CHAPTER II

LITERATURE REVIEW

2.1 Slaughterhouse operation

Pig slaughter

In the modern slaughter line, pigs are stunned by the gas CO_2 or with electric stunning (Grandin and Smith, 2004; Food Chain Evaluation Consortium (FCEC), 2007). The stunned pig is hoisted by the hind leg onto an overhead conveyor railing and then stuck to bleed over a bleeding trough. After bleeding, the carcass is moved through a steam tunnel or immersed for 3 to 6 minutes in the scalding tank which scald water temperature should be 60-62 °C, then carcass moved to the automatic dehairing machine, where the bristles, outer skin layer, and toenails are removed. The pig carcass is next passed through the singeing process where it is exposed to temperatures of 900°C to 1,000°C for 5 to 15 seconds to eliminate remaining hair. After singeing, the carcass is cooled down by showering with cold water and passed through a scraping machine to clean the skin. The pig carcass must be thoroughly cleaned before it enters flow into the 'clean area' for evisceration, during which bladder and sexual organs, intestines, the stomach, spleen and pluck set, i.e. heart, trachea, lungs and liver are removed and transported to separate edible and inedible visceral rooms for further processing. The carcass is split, and inspected. After post-mortem inspection, the carcass is then washed, weighed, and classified before chilling/freezing and maturation. Some slaughterhouses also do further processing (e.g. cutting, deboning, and further meat processing activities including grinding, mixing with additives, pickling, smoking, cooking, and canning) to produce retail cuts

(Food and Agriculture Organization of the United Nations (FAO) 2004; International Finance Coperation & World Bank Gruop, 2007; EFSA Panel on Biological Hazards (BIOHAZ), 2010).

In traditional slaughtering in South-East Asia, high number of traditional slaughtering practice still operate in old slaughterhouse or in small and medium slaughterhouse even though there are many modern slaughterhouses with good hygienic practice. Some traditional slaughterhouses are not closed or open air buildings with only simple and basic equipment and there is no clear separation between dirty and clean areas. Floor slaughtering is practiced and often, the entire process may be performed at the same spot. Stunning is not practiced. Pigs are usually restrained or hit at the head before sticking. For removal of hair and softening of the skin, scalding is done using hot water, either by soaking in a scalding vat or poured over the carcass. Dehairing is done either by flaming or knife scraping of hair which may be done on a table. The carcasses are then cut and eviscerated on the floor or hung up by the hind legs and split. As the carcasses are sold immediately there is no temperature control at any point (Heinz, 2008).

Poultry slaughter

Most large (slaughter > 6,000 birds/hour) and medium scale (slaughter 1,000-5,000 birds/hour) poultry slaughterhouses (Silverside and Jones 1992; FAO/WHO 2009) are equipped for and capable of automatic machine processing. Birds in crates are transported by trucks to the slaughterhouse, held in the lairage and subjected to ante-mortem inspection. The birds are then hung upside down by their feet in the shackles on a conveyor and moved to the electrical stunning machine. Slaughtering can be performed manually or by using an automatic circular knife system; anyhow, the birds are to bleed until total bleed-out. The birds are exposed to either steam or hot water in the scalding machine which is controlled by regulating temperature (50-65 °C) and time and adding a continuous counter-current flow of water. Then feathers are removed in a specially designed plucking machine. In larger scale slaughterhouses, evisceration is done mechanically. In medium scale operations, evisceration is

manually. The opened bird and the organs are presented for post-mortem inspection. After inside-outside bird washing, the carcasses are cooled down to or below 4°C by air chilling, spray chilling, or immersion chilling. The birds are weighed individually and separated via different conveyor lines either as whole bird or cut into parts. Products then go into chilling or freezing, packing, boxing and are kept in the storage (Verheijen et al., 1996; (FAO/WHO) 2002; Löhren, 2012).

In very small and (200 birds/day) small (slaughter 500 birds/hour) scale poultry processing operations (Silverside and Jones, 1992), slaughter is carried out manually using simple processing equipment. Poultry processing can be done using a conveyor line by hanging animals on their legs and using electrical stunning. In a more simple way, some operator use the funnel-shaped kill cones for restraining and bleeding and some slaughterhouse stun animals by simple electrical stunning before place headfirst into a cone, with the head and neck pulled downwards through the cone opening. Plucking is using a "dry pick method", most often by hand on a special machine or a wet scald method by dipping birds into scalding tank. Pin feathers may be removed by hand or a simple machine and evisceration is carried out on an overhead rail, carousel or table. Carcasses are washed and chilled with chiller facility or big ice tub before dispatch or further processing. Some operators don't do eviscerate and in some operators, carcasses and the respective giblets are put together before they are packed, chilled or frozen. Some carcasses are processed further into portions or poultry products (Silverside and Jones, 1992; Fanatico, 2003; Anderson and Hashley, 2012).

2.2 The practices in slaughterhouses in South- East Asia

The Food and Agriculture Organization reported in 2008 that most slaughterhouses of the 18 member countries of the Animal Production and Health Commission for Asia and the Pacific (APHCA, 2012) are officially registered but most of them are small - to medium scale and supply traditional meat markets with "hot" (unrefrigerated) meat due to consumer demand. Therefore, FAO requests slaughterhouses to be located close to the markets for rapid distribution. This, in turn,

is expected to influence the type of slaughter operation and construction, as well as the facilities used in such a slaughterhouse and limits its size to small and medium-size operations. It resulted in a high number of small slaughterhouses in this region whereas in developed countries most animals are slaughtered in large slaughterhouses (Heinz, 2008).

This FAO report also provides valuable information and descriptions of slaughterhouses in different APHCA countries. The slaughterhouse sector in Malaysia is well established. The accredited and licensed slaughterhouses in the Philippines are composed of around 500 plants, most of them slaughter pigs and are privately owned. Meat dealers or butcher shops rent the slaughter facilities, have their own workers and deliver unrefrigerated meat mainly to the so-called “wet markets” (Heinz, 2008).

In Vietnam, the largest meat consumption area is Ho Chi Minh City (HCMC) where slaughterhouses are mainly slaughtering pigs 29 abattoirs are officially registered in the HCMC metropolitan area and a few, two are officially registered, are specialized in cattle slaughtering. A large-scale pig slaughterhouse uses a continuous-line system. The semi-line systems use traditional ways to move the carcasses from stunning and bleeding to scalding and scraping, frequently dragging them along the floor; however, for eviscerating and splitting, the carcasses are suspended on rails (Heinz, 2008). One study in 2009 found that most of 10 studied slaughterhouse did all process from slaughter until dressing on the floor and improper cleaning and disinfection (Pham et al., 2009).

In Indonesia, cattle are the dominant slaughtered livestock; pigs are only slaughtered commonly in Java and Bali. There are 838 slaughter facilities registered throughout the country, which are categorized in two types: Type I which meets minimum hygiene requirements (154 units or 19%) and Type II which does not meet minimum hygiene requirements (684 units or 81%). Apparently butchers and meat dealers nowadays prefer using the small abattoirs scattered around the country to supply the traditional meat markets because the slaughter fees and transport costs for livestock and meat are lower (Heinz, 2008).

According to an FAO research in APHCA member countries on slaughter hygiene practices as animal welfare matters, non-suitable slaughter methods and by-product handling facilities and lack of concern among workers unnecessary on hygienic slaughtering were identified as the main problems. Hygienic practices are not applied on meat cutting, deboning, during transport and on transport facilities. Poor construction conditions, improper material and unmaintained structures result in ineffective cleaning and sanitation. Many countries lack of meat inspection and sanitary control as well as waste disposal and effluent treatment. Even though the pig skin is not removed and, thus, can protect the meat, bacterial contamination may come from scalding and the dehairing process where too high temperatures in scalding tanks cause the skin to be easily damaged during scraping. Contamination can also come from dirty water in the scalding tank.

The ideal slaughterhouse operation uses the line-slaughter system by hanging the carcass from bleeding until finished dressing, thus preventing contamination of the carcass. The other systems of pig slaughtering without electrical equipment are multi-tiered systems or in different levels of floor, roller table and also manual lifting. In this way pig carcasses are not on the floor and the slaughter process is done in a hygienic way. Furthermore, slaughterhouses in this region need to improve structure and installations with regards to waste management and effluent treatment. Machines and equipment needed can be locally produced to reduce the investment cost. Eventually, sanitary control measures must be efficiently enforced, and sanitary control personnel empowered to shut down operations or exclude facilities from the food chain if minimum requirements are not met (Heinz, 2008).

Slaughterhouses in developing countries may be supported and advised to make local or modify simple equipment e.g. to be used to restrain and stun animals for compliance with good animal welfare standards. Expensive high-tech equipment requires investments, is costly for maintenance and spare parts. Furthermore, workers are usually reluctant to use too complicated devices. Animal welfare practice during transport and slaughter can improve substantially by changing marketing systems.

Stakeholders should know their economic losses from bruises, skin damage or dead animals so that they can increase economic return by improved stunning, good management of transportation and, last but not least by training their own staff who handle transport and slaughter livestock (FAO, 2001).

The good hygiene practice in slaughterhouses should include well-planed, well-executed and controlled cleaning and sanitation programmes for rooms, machines and equipment. Cleaning and sanitation alone, however, will not assure a hygienic standard in production where process hygiene as well as personal hygiene is important factors. The overriding hygiene principle in processing is that clean and unclean operations are efficiently separated. This requires first of all a well-planned slaughter plant layout, where the purpose of any structure should be to protect the products against unintended contamination (Skaarup, 1985).

2.3 Domestic slaughterhouses in Thailand

2.3.1 Slaughterhouse and meat control in Thailand

There are three main agencies responsible for slaughterhouse and meat control in Thailand.

- The Ministry of Public Health (MOPH)'s main roles are setting up food standard for domestic consumption, sampling and quality assessment of food safety, sanitation and environmental health in markets and cooperation with DLD for controlling imported raw meat (MOPH, 2012; Thai FDA, 2013; Department of Health, 2013).

- Local government organizations being the Provincial Administrative Organization (PAO), City /Town /Subdistrict Municipality, Subdistrict Administrative Organization (SAO), the city of Pattaya and Bangkok metropolitan Administration (BMA). These local organisations are under the Department of Local Administration (DLA), Ministry of Interior and they operate government or municipality

slaughterhouses, give permission to slaughter animals and distribute meat and appoint meat inspectors (DLA, 2013).

- The National Bureau of Agricultural Commodity and Food Standards (ACFS) under the Ministry of Agriculture and Cooperatives is responsible for standard setting for agricultural systems, commodity and food items, and food safety from agricultural products, accreditation of certification bodies, and dialogue and negotiations with international trade partners on disputes concerning SPS/TBT issues (ACFS, 2013).

- The Department of Livestock Development is responsible for animal health and disease control, feed control, animal farm matters such as monitoring, certification and environmental issue, animal welfare, and import-export of live animals and animal product controls. For slaughterhouse control, DLD works to improve and update regulations and procedures, issues slaughterhouse licenses, registers meat dealers, supports training for involving DLD officer, personnel from local authorities and slaughterhouses, and monitors food safety and food hygiene of meat and animal products for domestic consumption and for exports to international markets (DLD, 2012; BLSC, 2013b).

2.3.2 Special issues related to Thai domestic slaughterhouses

Domestic Slaughterhouse holdings in Thailand are to be distinguished from municipal slaughterhouses and private slaughterhouses. Most slaughterhouse holders are the local municipalities. The “Study on Pork production and Distribution System for Establishment of Strategy on Pig Abattoir Construction in each Region of Thailand” by (Suphaprapakarn S., 2008) showed that private slaughterhouses were better than municipal slaughterhouses in improving towards a “Standard Slaughterhouse”.

In general, slaughterhouses in Thailand can be divided into three categories based on their daily slaughter capacity; large size, medium size and small size (BLSC, 2008). (Table 1).

Table 1 Categorization of Thai slaughterhouses

Species	Small Size (capacity in heads/day)	Medium Size (capacity in heads/day)	Large Size (capacity in heads/day)
Pig	1-50	> 50-100	> 100
Cattle, Buffalo	1-5	> 5-20	> 20
Sheep, Goats	1-5	> 5-50	> 50
Poultry	⩽ 500	> 500-4,000	> 4,000

Source: Manual on Slaughterhouses and Meat Distribution Standards Development (BLSC, 2008)

The slaughter process in a domestic slaughterhouse follows the conventional or "old system" with no stunning, slaughter on the floor and no chilling system or temperature control. A pig slaughterhouse questionnaire by DLD covering the whole country (Suphaprapakarn, 2004) found that there were about 3,040 registered pig slaughterhouses which applied for a licence but still did not receive it as only around 10% complied with the Thai domestic slaughterhouse standard. The standard covers basic good practices which define (i) location and construction of the building, (ii) machines, tools and equipment (iii) facilities (iv) hygiene control and (v) management. The pig slaughter process is still starting with beating at the pig's head followed by stabbing or cardiac puncture to kill the animal. In this DLD survey, it was also found that slaughterhouse operators were of the opinion that the obstacle for improvement was not lack of budget but they were rather afraid that the future profit would not cover the investment costs.

The majority of chicken meat or carcasses for the domestic market are supplied by large size slaughterhouses or integrated poultry production companies. Data collected in 2011 for Thailand (USDA, 2011) showed that integrated poultry

companies produced 3.10 million birds/day or around 84.5% from the total national production of about 22 million birds/week. A small size chicken slaughterhouse, however, will supply a small local area and sale whole birds without cutting and even sometimes without evisceration. In the latter the butcher will eviscerate and cut the chicken at the market or sale point.

2.3.2 Licenced slaughterhouses and slaughtered animals in Thailand

In August 2012 the total number of licenced slaughterhouses in all Thailand was 1,404 slaughterhouses, and in Livestock Region 1 144 slaughterhouses equivalent to 10% of all slaughterhouses in the entire country (BLSC, 2012b). From 2009-2012 (BLSC, 2012a; BLSC, 2013a), the number of licenced slaughterhouses increased every year with pig slaughterhouses receiving most licences followed by cattle slaughterhouses while there was an increase in number of licenced of poultry slaughterhouses in 2012 because DLD policy impelled registered slaughterhouse to improve for the licence (Planning Division, 2012). (Table 2).

Table 2 A breakdown of licenced slaughterhouse in Thailand in 2009 to 2012 by species

Species	No. licenced slaughterhouses in			
	2009	2010	2011	2012
Pig	525	544	547	694
Cattle	255	281	304	345
Pig-Cattle	200	222	222	220
Poultry	89	105	142	296
Sheep-Goat	1	1	1	1
Total	1,070	1,153	1,216	1,565

Source: Annual Report 2011 and 2012, Bureau of Livestock Standards and Certification, DLD

In 2012, boiler production totalled 137,646,821 heads and total chicken meat consumption was 935,798 metric tons (OAE, 2012).

DLD reports the estimated number of livestock (pig, cattle and buffalo) slaughtered in the whole country consisting of data from recorded legal slaughters and estimated illegal slaughter numbers. The estimated number of livestock slaughtered in 2011 was 5,528,573 heads with pigs accounting for 87.8% of the livestock slaughtered (Table 3).

For Livestock Region 1, the estimated slaughtered livestock number was 725,131 heads or 13.1% of the whole country, the number of slaughtered pigs was around 681,702 heads (94% of livestock slaughtered in Region 1), and of slaughtered cattle and buffalo was 43,429 heads (6% of livestock slaughtered in Region 1) (Information Technology Center, 2012).

Table 3 DLD estimated number of animals slaughtered in 2011 by Livestock Region in Thailand

Livestock Region	Estimated number of slaughtered livestock (in heads)			
	Total	Cattle	Buffalo	Swine
1	725,131	35,088	8,341	681,702
2	1,062,691	18,549	10,199	1,033,943
3	661,479	129,770	17,452	514,257
4	499,798	150,403	18,220	331,175
5	916,661	68,013	37,249	811,399
6	400,140	26,554	10,188	363,398
7	484,779	51,390	554	432,835
8	377,902	16,707	887	360,308
9	399,992	71,055	1,286	327,651
Total	5,528,573	567,529	104,376	4,856,668

Source: Information Technology Center, DLD 2012

2.4 Meat inspection in Thailand

2.4.1 Meat inspection procedures and recording

Meat inspection ensures that the meat is fit for human consumption and, thus plays on important role in protecting consumers and the. Ante-mortem inspection is the inspection of live animal prior to slaughter. Post-mortem inspection is dealing with the inspection of all parts of the carcass and the organs. If the inspector responsible finds abnormal symptoms in the ante-mortem inspection or abnormal lesions in the post-mortem inspection, the decision taken should be substantiated and categorizing which animals, carcasses, and /or organs should be either passed as fit for human consumption, rejected or condemned.

Adequate animal identification and record keeping systems are essential if full use is to be made of on-farm information relevant to ante-mortem and post-mortem inspection. For the decision that meat is fit for human consumption, it must be ensured that both ante-mortem inspection findings for an animal and post-mortem inspection findings are considered. Post-mortem inspection procedures should be established by the competent authority according to a science- and risk-based approach. In the absence of a risk-based system, procedures will have to be based on current scientific knowledge and practice (OIE, 2005).

The procedures of post-mortem inspection are varying in different countries. In Thailand, DLD set the guidelines for the good practice in domestic slaughterhouses and standardized the documents and recording sheet used ante-mortem and post-mortem inspection recording sheet. Only in slaughterhouses under the Slaughterhouse and Butcher Shop Improvement Project ante-mortem and post-mortem inspection is performed by DLD meat inspectors and reported to DLD as from April 2011. Under the Animal Slaughter Control and Meat Sale Act B.E. 2535 (1992), DLD transferred the authority for appoint official and meat inspector to the local authority. Therefore the management and reporting system of local authority on meat inspection may be

different and may vary practices and currently, there is a lack of sharing of information between responsible organizations.

2.4.2 Post-mortem inspection

In a study surveying one Thai pig slaughterhouse with 75,065 slaughtered pigs from January 2002 to September 2003 lung lesions were found to be 73% (Jongsatien, 2004), however, being the only reference for Thailand. In Lithuania, lesions detected during the period 2007–2009 were found in the respiratory tract with 78.98%, in the liver with 31.79%, the heart with 6.23% and the skin with 0.04% (Januškevičienė, 2010). A study in Austria during September 2007 to December 2010 in 264,039 slaughtered pigs found respiratory disorders such as pneumonia and pleuritis in 46.4% (Wanda, 2011). The post mortem finding in Sweden have been found emaciation, discoloration, cellulitis (0.35%), ascites (0.27%), hepatitis (0.13%) and pericarditis in the flock as the main lesion encountered during inspection (Löhren, 2012).

2.5 Bacterial contamination in meat

In a study on *Salmonella* spp. in food in Chiangmai and Lumpoon (Padungtod and Kaneene, 2006) reported a *Salmonella* spp. prevalence in pigs in slaughterhouses of 28% and in pork from the market of 29%.

During the period from February to April 2009, a total of 545 samples from pigs (210), carcasses (210), water (41) and workers (84) were sampled in three slaughterhouses in Khon Kaen. *Salmonella* spp. were isolated from 27.14% of pigs and from 36.67% of pig carcasses (Sithigon & Angkititrakul, 2011).

The DLD has monitoring plans for checking meat from domestic and export slaughterhouses and meat in markets which volunteered to join the DLD project, such as certified butcher shops under the DLD Slaughterhouse and Butcher Shop Improvement Project. The microbiological criteria of DLD as microbiological guidelines are given in Table 4. Meat samples from slaughterhouses and butcher

shops under the DLD pilot project are sent to the laboratory for hygiene monitoring by Aerobic Plate Count (APC), *Salmonella* spp. and *Staphylococcus aureus* testing.

Table 4 Microbiological guidelines for chilled/frozen meat and poultry Meat

Item	Aerobic Plate Count at 35°C/48 h (or at 30°C/72 h) (cfu/g)	Coliform (cfu/g)	*E. coli* (cfu/g)	*Staph. aureus* (cfu/g)	*Enterococci* spp. (cfu/g)	*Salmonella* spp. (in 25 g)
Criteria	$\leq 5.0 \times 10^5$	$\leq 5{,}000$	≤ 100	≤ 100	$\leq 1{,}000$	Not found
Method	BAM chapter 3:2001	AOAC 998.08	AOAC 998.08	ISO 6888:1999	Nordic 68:2011	ISO 6579:2002

Source: Bureau of Quality Control of Livestock Products. (DLD, 2008), (BQCLP, 2012)

Kueylaw (Kueylaw, 2008) found in a country-wide study of the DLD monitoring programme in domestic slaughterhouses for the period 2003 to2006 bacterial contamination of meat in 2006 by *Salmonella* spp. in 46.93%, Coliform and *E.coli* in 40.5 % and 52.32 %, of the samples respectively being higher than the DLD standard. For the monitoring period 2006-2008 (Chiangthian et al., 2009) *Salmonella* spp. was found in 1,884 out of 4,014 samples (46.93%) in 2006, in 2007, *Salmonella* spp. was found in 2,033 out of 4,360 samples (46.62%), and in 2008, *Salmonella* spp. was found in 835 out of 1,642 samples (50.85%). Eventually, the overall results of bacterial contamination of meat samples with *Salmonella* spp., Coliforms and *E. coli* in Livestock Region 1 from 2006-2009 were found to be 54.18%, 41% and 50.68%, respectively.

The DLD monitoring programme on slaughterhouse hygiene reported that the bacterial contamination of the meat samples from over all livestock regions was higher than the standards set (Table 4) during November 2010 - September 2011 about 70% (BLSC, 2012a) and during November 2011 - September 2012 (BLSC,

2013a) about 72% whereas in livestock region 1 it was 61% in November 2010 - September 2011 (BLSC, 2012a).