach in the development of the conceptual framework and in participatory problem identification from the outset. That framework demonstrates the complexity of the problem and the linkages between the different disciplines. This study follows the successful integrative approach which was used to gain an understanding of and develop a suitable research agenda in the case of the emergence of leptospirosis in Hawaii (59). This study evidences the importance of a transdisciplinary approach, as well as methods of implementing that approach as described and demonstrated by Pokras and Kneeland in their development of educational and policy initiatives to control the lead poisoning problem in wildlife, humans, and domestic animals (60).

The framework also includes socioeconomic factors affecting the improvement of slaughterhouses, for example, the association of education level and age with perceptions of food safety, as well as issues of income from slaughterhouses, living expenses, and family debt that could affect opportunities for investment in slaughterhouse improvements.

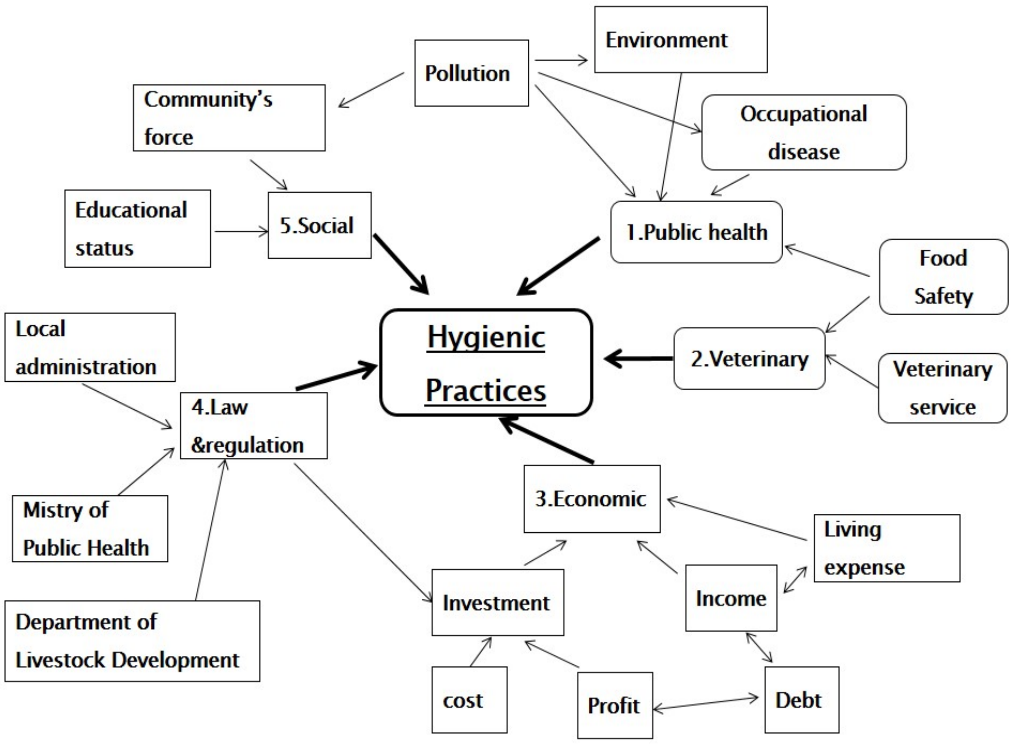

Figure 4: The conceptual framework of the study

4.2 Laws and regulations governing slaughterhouses in Thailand

The main regulation regarding slaughterhouse control is the Ministerial Regulation on Determination of Criteria, Procedures and Conditions for Establishing Slaughterhouses, Lairage and Animal Slaughter B.E. 2555 (2012). This regulation consists of seven topics: (1) the location of the slaughterhouse, e.g., slaughterhouses must be situated far away from communities); (2) the area and structure of the slaughterhouse buildings, e.g., the slaughtering process must be conducted in a concrete building and there must be a fence around the slaughterhouse; (3) local infrastructure and the area inside of the slaughterhouse, e.g., the area inside the slaughterhouse building must be appropriate for operations, easy to clean, and include separate clean and dirty zones; (4) equipment and facilities management, e.g., facilities used in the slaughtering process must be easy to clean; (5) holding pens, e.g., pens where birds are maintained for 8–10 hours before slaughter must be constructed of concrete and must prevent pathogens contamination of the slaughtering process; (6) waste management systems; and (7) hygiene management, e.g., cleaning the slaughterhouse every day after operation. To be licensed by the DLD, all slaughterhouses in Thailand must comply with this regulation.

In addition, good manufacturing practices (GMPs) for poultry slaughterhouses were announced, and their adoption has been mandatory since 2006. However, in practice, the GMP guidelines, which were intended to further improve operations including hygiene standards, have been enforced only in slaughterhouses which have been issued a government license, most of which are larger operations.

4.3 Implementation of standard slaughterhouse regulations

In the FGDs with DLD regional officers (provincial and district) on the implementation of laws and regulations, the officers accepted that they could not strictly enforce the ministerial regulatory criteria intended to promote the improvement of small-scale slaughterhouses. They acknowledged that the criteria are intensive and require high levels of investment, making them suitable for large- and medium-scale operations which generate sufficient profit, but not for small-scale facilities with low productivity and small profits. They agreed that if they attempted to strictly enforce the regulations, they would meet resistance from the slaughterhouse owners. They also acknowledged that during their regular visits to slaughterhouses every three to four months, they should focus on establishing a spirit of collaboration and cooperation in order to promote hygienic management and disease control in slaughterhouses rather than strictly enforce the regulations. They also indicated that the current regulations should be more flexible and practical. As one officer said, “It would be useful if there was a prototype or a blueprint of a good, hygienically managed slaughterhouse that owners could use as a model for investment”. The majority of the participants agreed with this comment.

Department of Livestock Development regional officers agreed that the current laws and regulations are, in fact, more suitable for large- and medium-scale operations which can afford the necessary high investment. Nonetheless, the DLD is attempting to encourage even small-scale poultry slaughterhouses to meet the standard. The slaughterhouse blueprint developed by the DLD and distributed to officers and slaughterhouse owners, however, is designed for operations processing 200–300 birds/day which is four or more times the daily production of small-scale slaughterhouses. Thus, the DLD-proposed blueprint poses a considerable challenge to small-scale slaughterhouses.

DLD officers indicated an awareness of the need to work integrative with officers from other agencies, including public health officers and local administrative officers, in order to improve food safety. However, they mentioned that there were obstacles to such joint efforts. For example, working with local administrative organizations was problematical because those organizations still had no official role in that area or any personnel specifically responsible for slaughterhouse control. In the case of Public Health agencies’ work with food safety control, their main focus is on meat products sold in the market rather than conditions at slaughterhouses. On a positive note, just over half the participants (54.5%) indicated that they were willing to work in an integrative manner with other agencies to address issues of food safety. Table 7 summarizes the reflections of the participants regarding the themes of the FGDs.

Table 7: Reflection of DLD officers from FGDs

	FGD topics	Agreement (%)
1.	Current regulation is suitable and practical for small-scale poultry slaughterhouse	0.0
2.	Current regulation is only suitable for large- and medium-scale poultry slaughterhouse	77.3
3.	The officer could effectively enforce the regulation	0.0
4.	The current regulation should be flexible and practical for a small-scale slaughterhouse	72.3
5.	Blueprint of well-managed small-scale facilities is very useful	90.9
6.	DLD officers have problem of working with other associated officers to improve the slaughterhouses	68.2
7.	DLD officers still have to carry out integrative work with associated officers to improve food safety	54.5

4.4 Food safety perception and the possibility to improve according to the slaughterhouse regulations

Of the participating slaughterhouse owners (table 8), 46.3% were male; 48.8% were 50–59 years old; 68.3% had completed primary school; 24.4% had been operating a slaughterhouse for 11–15 years; 82.9% slaughtered 1–50 birds/day; and 100.0% did not have a DLD license for slaughtering.

Table 8: Characteristics of participating slaughterhouse owners in the study

Characteristics	**Number**	**Percentage**
Gender		
Male	19	46.3
Female	22	53.7
Age group (in years)		
21–29	1	2.4
30–39	9	22.0
40–49	8	19.5
50–59	20	48.8
>60	3	7.3
Education		
No education	1	2.4
Primary	27	65.9
Secondary	10	24.4
Diploma	2	4.9
Bachelor	1	2.4
Productivity (birds/day)		
1–50	34	82.9
51–100	4	9.7

101–150	2	4.9
151–200	0	0.0
>200	1	2.4
Income from slaughterhouse operation (THB)		
<10,000	6	14.6
10,000-30,000	14	34.1
30,001-60,000	13	31.7
60,001-90,000	1	2.4
>90,000	7	17.1
License for slaughtering		
Yes	0	0.0
No	41	100.0

The zoonotic diseases and food safety perception of the slaughterhouse owners was determined. The results showed that there was the only high perception only on the possible transmission of the diseases from sick birds. Contrary, perception on important statement such as cleaning measures and zoonotic knowledge were low. This result might causing as improper hygienic practices were commonly observed in majority of the slaughterhouse. Table 9 shows the perception of zoonotic diseases and food safety of slaughterhouse owners

Data from interview regarding slaughterhouse owners' perceptions of relevant laws and regulations, 33 out of 41 owners (80.5%) stated that some of the criteria in the current standard regulation were impractical for small-scale slaughterhouses. For example, meat from most of the smaller slaughterhouses was not inspected because the limited slaughterhouse income was not sufficient to hire a meat inspector. Owners stated that they would have to stop operating their business if the DLD strictly enforced all the standard slaughterhouse regulation requirements. Although 25 out of 41 owners (61%) accepted that they did need to improve their slaughterhouses, they indicated a desire that the regulatory criteria be more practical.

Table 9: The perception of zoonotic diseases and food safety of slaughterhouse owners using Likert scale

No.	Topics	Mean score	Std. Deviation
1	The sick poultry can transmit the disease to human	3.54	1.048
2	The dead poultry can transmit the disease to human	2.41	1.309
3	Inspection the meat after slaughter is important	2.37	1.142
4	The pathogen can contaminate to the slaughterhouse area	2.37	1.199
5	The poultry which look healthy can transmit the disease to human	2.20	1.128
6	The pathogen can spread into the environment	2.13	.806
7	The withdrawal period for slaughterhouse is important	2.04	.965
8	The workers can protect themselves from diseases	1.98	.856
9	The unqualified meat should not be consumed	1.96	1.032
10	The pathogen can be eliminated	1.89	.875
11	Inspection the chicken before slaughter is important	1.85	.788
12	The unqualified chicken should not be slaughtered	1.85	.942
13	The workers in slaughterhouse should have zoonotic prevention knowledge	1.76	.705
14	The slaughterhouse cleaning measures are important	1.48	.547

Remark: Strongly agree=5, agree=4, indifferent=3, disagree=2, strongly disagree=1

4.5 Slaughtering processes

The process of slaughtering was carried out in open-air buildings as follows: the birds were killed with a sharp knife, and the carcasses were scalded in a water tank at a temperature of 50–70°C for 2–3 minutes. De-feathering was done using semi-automatic de-feathering machines. The carcasses were cleaned by dipping them in a bucket of water. Evisceration was done by hand, using a knife to cut open the carcasses; this process was carried out on chopping blocks placed on the floor. The carcasses were then dipped in hot water (50–70°C) to firm up the skin, then stored in a small vessel containing ice. The wastewater from the slaughtering process was discharged directly onto the area around the slaughterhouses. Figure 4 showed the slaughtering process and table 10 showed results from observation and checklist according to the criteria of slaughterhouse regulation.

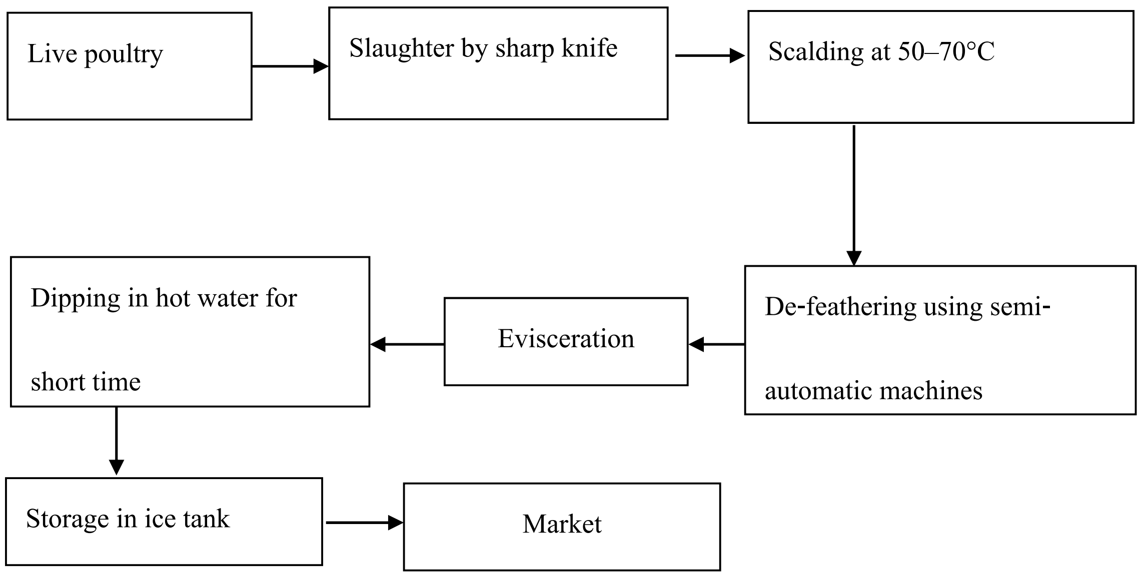

Figure 4: Traditional slaughtering processes in studied small scale poultry slaughterhouses

Table 10: The assessment of slaughtering process management according to the Ministerial regulation (N=41)

Criteria	Implement		Not implement	
	Number	Percent	Number	Percent
1. Implement ante-mortem the birds	0	0.0	41	100.0
2. Poultry are not contact with the floor during slaughtering.	1	2.4	40	97.6
3. Slaughtered poultry are washed and cleaned.	41	100.0	0	0.0
4. Scalding water temperature is high enough for defeathering	41	100.0	0	0.0
5. Slaughtered poultry are completely defeathered	41	100.0	0	0.0
6. Offal are completely removed by appropriate equipment	1	2.4	40	97.6
7. Carcass are not be contaminated by contents of offal	0	0.0	41	100.0
8. Poultry carcasses are washed by water after bleeding, defeathering and eviscerating	41	100.0	0	0.0
9. Carcasses chilling	0	0.0	41	100.0
10. Have proper storage of poultry meat after slaughter	3	7.9	38	92.1

4.6 Slaughterhouses' structure and hygienic management

The majority of the small-scale slaughterhouses, did not satisfy all of the seven criteria described in the slaughterhouse law and regulation. The owners constructed simple facilities with only necessary equipment and located within their community (Table 11). Birds were sold only in the local community the same day they were slaughtered, but quantities were small, just enough to meet local demand. Incomes were limited and not sufficient to invest in improvements to the slaughterhouses to meet the Ministerial criteria, resulting in improper general and personal hygienic management were commonly observed in the slaughterhouses. (Table 12, 13)

Table 11: Results of the assessment of the slaughterhouses' site and structure (N = 41)

Criteria	Suitable	Unsuitable	Not implemented
1. The slaughterhouse is not located in a community	0	41	–
2. The condition of the area outside the slaughterhouses (e.g., fenced and clean area)	1	40	
3. The structure of the building (e.g., concrete with good ventilation)	2	39	–
4. The condition of the area inside the building (e.g., separate dirty and clean areas)	2	39	–
5. Equipment and facilities (e.g., easy to clean)	1	40	–
6. Holding pen exists	1	2	38

Table 12: General hygiene and environmental management (n=41)

	Criteria	Implement		Not implement	
		Number	Percent	Number	Percent
1.	Have an effective pest control program inside and outside the production building	3	7.9	38	92.1
2.	Adequate hand washing facilities are provided	0	0.0	41	100.0
3.	Storage facilities are provided to avoid any contamination	1	2.4	40	98.6
4.	Chemicals are stored separately from the production area	3	7.3	38	92.7
5.	Garbage bin with lid is provided	7	17.0	34	82.0
6.	Plant and equipment are cleaned before and after operation	2	4.9	39	95.1
7.	Have withdrawal day in a week for cleaning the plant.	23	56.1	18	43.9
8.	Use treated water to avoid any contamination	0	0.0	41	100.0
9.	Proper waste management	7	17.0	34	82.0

Table 13: Personal hygienic management (N=41)

Criteria	Implement		Not implement	
	Number	Percent	Number	Percent
Workers have physical examination at least once a year	2	4.9	39	95.1
Workers wash their hands with soap and disinfectant before entering the production area	3	7.3	38	92.7
During operation hours, worker wear clean and disinfected protecting clothing, aprons, bouffant cap for full hair coverage, mask, and boots	1	2.4	40	98.6
Personal effects and food are prohibited to production area	1	2.4	40	98.6
Protecting clothing, aprons, bouffant caps, mask, boots, tools and equipment are cleaned after work and stored in the specific rooms	1	2.4	40	98.6
Smoking, eating, chewing or spitting are prohibited in production area	2	4.9	39	95.1

4.7 Prevalence and antimicrobial resistance of *Salmonella* spp. isolated from meat, slaughtering process, and environment

The prevalence of *Salmonella* was 3.17% in live poultry and 7.32% in carcasses. It was also found on utensils used in the slaughtering process, in both water used in the slaughterhouses and in waste water, and the soil around the processing plants, but it was not found on workers' hands. The prevalence of *Salmonella* in chickens before slaughtering, during the slaughtering and dissecting process, and in the local environment is shown in Table 14 and the serotypes of *Salmonella* identified are shown in Table 15.

As for the drug resistance is concerned, it was found that 44.30% of samples of *Salmonella* (35 of 79) were resistant to nalidixic acid, followed by streptomycin 41.77% (33/79), ampicillin 34.18% (27/79), tetracycline 34.18% (27/79), and sulfamethoxazole/trimethoprim 20.25% (16/79). The pathogen was also found to be sensitive to chloramphenical, ciprofloxacin, and cefotaxime as 100% sulfamethoxazole/trimethoprim in 79.75% of samples (63/79). In addition, 68.35% (54/79) of the pathogens were resistant to at least one antimicrobial, while 50.63% (40/79) of the pathogens were multidrug resistant (Table 16).

Table 14: The prevalence of *Salmonella* in small scale slaughterhouses

Sampling points	**Slaughterhouses testing positive**	**Positive samples from slaughterhouses**
Live poultry	14.6% (6/41)	3.17% (13/410)
Holding pens	12.20% (5/41)	12.20% (5/41)
Worker hands	0.0% (0/41)	0.0% (0/41)
Knives	2.4% (1/41)	4.65% (2/43)
Defeathering machines	7.32% (3/41)	7.32% (3/41)
Cutting boards	13.0% (3/23)	13.0% (3/23)
Meat cleaning buckets	9.8% (4/41)	9.8% (4/41)
Carcass storage boxes	2.4% (1/41)	9.76% (4/41)
Slaughterhouse floors	29.3% (12/41)	29.3% (12/41)
Water used in plants	2.4% (2/41)	2.4% (1/41)
Waste Water	21.95% (9/41)	21.95 (9/41)
Soil around the plants	29.27% (12/41)	29.27 (12/41)
Carcasses	39.0% (16/41)	7.32 (30/410)

Table 15: Serotypes of *Salmonella* isolated from small scale slaughterhouses

Serotypes	Number	Percentage
***S.* Corvallis**	12	15.19
***S.* Rissen**	11	13.92
***S.* Hadar**	10	12.66
***S.* Enteritidis**	8	10.13
***S.* I. 4,5,12 : i : -**	7	8.86
***S.* Stanley**	7	8.86
***S.* Weltevreden**	7	8.86
***S.* Braenderup**	3	3.80
***S.* Mbandaka**	3	3.80
***S.* Weltevreden var.15+**	2	2.53
***S.* Brunei**	2	2.53
***S.* Agona**	1	1.27
***S.* Bovismorbificans**	1	1.27
***S.* Hvittingfoss**	1	1.27
***S.* Muenchen**	1	1.27
***S.* Poona**	1	1.27
***S.* Singapore**	1	1.27
***S.* Typhimurium**	1	1.27
Total	79	100.00

Table 16: Antimicrobial resistance in *Salmonella* serotypes isolated from small scale slaughterhouses

Serotype	No. of isolates	No. of *Salmonella* isolates resistant to each antimicrobial								
		AMP	C	CIP	CTX	NA	NOR	S	TE	SXT
***S.* Corvallis**	12	0	0	0	0	12	0	0	0	0
***S.* Rissen**	11	11	0	0	0	0	0	11	11	11
***S.* Hadar**	10	0	0	0	0	10	0	10	5	0
***S.* Enteritidis**	8	7	0	0	0	8	0	2	1	0
***S.* I. 4,5,12 : i : -**	7	5	0	0	0	1	0	7	7	4
***S.* Stanley**	7	1	0	0	0	0	0	1	1	0
***S.* Weltevreden**	7	0	0	0	0	0	0	0	0	0
***S.* Braenderup**	3	2	0	0	0	2	0	0	0	0
***S.* Mbandaka**	3	0	0	0	0	0	0	0	0	0
***S.* Weltevreden var.15+**	2	0	0	0	0	0	0	0	0	0
***S.* Brunei**	2	0	0	0	0	0	0	0	0	0
***S.* Agona**	1	0	0	0	0	0	0	0	0	0
***S.* Bovismorbificans**	1	0	0	0	0	0	0	0	0	0
***S.* Hvittingfoss**	1	0	0	0	0	0	0	0	0	0
***S.* Muenchen**	1	0	0	0	0	1	0	1	1	0

***S.* Poona**	1	1	0	0	0	0	0	1	1	1
***S.* Singapore**	1	0	0	0	0	1	0	0	0	0
***S.* Typhimurium**	1	0	0	0	0	0	0	0	0	0
Total	79	27	0	0	0	35	0	33	27	16

AMP = ampicillin, C = chloramphenicol, CIP = ciprofloxacin, CTX = cefotaxime, NA = nalidixic acid, NOR = norfloxacin, S = Streptomycin, TE = tetracycline, SXT = sulfamethoxazole/trimethoprim

The importance of *Salmonella* as a public health hazard was clearly demonstrated in this study, which found a prevalence of 7.3% in the final product (chicken carcasses). That figure is close to the 9% prevalence of *Salmonella* in poultry carcasses after slaughtering and final products in Thai slaughterhouses reported in a study by Padungtod and Kaneene in 2006 (8), but much lower than in other studies, e.g., Kueylaw et al. in 2008 found a prevalence of *Salmonella* of 43%. Reports from elsewhere in the world also indicate a higher prevalence of *Salmonella* (44). For example, Elgroud et al. reported in 2009 that the prevalence of *Salmonella* in chicken slaughterhouses in Algeria was over 53% (61), while Fuzihara et al. reported in 2000 a 42% prevalence of *Salmonella* in chicken carcasses from small-scale poultry slaughterhouses in Brazil (62). Similarly, Bohaychuk et al reported in 2009 that the prevalence of *Salmonella* in poultry slaughterhouses in Alberta City, Canada was 37% (39), while Capita et al. found in 2006 that the prevalence of *Salmonella* in chickens from slaughterhouses in Spain was 17.9% (63).

Salmonella prevalence in these reports is significantly higher than that found in this study. One possible reason for the lower Salmonella prevalence found in the current study could be that the survey was conducted at small-scale facilities, the majority of which processed fewer than 50 birds/day. Processing fewer birds might result in a lower bacterial load in those facilities and thus a lower *Salmonella* prevalence in carcasses compared with other studies such as the one by Padungtod and Kaneene (8), which was done in medium- and large-scale slaughterhouses. Moreover, the traditional slaughtering process commonly found in smaller operations includes the final processing step of immersing the carcass in hot water for a short time to firm the skin. Immersion makes the skin more attractive, an important factor for small-scale operations which sell the final product (carcasses) in the local community. That process also has the effect of decreasing pathogen contamination. However, this method could also have the negative effect of increasing the temperature of the carcasses, making them more suitable for bacterial growth and thus more susceptible to rotting. For that reason, it is not appropriate for carcasses treated this way to be stored overnight.

The 29.3% prevalence of *Salmonella* contamination found in soil collected around slaughterhouse buildings and the 21.9% contamination rate in wastewater drained onto the area around the slaughterhouse without treatment, however, is evidence that improper hygienic practices can affect not only end consumers, but also members of the local community and the surrounding environment. These results mirror findings in previous studies in other regions of the world. For example, 100.0% of sludge samples collected from eight pig and five poultry slaughterhouses in Belgium and the Netherlands were found to be contaminated with *Salmonella* (64), and 7.4% of treated effluent samples from seven pig and seven poultry slaughterhouses in Brazil taken in 2003–2004 were positive for *Salmonella* spp. (65). Seven out of 22 samples (31.8%) obtained in 1993 from untreated wastewater from Nigerian slaughterhouses and river water collected at sites near those slaughterhouses tested positive for *Salmonella* (66). Thus, it can be inferred that slaughterhouses are a potential source for dissemination of foodborne pathogens into the environment, especially where poorly treated or untreated wastewater is discharged directly into the environment.

In this study, 100% of the pathogens were sensitive to chloramphenicol, ciprofloxacin, and cefotaxime. This finding is consistent with the results of antimicrobial resistant surveillance of food-borne pathogens in the EU countries which found that *Salmonella* was also susceptible to new antimicrobial agents such as cefepime, cefotaxime, and ciprofloxacin (67). This study further found that 44.30% of pathogens were resistant to nalidixic acid, which conforms to a previous study in Thailand by Padungtod and Kaneene which reported that *Salmonella* isolated from pigs and chickens in Northern Thailand in 2002 and 2003 was resistant to tetracycline and nalixidic acid (8). It also conforms to the study by Akbar and Anal which reported that *Salmonella* isolated from chicken in Bangkok was resistant to tetracycline and nalixidic acid (68). It has been reported that resistance to nalixidic acid might reduce the efficacy of members of the fluoroquinolone drug group such as enrofloxacin which has been widely used to control animal diseases (69). Moreover, de Jong et al. also reported that the extensive use of antimicrobials in both humans and animals was a fundamental cause of drug resistance (70). From these findings, it appears that antimicrobial resistant *Salmonella* might affect the use of antimicrobial agents for treatment of bacterial diseases both in humans and in animals.

In this study, 50.63% of the isolates were found to be multidrug resistant. That finding agrees with previous reports from around the world, e.g., Spain, Vietnam (71-73), Algeria (61), China (74), United States (61), and Brazil (75,76). In Thailand, Chuanchuen et al. reported that 67% of *Salmonella* was MDR (77). Because the resistance of *Salmonella* to antimicrobial agents could affect both livestock production and public health, it is essential to closely monitor the problem of drug resistance and to urgently encourage the prudent use of antimicrobial agents in the EU countries and elsewhere as recommended by various studies (78-82).

4.8 Policy advocacy

The meeting with policy-level DLD officers and the researchers was set up in 17 April 2013. This meeting aimed to consult and advocate the high-level DLD officers regarding the current situation, problems, and it's solving option. The participants include director of the Bureau of Livestock Standards and Certification, Chief of Slaughterhouse Control Division, and the officers responsible for slaughterhouse control.

Results from the meeting clarified that DLD officers agreed to the situation of small-scale poultry slaughterhouses and complications to get a license. The discussion confirmed more flexible regulations to get slaughterhouse license for small-scale slaughterhouses. Therefore, the policy is to assist small-scale slaughterhouse to get license through a more flexible regulation. Key points of policy landscape and situation include;

- DLD understands that small-scale SH is important as a livelihood, a part of culture and community. Therefore, the policy is to assist small-scale SH to get license through a more flexible regulation.
- The slaughterhouse control Act has been in place since 1992 under the responsibility of the Ministry of Interiors. There were attempts for strict enforcement since 2008 - 2009 in order to standardize the practices for both

domestic & exporting meat products. The deadline for slaughterhouses to obtain a license was in 2010, however, no enforcement until now.

- At the moment, a revised slaughterhouse regulation is in progress.
- Food education concept is a key approach adopted by DLD to deal with food safety issues and farms and slaughterhouse standard for more than 10 years. One of the campaigns is 'hygienic meat stall certification' in wet markets. So far, there are 2,500 certified meat shops nationwide.
- Inter-agency collaboration are challenging, either between 3 slaughterhouse law enforcement authorities or between DLD and Food and Drug Administration, Ministry of Health who regulates selling points/ markets.
- Food safety requires cooperation from both DLD (from farm to slaughterhouse and transportation to the market) and FDA (meat products & meat shops).

The guideline to encourage the small scale poultry slaughterhouse to improve the plant according to the laws was also discussed. The proposed implementation included;

- DLD categorized small-scale slaughterhouses into 3 groups, each requires different support: 1) already obtained license; 2) in the process of applying for SH license; 3) no intention to apply for a license. The last group would eventually be closed down.
- DLD would focus on group 2. For this group, district level DLD has responsibility to survey the slaughterhouses located within the areas and provides suitable assistance. However, DLD accepts that there are limitations of district level staff, e.g. knowledge on regulations, workload.
- DLD proposed a blueprint for small-scale slaughterhouse which would cost approximately THB 400,000 to invest. This model is cost-effective for slaughterhouse that slaughters at least 200 birds/ day. The blueprint of the small scale slaughterhouse was showed in Figure
- Some of the slaughterhouse regulation criteria could be flexible. For instance, the location of the slaughterhouse (most of slaughterhouses are in the community and

slaughterhouse owners require to improve their existing slaughterhouse, they are not willing to move to a new location).

- The minimum requirement of good practice of small scale poultry slaughterhouse was determined the criteria include;
    a) Slaughtering process cannot be done on the floor. Recommended practices are to hang the carcass on a rail or slaughter & cut the carcass on tables.
    b) Strictly separate clean and dirty zones
    c) Water used in slaughterhouse should be treated with chlorine before use.
    d) Standard hygienic practice for the workers is to wear an apron, boots, and a mask.
    e) Proper meat storage
    f) Clean and disinfect the slaughterhouse before and after the operation with disinfectant before and after slaughtering.
    g) Proper waste management system should be in place (for waste water & products)

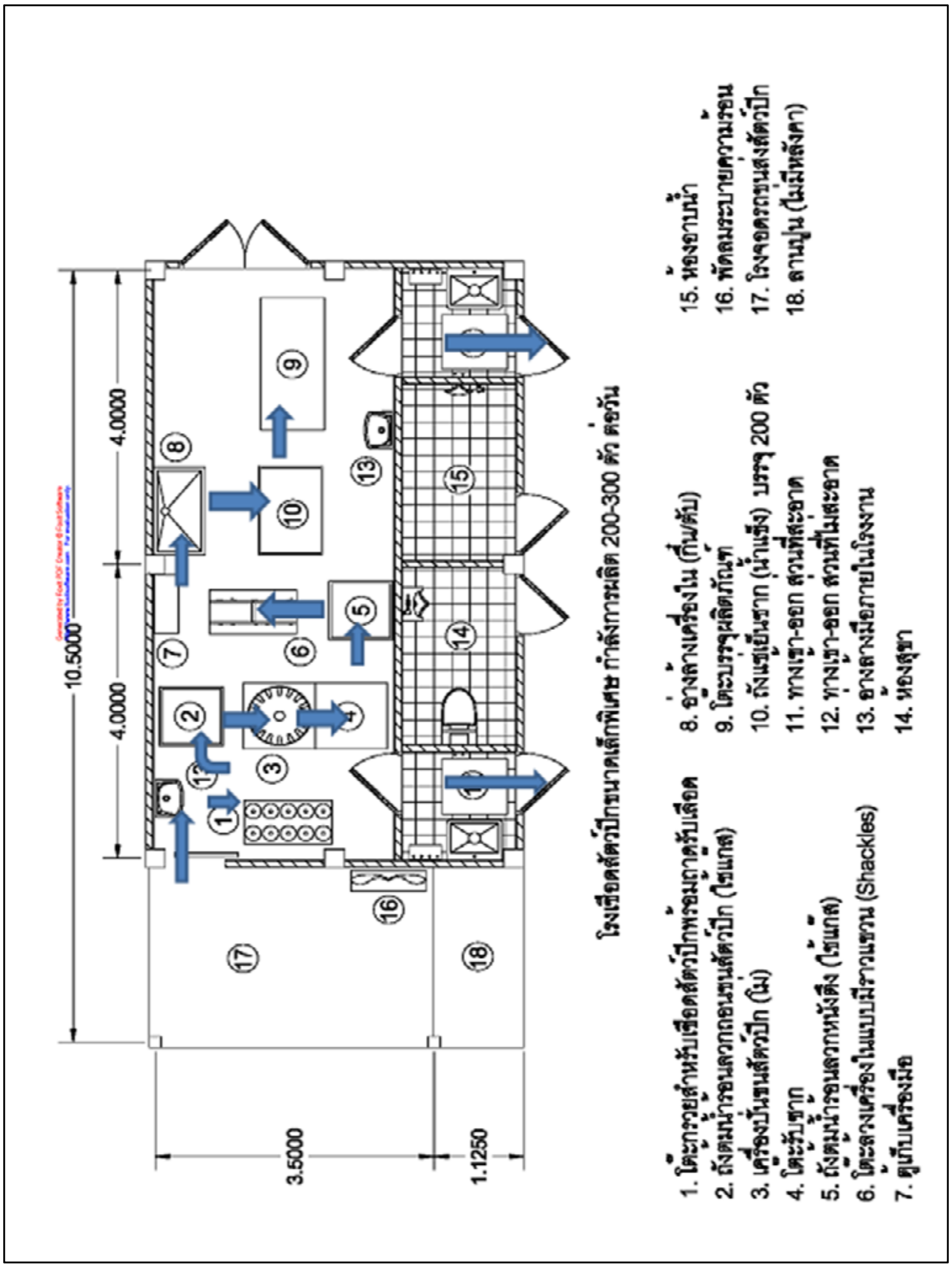

Figure 5: The small scale poultry slaughterhouses (200-300 bird/day) developed by DLD

4.9 Implementation of the improvement guideline to develop model of feasible and good practices in small scale poultry slaughterhouse

To implement the model of the feasible and good practices of the small scale poultry slaughterhouse. The blueprint was developed by using a combination of the research findings and minimum requirement. The investment cost of this model small scale poultry slaughterhouse was THB 200,000 and was implemented in Thung Chang district, Nan province. The blueprint is showed in figure.

Before implementation, stakeholders associated with slaughterhouses in the area were identified using stakeholder analysis and included in the study in the early stage. Brainstorm meeting with identified stakeholder were set up in order to implement the knowledge transfer.

The slaughtering process of the chicken of this raising group was traditional practice as described previously. To determine the effectiveness of the recommended practices, the meat samples were collected and test for Coliform and Total bacterial count in meat products which is showed in table

This finding indicated that the developed blueprint and the minimum requirement were feasible, that the operator can invest and operated. The model used could potentially be replicated elsewhere in Nan Province as well as in other Thai provinces. However, to address wider impact, continued policy advocacy were required

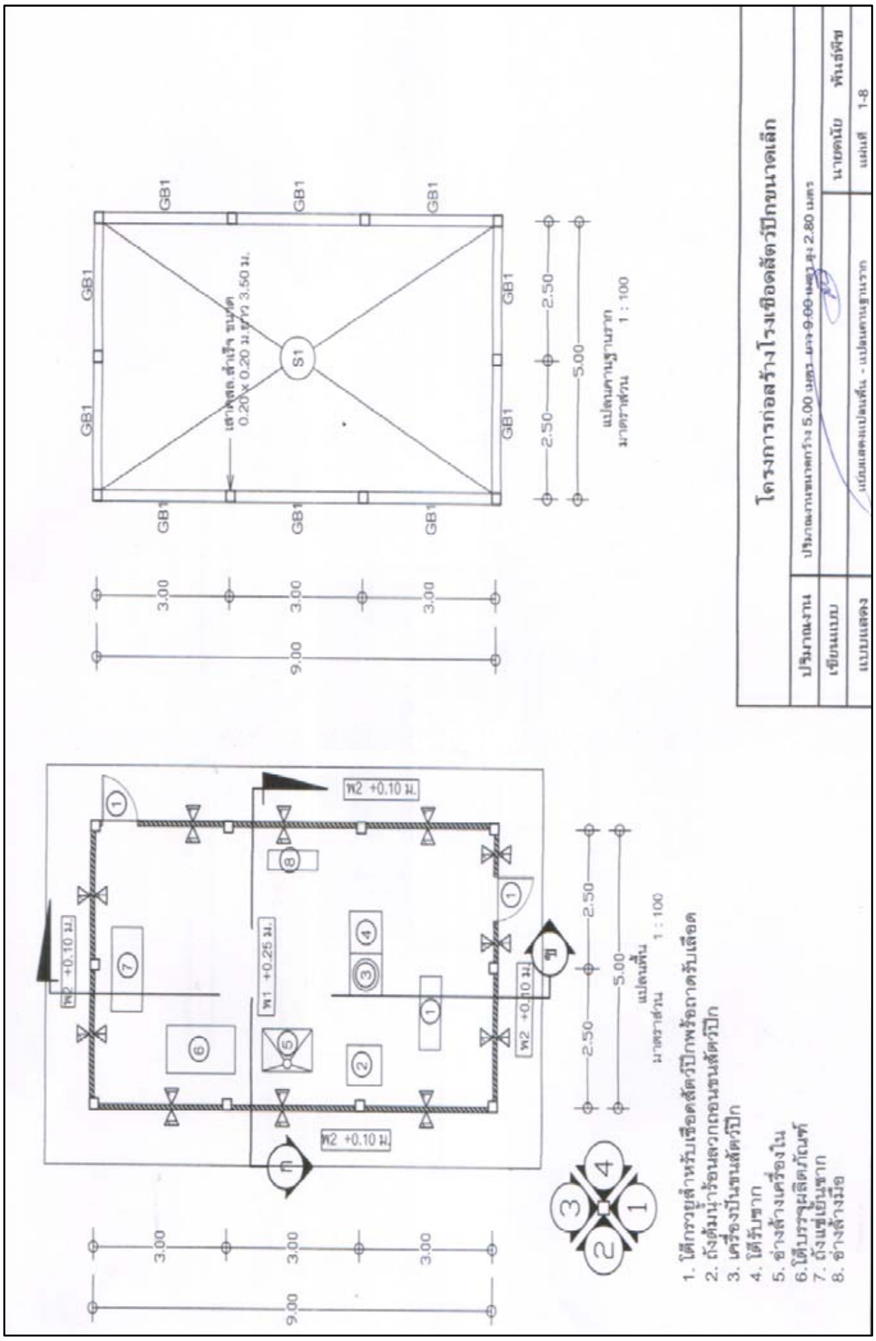

Figure 6: model of feasible and good practice of small scale poultry slaughterhouse developed from this study

Table 17: *Salmonella spp*. and Coliform bacteria from chicken meat before and after implementation

Test	Results	
	Before implementation	**After implementation**
Salmonella spp.	Not found (N=10)	Not found (N=9)
Coliform bacteria		
No 1	>1100 MPN/g	<2.0 x 10^2 CFU/g
No 2	43 MPN/g	<2.0 x 10^2 CFU/g
No 3	23 MPN/g	<2.0 x 10^2 CFU/g
No 4	2.4x10^4 CFU/g	<2.0 x 10^2 CFU/g
No. 5	1.6x10^3 CFU/g	<2.0 x 10^2 CFU/g
No 6	5.0x10^4 CFU/g	6.0 x 10^2 CFU/g
No 7	1.8x10^3 CFU/g	<2.0 x 10^2 CFU/g
No 8	7.2x10^2 CFU/g	<2.0 x 10^2 CFU/g
No 9	1.8 x 10^3 CFU/g	<2.0 x 10^2 CFU/g
No 10	2.8x10^2 CFU/g	NA

*NA= Data not available

Table 18: Total bacteria count from chicken meat before and after implementation

Test (Total bacteria count)	Results	
	Before implementation	**After implementation**
No 1	1.0×10^5 CFU/g	2.2×10^3 CFU/g
No 2	3.6×10^3 CFU/g	1.3×10^4 CFU/g
No 3	3.2×10^3 CFU/g	1.1×10^4 CFU/g
No 4	1.5×10^5 CFU/g	8.0×10^2 CFU/g
No. 5	4.8×10^4 CFU/g	1.3×10^4 CFU/g
No 6	5.0×10^4 CFU/g	3.4×10^4 CFU/g
No 7	1.1×10^5 CFU/g	2.2×10^5 CFU/g
No 8	8.4×10^4 CFU/g	2.5×10^5 CFU/g
No 9	6.2×10^3 CFU/g	6.7×10^5 CFU/g
No 10	4.1×10^4 CFU/g	NA*

*NA= Data not available

CHAPTER 5

CONCLUSION AND SUGGESTIONS

The use of the Ecohealth approach to develop conceptual framework

This study aimed to elucidate the status of small scale poultry slaughterhouses and their affect to ecological in the community in order to enhance hygiene and functioning of small scale slaughterhouses in communities by using the Ecohealth approach. Integrative research was used to elucidate the sanitation and disease prevention practices in small scale poultry slaughterhouses in Northern Thailand. Initial steps included the identification of stakeholders associated with meat production chain, development of a research framework, and designing the methodology based on stakeholder consultations. The framework and methodology derived combined at least five issue areas corresponding to the following disciplines; 1) public health 2) socio-economic 3) policy 4) veterinary and 5) community and environment.

This study could elucidate that Ecohealth approach was well applied in this study. Various fields including Veterinary Medicine, Public Health, Social Sciences, Economics, and Ecology were successfully collaborated and applied. Conceptual framework could be developed. The importance and interaction among each discipline were demonstrated. However, applying Ecohealth in actual situation is still challenging. It needs a further study. In surveillance, prevention, and controlling emerging infectious diseases, including Salmonellosis, using the Ecohealth approach, one factor related to success is the on-going cooperative participation of individuals from diverse academic and private areas. Operational plans for the short term, the medium term, and the long term are necessary and require significant cooperation of both efforts and spirit. In many networks, members working together as a team rely heavily on the expertise of each of the individual team members. Thus the development and improvement of the organization, the individuals, the network, and the links are all important to the strengthening of the Ecohealth network.

Law regulation of poultry slaughterhouses and its implementation

The main regulation regarding slaughterhouse control is the Ministerial Regulation on Determination of Criteria, Procedures and Conditions for Establishing Slaughterhouses, Lairage and Animal Slaughter B.E. 2555. To be licensed by the DLD, all slaughterhouses in Thailand must comply with this regulation. In addition, good manufacturing practices (GMPs) for poultry slaughterhouses were announced, and their adoption has been mandatory since 2006. However, in practice, the GMP guidelines have been enforced only in slaughterhouses which have been issued a government license.

However, the result of this study demonstrated that most of small scale poultry slaughterhouses could not address these regulations because the criteria are intensive and require high levels of investment, making them suitable for large- and medium-scale operations which generate sufficient profit. The recommendation of the government officers indicated that the current regulations should be more flexible and practical for small scale plants.

Regarding slaughterhouse owners' perceptions of relevant laws and regulations, the majority of the owners concluded that the criteria in the current standard regulation were impractical for small-scale slaughterhouses. They pointed that they would have to stop operating their business if the DLD strictly enforced all the standard slaughterhouse regulation requirements. Although most of the owners accepted that they did need to improve their slaughterhouses, they indicated a desire that the regulatory criteria be more practical.

Food safety perception of small scale poultry slaughterhouse owners and hygienic practices

The results of zoonotic diseases and food safety perception of the slaughterhouse owners showed that there was the only high perception only on the possible transmission of the diseases from sick birds. Contrary, perception on important statement such as cleaning measures and zoonotic knowledge were low. It could be suggested that the perception of the zoonotic knowledge, the diseases control and prevention in the slaughterhouse should be improved.

This study could be concluded that good hygienic management is not widely practiced in small-scale slaughterhouses in northern Thailand. This study elucidated that, in general, hygienic practices did not fully follow existing regulations and that the government provided guidelines are not implemented by many slaughterhouses. The presence of *Salmonella* in slaughtering process was evident of improper hygienic practices. Therefore, the improvement of hygiene management of small scale poultry slaughterhouse should be urgently improved.

***Salmonella* contamination in slaughtering processes and environment**

This is also the first comprehensive study describing the prevalence of *Salmonella* contamination and the antimicrobial resistance of that pathogen on the processing lines and in the environment surrounding small scale poultry slaughterhouses in Thailand. The study found contamination of *Salmonella* in raw poultry meat, on utensils used in processing, in waste water and in soil around the slaughterhouses, indicating they are sources of the spread of *Salmonella* both in raw poultry meat and also in the surrounding environment and local communities. The five most common *Salmonella* serotypes found in this study were among the top 10 serotypes causing human salmonellosis in Thailand, signifying a significant public health threat. In addition, the serotypes had a high rate of multidrug resistance. These findings highlight the importance of and the urgent need for controlling the use of antimicrobials in animal production and for improving management of small scale poultry slaughterhouses.

Development of guideline of hygienic improvement of small scale slaughterhouse

Policy advocacy was performed through meeting with high-level DLD officers who are responsible for slaughterhouse control in Thailand. The instruction and minimum requirement for enhancing small scale poultry slaughterhouse to address food safety was developed and then pilot tested with native chicken raising group in Nan province. The laboratory results indicated that the biological meat quality including Coliform bacteria and total bacterial count contamination in poultry meat was lower compared with before implementation.

In conclusion, this study could indicate that there were complex factors affecting to the hygienic management of the slaughterhouse. The contamination of *Salmonella* spp. in slaughtering process, meat, as well as the environment was clearly demonstrated that the potential risk for public health and ecological facet. These research findings were advocated for policy-level DLD officers and then the cost-effective model of feasible and good practice small scale poultry slaughterhouse was developed and tested. This study also demonstrated the potential of the Ecohealth approach for addressing a critical problem and it's solving at the interface of rural development and public health.

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APPENDIXES

APPENDIX A

Questionnaire for Slaughter house

Name of interviewee……………………………………………………….**Code**…………………...

Name of interviewer……………………………….**code of interviewer**………………………….

Date of interview………/…………………./…………..

1. Address

Address	
Telephone	
Fax	
GPS profile	

2. Reference to other holdings or geo-physical points

Places	**Name**	**Distance from slaughter house**	*GPS*	
			X utm	*Y utm*
Community				
Poultry farm				
Poultry market/wet market				
Main road				
Water sources				

3. Demographic data

1. How many family members do you have	Specify…………………	
2. How many members involve to the business?	O Man………………	O Woman…………………
3. Do you hire anyone to work with you	O Yes	O No
4. If yes how many people you hired	O Full time Men………………. Women………….	O Part time Men………………. Women………….
5. Respondent	O Owner	O family members
	O Worker	
6. Sex of the owner	O Male	O Female
7. Age	O < 20 yrs	O 21-29 yrs
	O 30-39 yrs	O 40-49 yrs
	O 50-59 yrs	O >60 yrs
8. Educational status	O None	O Primary
	O secondary	O Diploma
	O Bachelor	O Higher than Bachelor
9. How long for running the business	O 1-5 yrs	O 6-10 yrs
	O 11-15 yrs	O 16-20 yrs
	O 21-25 yrs	O > 25 yrs

4. Capacity

Animal	Average number of head /day	Average number of head /week
1. Chicken		
2. O Broiler		
3. O layer		
4. O Native chicken		
5. Other poultry (identify)…. …….. ……..		
6. Other animals (identify)….. ……..		
7. Origin of the chicken	O Inside the province (%……….)	O Outside the province (%……….)

5. Biosecurity

1. Do you carry out a withdrawal day	O Yes	O No		
2. When was the last withdrawal day? And the day before?	Specify..			
3. If things are very busy, is it necessary to miss the withdrawal day	O Yes	O No		
4. The source of water used for cleaning	O Tap water	O Underground	O Surfaced water	O Other......... ....
5. What is used to clean	O Disinfectant	O Detergent	O Hot water	O Other.......
6. Frequency of cleaning and adequacy of cleaning	O Every day	O Specify		
7. Type of disinfectant	O Specify..			

6. Disease control management

1. Water sources	O Tap water	O Underground	O water ways	O other ....
2. Share water source with community (surface water)	O Yes	O No		
3. Is running water available in each room?	O Yes	O No		
4. Treat water before use	O Yes	O No		
5. Method of cleaning the truck	O disinfectant bath	O disinfectant house	O disinfectant spray machine	O None
6. Method of cleaning of the staff	O bathing	O Hand and foot bath	O Other	O None
7. Record of people in-out SLH	O Yes	O No		
8. Presence of pest control	O Yes	O No		

9. Use only chemicals approved by FDA	O Yes	O No		
10. Chemicals used in slaughterhouses properly stored	O Yes	O No		

7. Veterinary services

1. Are there regular inspections of the SH	O 1 time/yr	O 2 times/yr
	O 1 time/month	O never
	O Don't remember	O Other……………………
2. If yes, by whom	O DLD officer	O MPH officer
	O Environmental officer	O Other…………………..
3. When did the last time	O Specify………………………………………………………..	
4. Can you recognize the sick birds	O Yes	O No
5. If yes, how the owner/worker handle sick poultry	O Slaughter them	O Condemn
	O Treatment	O Send back to farm
	Other………………..	
6. How the owner/worker handle dead poultry (abnormal dead)	O Slaughter for own consumption	O Slaughter and sell
	O dispose by burying	O Dispose by burning
	O throwing	O Feed to companion animal
	O Others …………………………………..	
7. How the owner/worker handle dead poultry 8. (Normal dead)	O Slaughter for own consumption	O Slaughter and sell
	O dispose by burying	O Dispose by burning
	O throwing	O Feed to companion animal
	O Others …………………………………..	
9. Is there inspection of chicken before	O Yes	O No

slaughtered		
10. If yes, by whom?	O Vet	O Paravet
	O Others	O None
11. If he finds a problem what he will do?	O Condemn	O Do nothing
12. Inspection of carcasses	O Yes	O No
13. If he finds a problem what he will do?	O Condemn	O Do nothing
14. How many are rejected per day (number and %)	Specify………………………………………………………	
15. What are the causes of the rejection	O Rot	O The chicken die by diseases
	O Contaminate with waste	O Other……………
16. What do you do with rejected carcasses (Multiple choices)	O own consumption	O sell
	O dispose by burying	O Dispose by burning
	O throwing	O Feed to companion animal
	O Others………………….	

8. Health status

1. Work hours/day	………….hours/day	
2. Work day/week	………….day(s)/week	
3. Use of protective equipment	O Mask	O Glove
	O Other………………	O None
4. - How you use them	O Always use	O Sometimes
	O Never	
5. - Why you use them	O Avoid disease	O Followed the regulation
6.	O Other…………………..	
7. - Why you do not use them	O Not available	O Too expensive
	O Too uncomfortable	O Not needed
8. Condition of equipment	O Clean	O Dirty
	O Intact	O Damage

9. In the past month, do you have health problems	O Yes Specify what symptoms: - Diarrhea - Vomiting - Stomach pain - Back pain - Arm pain	O No If NO then ask for the last 6 months
10. If Yes please identify the problem	O Injury	O Respiratory problem
	O Gastrointestinal problem	O Fever
	O Muscle pain	O Skin problem
	O Allergy	O Other......................
11. When you got sick what did you do?	See doctor	Buy medicine
	Nothing	Other.........................
12. How much days pay lost/day	O Specify...	
13. How much expense incurred for medicine, travel, child minding etc	O Specify...	
14. Have you every checked for health status	O yes	O No
15. If yes when for the last time	O Specify...	
16. If yes how many times you check /year	O <1time/yr	O 1 time/yrs
	O 2 times/yrs	O >2 times/yrs
17. In general, what is your health status	O Excellent	O Good
	O Fair	O Poor
18. In case you get sickness, do you withdraw for the work	O yes	O No
19. How much you spend to cure you sickness	O Specify...	
20. How many days you lose from illness over 6 months period	O Specify...	

11. Environmental management

1. Method of liquid waste treatment before draining	O Clarifier	O Treated pond	O Others ………………	O None
2. Liquid waste draining site	O SLH area	O Community	O Stream	O Other…..
3. Method to treat the feathers	O bury	O burn	O sell	O Other……… …………
4. Method to treat the feces	O dry	O discard	O other …………………	O None
	O bury	O composting		
5. Method to treat solid waste other than feces (feathers and others)	O burn	O discard	O other …………………	O None
6. Human exposure to the waste: Are people in contact with wastewater and feces?	O Yes	O No		
7. Reuse of the waste: Do people use wastewater for irrigation and feces for fertilising field?	O Yes	O No		
8. Waste water draining site	O SLH area	O Community	O Other…..	O None

10. Socio-economics

1. Did you borrow money to conduct your operations between July 2010 and June 2011?	O Yes How much? ……………. From where? ……………….	O No		
2. After borrowing, do you get enough funds to conduct your operations?	O Yes	O No		
3. Did you sell goods on consignment?	O Yes	O No		
4. What percentage of your sales are made on consignment?	O Yes	O No		

5. On average, how long is the period of consignment?	O ------------(what is the unit here?)	O No		
6. Has your business ever had contracts for the production of carcass?	O Yes what percentage of your total carcass sales? ……………	O No		
7. Your business ever had contracts for procurement of live poultry? ………………………..	O Yes what percentage of your total procurement of live poultry? ………………	O No		
8. How do you consider the profitability of your … activities during the period from July 2009 to June 2010	O Good	O Fair	O Poor	
9. How do you consider the profitability of your … activities during the period from July 2010 to June 2011?	O Good	O Fair	O Poor	
10. If the profitability ranking changed between last year and this year, what is the main reason for the change in the profitability ranking of your business activities?	1. Sale price	2. Purchase price	3. Volume of trade	4. Competition level
	5.Labor costs	6. Intereste rate	7. Technology level	8. Other
11. Percentage of slaughtering business in total income?	……………………..			

11. **Zoonotic aspect perception**

Topic	Strongly agree	Agree	Indifferent	Disagree	Strongly disagree
1. The sick poultry can transmit the disease to human					
2. The poultry which look healthy can transmit the disease to human					
3. The dead poultry can transmit the disease to human					
4. The pathogen can contaminate to the slaughterhouse area					
5. The pathogen can spread into the environment					
6. The pathogen can be eliminate					
7. The slaughterhouse cleaning measures is important					
8. The withdrawal period for slaughterhouse is important					
9. Inspection the chicken before slaughter is important					
10. Inspection the meat after slaughter is important					
11. The unqualified chicken should not be slaughtered					
12. The unqualified meat should not be consumed					
13. The workers in slaughterhouse can protect themselves from diseases					
14. The workers in slaughterhouse should have zoonotic prevention knowledge					

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List of publications

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