2. LITERATURE REVIEW

2.1 Back ground on *Salmonella*

2.1.1 Microbiology

The *Salmonellae* bacteria are members of the family Enterobactericeae. They are Gram-negative rod-shaped, non spore forming, and facultative anaerobic (Pawsey, 2002). They are straight rods 0.7-1.5 x 2-5μm. *Salmonella* has the capacity to grow under either aerobic or anaerobic conditions (Krieg and Holt, 1984) and are non-encapsulated and non-sporular. They grow optimally at 37 ^{o}C on ordinary culture media, with developed small colonies of 2 to 4 mm in diameter, smooth, shiny and homogenous.

Salmonella growth may still occur in a wide pH range (4.5 to 9.5) depending on the surrounding conditions. The temperature range at which *Salmonella* has been growing is 2 ^{o}C to 54 ^{o}C (*S.* Typhimurium). Regarding available moisture, growth inhibition has been reported for water activity (a_w) values below 0.93 (Doyle *et al.*, 2001). A salt content of 3-4% generally inhibits the growth of *Salmonellae*, but increasing temperature is increase salt tolerance. However, a salt content above 8% is bactericidal for salmonellae (Jay *et al*., 2005). Except the rare non-motile *Salmonella* serovars such as *S.* Gallinarum and *S.* Pullorum, the vast majority of *Salmonella* is motile and propelled by peritrichous flagella. The motile *Salmonella* may lose their ability to develop flagella under the effect of sublethal ”stress”, caused by external physicochemical influence such as refrigeration or high temperatures (Krieg and Holt, 1984., Doyle *et al.*, 2001).

Salmonellae catabolize D-glucose and other carbohydrates with the production of acid and gas. They are oxidase negative and catalase positive, grow on citrate as a sole carbon source, generally produce hydrogen sulfide,

decarboxylate lysine and ornithine, and do not hydrolyze urea. Many of these traits have formed the basis for the presumptive biochemical identification on *Salmonella* isolates, as shown in table 1.

Table 1: Biochemical characteristic of *Salmonella* (Quinn *et al.*, 1994)

Biochemical characteristic	Reaction
Indole	-
Methyl	+
Voges-proskauer	-
Citrate	+
Oxidase	-
Catalase	+
Urease	-
Phenylalanine deaminase	-
Hydrogen sulphide	+
Lysine decarboxylate	+
Ornithine decarboxylate	+
Motility (36 ^{o}C)	+
Acid produced from lactose	-
Acid produced from glucose	+

+ = positive reaction; - = negative reaction

2.1.2 Taxonomy

The *Salmonella* group contains over 2541 serovars (table2) identified serologically by combination of the somatic (O) Lipopolysacharides (LPS) on the external surface of bacteria outer membrane, flagella (H) antigens associated with the peritrichous flagella and the capsular (Vi) antigen, which can be found in *Salmonella* serovars Typhi, Paratyphi and Dublin. *Salmonella* consists of two species, *Salmonella enterica* and *Salmonella bongori*. There are six important subspecies belonging to *Salmonella enterica* species namely, *S.enterica* subsp. *enterica, S.enterica* subsp. *salamae, S.enterica* subsp. *arizona*, *S.enterica* subsp.*diarizonae*, *S.enterica* subsp.*houtenae*, *S.enterica* subsp.*indica.*

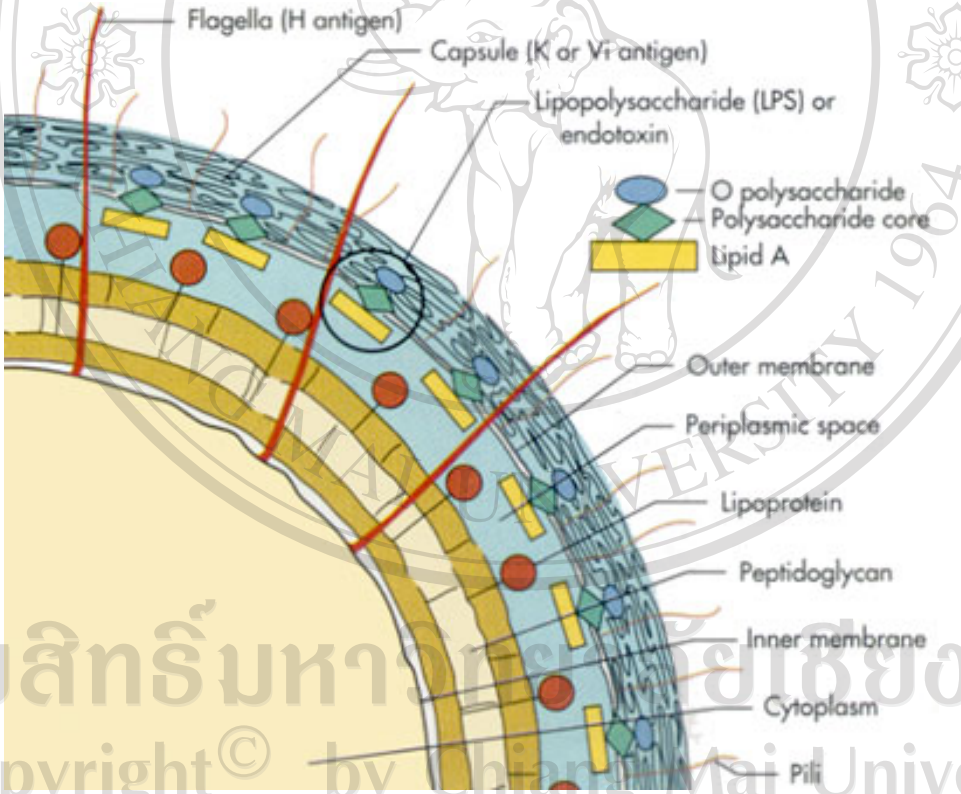
Actual number of serovars in each species and subspecies are 2,541serotypes (serovars) defined by the WHO Collaborating Centre for Reference and Research on *Salmonella* (Popoff *et al.*, 2001).

Table 2**:** *Salmonella* species and subspecies (Popoff *et al.*, 2001)

Salmonella species and subspecies	No. of serotypes
Salmonella enterica	2,480
S. enterica subspecies *enterica*	1,504
S. enterica subspecies *salamae*	502
S. enterica subspecies *arizonae*	95
S. enterica subspecies *diarizonae*	333
S. enterica subspecies *houtenae*	72
S. enterica subspecies *indica*	13
Salmonella bongori	22
TOTAL	2,541

2.1.3 Serotyping

Salmonella has three major antigens (figure 1), somatic (O), lipopolysaccharides (LPS) on the external surface of the bacterial outer membrane and are determined by specific sugar sequences on the cell surface, flagella (H) antigens associated with the peritrichous flagella may occur in either or both of two forms called phase 1 and phase 2, and the capsular (Vi) antigen, which occur in *Salmonella* serovars Typhi, Paratyphi C and Dublin. This antigen is located in an external polysaccharide microcapsule and is associated with virulence for particular hosts (Krieg and Holt, 1984; Doyle *et al.*, 2001).



Source: Murray *et al.*, 2002

Figure 1: Schematic representation of the antigen structure of *Salmonella* spp. showing the relative locations of O, H and Vi antigens

These are heterogeneous structures, and antigenic specificity is determined by the composition and linkage of the O group lipopolysaccharides. Mutations that affect the lipopolysaccharides may lead to new O antigens. In many serovars the flagella H antigens can switch between two types. This switching results in two alternative sets of H antigens. Because H antigens are less heterogenous than the carbohydrate side chains, considerably fewer H antigenic serovars exist. *Salmonella* serovars are placed into 67 serogroups (A to 67) designated with letter or numbers according to similarities in content of one or more O antigens. Example of antigenic structure formula for some *Salmonella shows* in Table 3.

Table3: Example of antigenic structure formula for some *Salmonella* serovars

Serovar	Sero-group	Somatic O antigens	Flagellar H antigens	
			Phase 1	Phase 2
S. Paratyphi	A	1, 2, 12	a	(1,5)
S. Thyphimurium	B	1, 4, (5), 12	i	1,2
S. Typhi	D	9, 12, (Vi)	c	1,2
S. Enteriditis	D	1, 9, 12	g, m	(1,7)
S. Gallinarum	D	1, 9, 12	-	-

2.2 Epidemiology of *Salmonella* in pig production lines

Pigs may became healthy carriers of *Salmonella*; consequently they can be introduced and spread into each stage of the pig production line, for example spread within the herd, environments, via feeds at the farm production, at slaughtering process by cross-contamination, in post-slaughter processing, or at the moment of food catering and preparation (Lo Fo Wong and Hald, 2000). Once introduced, *Salmonella* can be spread in the farm or the firm and go via the entire pig production line to the consumers (van der Gaag *et al.,* 2002).

There seems to be variation of *Salmonella* prevalence depending on the group of pigs. Several investigations of the distribution of *Salmonella* status have been done throughout the pig production line. The investigation of Korsak *et al*. (2003) reported that the percentage of *Salmonella* positive fecal samples in sows (8.1%) was significantly higher than the young and lactating sows (2.9%). Percentage of positive samples for feces collected during fattening stage was 5.6%. The results of Nollet *et al*. (2005) from farrow to finish pigs in Belgium indicated that *Salmonella* prevalence in the sow during gestation, around farrowing and during lactation were 10%. The study in Quebec showed difference of *Salmonella* contamination in different levels of the integrated production, replacement sows (15.9%) and finishing for gilts (21.9%) were the most contaminated levels (Letellier *et al*., 1999).

The results from the study of Korsak *et al*. (2003); Nollet *et al*. (2005) and Letellier *et al*. (1999) showed low prevalence of *Salmonella* in sows but some reports have shown contrasting results; the study of Van der Wolf et al. (2001) showed an increase of *Salmonella* prevalence 40.5% in 1996 to 60.6% in 1999 and also in the finishing pigs the positive samples percentage was 23.7% in 1996 to 24.5% in 1999. Rodriqez et *al*. (2006) determined the *Salmonella* prevalence in swine farm as 57.3%. The occurrence of *Salmonella* was lower on dairy farms (17.9%), poultry farms (16.2%), and beef cattle farms (8.5%). The most commonly isolated serotypes was *S.* Anatum (48.4%) and they concluded that significant reservoirs of *Salmonella* populations still exist in swine production facilities. Davies, *et al*. (1998) examined faeces from 792 pigs in 7 farms: 1 gilt farm, 2 breeding farms, 1 nursery farm and 3 finishing farms. *Salmonella* was isolated from all farms and 12 % from fecal samples. Prevalence of *Salmonella* ranged from 3.4% at the gilt farm to 18 and 22% respectively at the breeding farms. The most frequent serotype found on the finishing farms was *S.* Typhimurium, which was not isolated on the breeding or nursery farms. They concluded that vertical transmission was unimportant as source of *Salmonella* for finishers and high prevalence in breeders implicated feed. This was in agreement with the finding of Berend *et al*. (1996).

From investigation in Midwest U.S. (Bahnson *et al*., 2006), risk factors were identified for harboring *Salmonella enterica* among slaughter-weight pigs. Samples were collected on farms (feces) and at slaughter (distal colon content, cecal content and ileocolic lymph nodes). The mean individual pig prevalence was 5% for feces, 4% for distal colon content, 15% for ileocolic lymph nodes, and 17% for cecal contents. The five most common serotypes were *S*. Agona, *S*. Derby, *S*. Schwarzengrund, *S*. Typhimurium, and *S*. Senftenberg. Berend *et al*. (1997) estimated that in general between 5-30% of the carcasses produced may contain *Salmonella*. Risk factors were inadequately cleaned polishing machines, inadequate during evisceration, i.e. faulty evisceration and hygiene practices. An estimated 5-15% of carcasses contamination occurred during polishing during evisceration practice 55-90% and during processing 5-35%.

Generally, pigs infected with *Salmonella* can start shedding bacteria during seroconversion period about two weeks after infection. During recovery, an animal can remain in a carrier state and may become serological negative again. Although, *Salmonella* still colonizes in the gut, they may be also invasive and penetrate to the lymphoid system, the body stimulating immune response and antibody production. Thhere antibody can be used for monitoring by using the serological testing.

In Thailand, Patchanee *et al.* (2002) reported that the prevalence of *Salmonella* increased to 82.5 % at slaughterhouse compared to 69.5 % at the farm level. In the studies of *Salmonella* in pork chain, the prevalence in retail pork products decreased to 34.5 % (Sanguankait, 2005) compared with the prevalence at slaughterhouse in lymphnodes of 64.1 % (Chantong, 2005) and the prevalence at fattening farm level in feces of 62.9 % (Dorn-in, 2005). *Salmonella* is widespread in pigs with an average prevalence 6-82.5 % (Table 4) (Padungtod *el al*., 2006; Angkititrakul *et al*., (2005); therefore the chance of infection is relative high. There are various serotypes (Table 5). However, the most common serotypes in pigs were *S.* Rissen and *S.* Typhimurium (Sanguankait, 2005; Chantong, 2005; Dorn-in, 2005). These belong of the most common *Salmonella* infections in humans (Bangtrakulnonth *et al*, 2006)**.**

Table 4: The prevalence of *Salmonella* in pigs

Year	Pre slaughter pigs	slaughter pigs	Pig products
1999	69.5% (Patchnee *et al*., 1999)	82.5% (Patchnee *et al*., 1999)	-
2005	62.9% (Dorn-in, 2005)	64.1% (Chantong, 2005)	34.5% (Sanguankait, 2005)
2006	6% (Padungtod and Kaneene, 2006)	28% (Padungtod and Kaneene, 2006)	29% (Padungtod and Kaneene, 2006)

Table 5: Distribution of *Salmonella* serotypes in pigs

Serotype	Pre slaughter pigs (Dorn-in, 2005)	slaughter pigs (Chantong, 2005)	Pig products (Sanguankait, 2005)
S.Rissen	45.4%	45.9%	43.3%
S. Typhimurium	18.6%	10.8%	16.3%
S. Stanley	11.2%	11.7%	6.3%
S. Krefeld	3.1%	-	10.6%
S. Lagos	-	-	6.0%
S. Waltevreden	3.7%	-	-
S. Anatum	2.4%	-	-

2.3 Distribution of *Salmonella* in humans, Thailand

Bangtrakulnonth *et al*., (2004) reported from Thailand that the most common *Salmonella* serotype causing human salmonellosis between 1993 and 2002 was *Salmonella enterica* Weltevreden. The samples were collected from all diagnostic laboratories in Thailand, using both direct plating and enrichment broth. A total of 70,235 isolates were confirmed as *S.enterica*. All strains identified as *S. enterica* were serotyped according to the Kauffman-White Serotyping Scheme. *Salmonella* antisera (S and A Reagent Laboratory LMT,Bangkok, Thailand) were used in that serotyping. A total of 118 serotypes were identified among the 44,087 isolates from humans. The 25 prevalent serotypes accounted for 86% of the isolates. The distribution of *Salmonella* serotypes in Thailand during 1993 – 2002 by different reservoirs is represented in Table 6.

To assess the human salmonellosis situation in Thailand, several surveillance activities are carried out under the collaboration between the Ministry of Agriculture and cooperatives and the Ministry of Public Health. Year 2002-2006, a change of serotype distribution to other serotypes such as *S*. Enteritdis and *S*. Rissen infection in humans was observed. These serotypes were previously rare, but now belong to the most commonly isolated serotypes as shown in Table 7.

Table 6 : The 10 common serotypes of *Salmonella* isolates from humans in 1993 to 2002, Thailand (Bangtrakulnonth *et al*., 2004)

Serovars	Year and number of isolates (%)										
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
Welttevreden	443	574	816	337	335	485	862	660	657	322	5,491
	(13.5)	(9.9)	(12.3)	(9.3)	(9.7)	(11.6)	(18.0)	(16.1)	(16.9)	(7.9)	(12.5)
Enteritidis	473	833	877	489	365	396	401	306	357	515	5,010
	(14.3)	(14.4)	(13.2)	(13.4)	(10.5)	(9.5)	(8.4)	(7.5)	(8.6)	(12.6)	(11.4)
Anatum	146	397	568	229	298	320	235	412	340	318	3,263
	(4.4)	(6.9)	(8.5)	(6.3)	(8.6)	(7.6)	(4.9)	(10.1)	(8.2)	(7.8)	(7.4)
Derby	368	650	576	277	252	251	141	156	111	107	2,889
	(11.2)	(11.3)	(8.7)	(7.6)	(7.3)	(6.0)	(3.0)	(3.8)	(2.7)	(2.6)	(6.6)
1,4,5,12:i:ssp.I	193	272	422	355	212	228	248	248	336	290	2,804
	(5.9)	(4.7)	(6.3)	(9.8)	(6.1)	(5.4)	(5.2)	(6.1)	(8.1)	(7.1)	(6.4)
Typhimurium	154	216	326	238	305	278	258	205	175	167	2,322
	(4.7)	(3.7)	(4.9)	(6.5)	(8.8)	(6.6)	(5.4)	(5.0)	(4.2)	(4.1)	(5.3)
Rissen	54	162	222	143	295	246	317	287	259	334	2.319
	(1.6)	(2.8)	(3.3)	(3.9)	(8.5)	(5.9)	(6.6)	(7.0)	(6.3)	(8.2)	(5.3)
Stanley	64	147	186	85	99	147	245	210	242	263	1,688
	(1.9)	(2.5)	(2.8)	(2.3)	(2.9)	(3.5)	(5.1)	(5.1)	(5.9)	(6.4)	(3.8)
Panama	31	64	9	80	173	172	264	209	160	230	1,474
	(0.9)	(1.1)	(1.4)	(2.2)	(5.0)	(4.1)	(5.5)	(5.1)	(3.9)	(5.6)	(3.3)
Agona	118	215	236	103	102	76	95	76	75	90	1,096
	(3.6)	(3.7)	(3.6)	(2.8)	(2.9)	(1.8)	(2.0)	(1.9)	(1.8)	(2.2)	(2.7)

Table 7: Top-ten *Salmonella* isolates from human

(Bangtrakulnonth *et al*, 2003; Bangtrakulnonth *et al* 2005; Bangtrakulnonth *et al* 2006)

Serotypes	Year/percentage		
	2003	2005	2006
S. Enteritidis	11.47	10.8	18.46
S. weltevreden	11.09	9.02	6.89
S. Stanley	8.55	12.43	10.68
S. Anatum	6.42	4.80	3.86
S. Rissen	6.36	8.91	7.64
S. Corvallis	3.91	5.72	4.16
S. Choleraesuis	3.39	4.82	7.95
S. Albany	2.95	-	
S. Hadar	2.89	-	
S. Panama	2.89	-	
S. typhimurium	-	2.64	3.28
S. Virchow	-	2.29	
S.I 4, 5, 12: i: -	-	2.21	4.3
S. Kedougou	-	-	2.73
Others	59.89	36.17	30.06
Total	100	100	100

2.4 Salmonellosis

2.4.1 Swine salmonellosis

The epidemiology of salmonellosis in pigs must be regarded as a disease of pigs and *Salmonella* infection or contamination of pork carcasses and products. The clinical sign of salmonellosis in pigs varies from case to case depending on serotype virulence, host resistance and the infectious dose. However, the most common clinical signs may be the result of either septicemia caused by *S*. Choleraesuis and/or enterocolitis mainly caused by *S*. Typhimurium. Both forms of disease can occur in intensively kept pigs, reared and weaned, but may be observed occasionally in finishing pigs or adult breeding stocks (Wilcock and Schwartz, 1999).

Infections in the affected adult pigs are unapparent or may be present with a wide range of symptoms, from mild fever to sudden death without diarrhea in case of septicemic salmonellosis. Watery diarrhea with a low mortality rate may be found in case of enterocolitis. Most pigs recover completely but remain carriers and intermittent shedders for several months (Swanenburg *et al*., 2001). However, even though the reservoir may not result in no clinical signs, it can constitute a source of Salmonella contaminated food stuffs. It is easily transmitted within the herds via direct contact and, most important introduction of an infected carrier animal and constitutes to a risk humans.

2.4.2 Humans Salmonellosis

Many strains of *Salmonella* are zoonotic agents, spreading to humans from contaminated food. Human salmonellosis usually takes the form of a self-limiting food poisoning (Enterocolitis) caused by the non-typhoidal organism, but occasionally manifests as a serious systemic infection (enteric fever) caused by *S.* Typhi and related paratyphoid organism. Particular serovars show a strong tendency to produce a specific syndrome such as *S.* Typhi and *S.* Paratyphi (enteric

fever), *S.* Typhimurium and *S.* Enteritidis produce gastroenteritis, *S.* Cholerasuis produces septicemia or focal infections. However, any serotypes can produce any of these syndromes.

Most persons infected with *Salmonella* can develop acute or chronic symptoms. Acute symptoms show sign of nausea, vomiting, diarrhea, fever, and abdominal cramp within 6-48 hours after ingestion of contaminated food or water. The duration of fever and diarrhea varies, but is usually 2 to 7 days. Chronic consequence, arthritis symptoms may follow 3-4 weeks after onset of acute symptoms. Acute symptoms may be prolonged, again depending on host factors, ingested dose, and strain characteristic. But normally most persons recover without treatment. However in some persons such as infant, elderly, and immunodeficient person the diarrhea may be severe, that the patient needs to be hospitalized. In these patients, *Salmonella* may spread from the intestine into the blood stream caused of septicemia leading to death. *Salmonella* cases can be treated with ampicillin, gentamicin, ciprofloxacin or trimethoprim/ sulfamthoxazole.

2.5 Detection and identification of *Salmonella*

The two most commonly used diagnostic methods for detection of *Salmonella* infections are the microbiological examination of feces, caecal contents, swab samples or lympnodes and the serological examination of blood sample or meat juice (Lo Fo Wong and Hald, 2000). The use of the standard cultural method for *Salmonella* detection requires 3 days for a negative answer and 4-5 days to confirm the presence of *Salmonella* in a sample and to identify the strain.

A motility enrichment procedure using modified semisolid Rappaport-Vassiliadis (MSRV) medium for salmonellae detection from food products was described (De Smedt *et al*., 1986; De Smedt and Bolderdijk, 1987). With this technique, salmonellae could be detected and serologically confirmed within 48 hrs. The productivity of this method was reported to be higher than that obtained with tetrathionate brilliant green broth (De Smedt and Bolderdijk, 1986). The major

advantage of MSRV medium is its ability to detect low levels of *Salmonella* in samples and its efficiency in isolating *Salmonella* among competitive microflora (De Smedt and Bolderdijk, 1987). However, in this study most or all of the test samples were artificially contaminated. Artificially contaminated food samples generally fail to reproduce the more challenging ecological and physiological diversity encountered in naturally contaminated foods. Experience has shown that studies under such conditions may not constitute a firm basis for drawing definitive conclusions on method performance.

Serology can be used to follow the improvement of an integrated pig production system, but is not the unique solution for assessing risk of *Salmonella* shedding from specific herds (Korsak *et al*., 2006). Thus immuno-serological tests have been developed for the detection of *Salmonella* and it can be broadly divided into those based on enzyme-labeled antibodies (ELISA), fluorescent antibody staining, radioimmunoassay and other methods. ELISA is the most popular technique taking only about 2 hours to perform. ELISA has the disadvantage that we can not be sure that the infection is still present at the moment of positive results. Furthermore, it will not detect infections that occurred shortly (1-2 weeks) before sampling (Van der Wolf *et al.*, 2001). However, serological testing can be of use for a measure of historical exposure, which may or may not correlate with biological results at the time of sampling. Due to the low sensitivity of culture method, apparent 'false-positive serological results may as well represent real infections, which was not detected by bacteriological testing (Lo Fo Wong et al., 2003).

2.6 The pig production in Thailand

Pig production in 2006 was estimated to be around 11.33 million pigs; a rise of 4.2% year on year basis, the increase in pork consumption is a side effect of the concern about chicken consumption because of the bird flu. Therefore, pork has been become the second most important meat in Thai consumption. Pig production

in Thailand followed a cycle of pig's price. This can lead to boom-bust cycles as a result of an oversupply of pigs and the pig raisers suffer from heavy losses.

Thailand's main producing regions locate in the Central part, while in the Southern has the smallest number of pigs. Most of the pigs produced in Thailand are consumed domestically because of the presence of Foot and Mouth disease (FMD) in some of producing areas. Export markets are limited to Hong Kong, Singapore, Japan, South Korea and Malaysia. At the moment, a larger part of the export is ready to eat meals exported to Japan and Europe. Only Hong Kong accepted fresh pork meat from Thailand. Due to the existence of FMD, the European Commission has not yet permitted Thai pork meat into the European Union.

In recent year, the development of commercial pig raising farms has seen the role of the small intermediaries diminish in importance. Contacts growing of pigs take place with feed milling, companies providing piglets, animal feed, veterinary service and farm management skills to contacted pig grower. Basically pig production systems compose of two compartments. The first compartment is breeder farm which consists of breeding, gestating, and farrowing units. The other is the fattening farm which consists of nursery and fattening units. The breeder farm produces weaned piglets and distributes them to the fattening farms. Mostly the fattening farms are contract farms of the private company, which fatten the piglets until the weight up to 100-110 kg in 165 days. The minimum conditions are that FCR (Feed Conversion Ratio) should not exceed 2.7 and the mortality rate not higher than 3 percent. Price-rate incentives are awarded if the performance is better than the conditions. On the other hand, if the feed used exceeds the requirement, the farmer will have to bear the cost difference. After finishing pigs, the farmers sell it back to the private company and the animals are transported to their slaughter house. The slaughter pigs are kept in the holding pen for a few hours with water supply for resting and calming down. The pigs are slaughtered, carcasses is processed further and transported to retail in supermarkets (flowchart in figure 2).

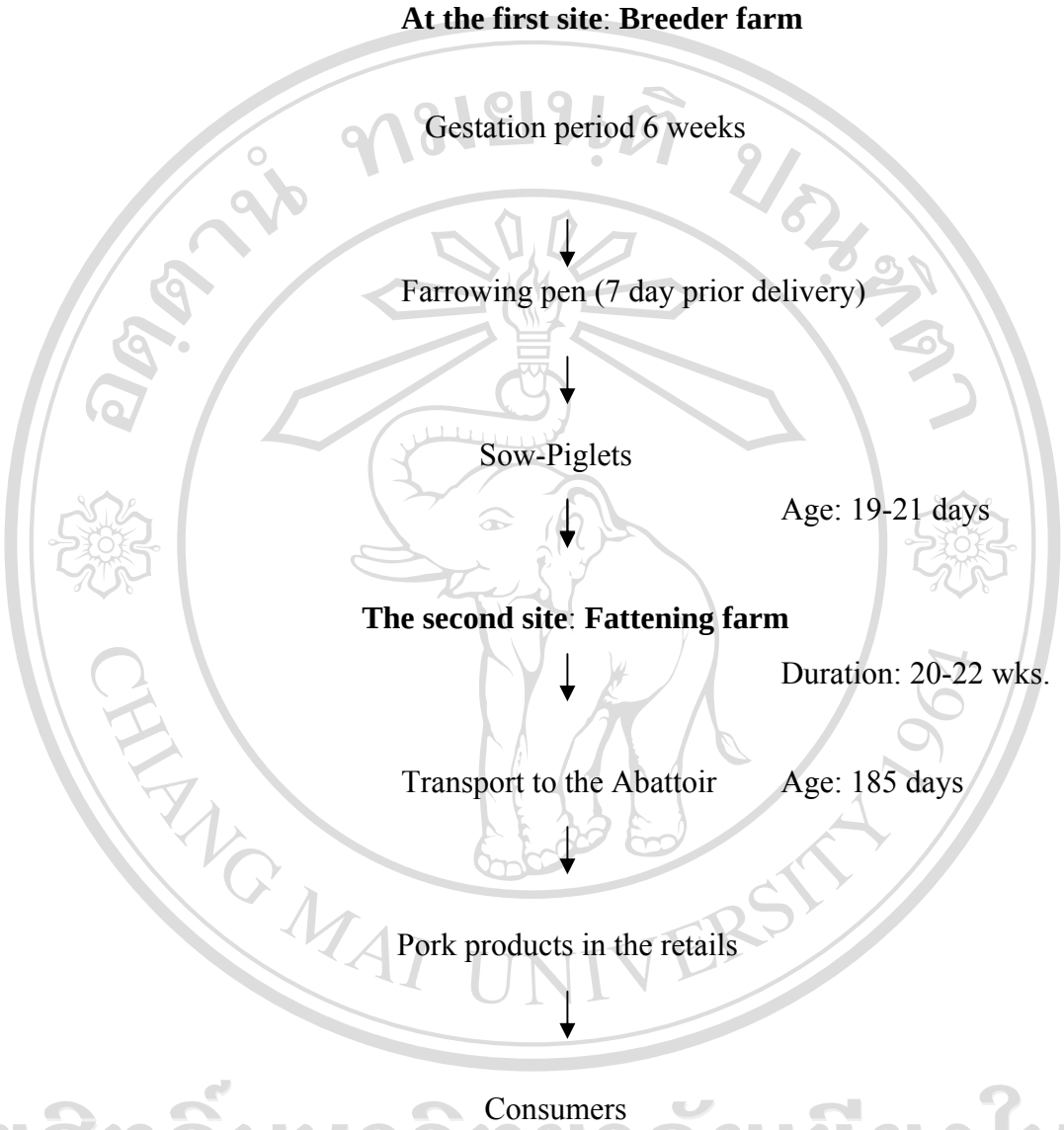


Figure 2: Flowchart of pig production lines in Thailand

2.7 Sow management

Sows are responding to a good management by following the strategies that help to maximize productivity. Overall productivity in the herd includes mating systems farrowing systems and culling systems. The sows are currently checked on problems, in farrowing unit for example poor litter size, poor mothering ability and low fertility. At the same time, it is importance to have a supply gilt available to replace sow that are to be culled.

In the mating unit, the workers have a responsibility to recognize the sow oestrus and to serve at the correct time. The sows are served during the period of peak fertility which will reduce the likelihood of sow returning to service or producing small litter. In The farrowing or parturition is a critical stage in the whole reproductive cycle. Because problems at this stage very quickly lead to high mortality rates and reduce productivities in sow and piglets. Two or three weeks prior to farrowing, the sow should be wormed to minimize the possibility of passing worms to the newborn piglets. One week before farrowing the sow should be washed with soupy water to remove the dung, and then removed to the farrowing quarter waiting for delivery. After delivery, the sows are examined for any diseases problems, particularly MMA which have to treat immediately.

At weaning, the sows have to separate from the piglets in order to stimulate an estrus and get sow to conceive again as soon as possible. Under normal conditions, removal of the sow from the piglets and the cessation of sucking trigger ovarian activity and estrus within four to seven days.

2 .8 Control of *Salmonella* in pigs

Salmonella is an importance foodborne pathogen associated with pork consumption in humans. From this result, the issue about the food safety has been considered and contributed the *Salmonella* control at all stages of the pig production. Especially, the export countries develop standards for swine production

In many countries, *Salmonella* control efforts reduce the incidence of *Salmonella* at farm level through to retail. A risk factor analysis of *Salmonella* infection in finishing pigs showed that feeding acidified or fermented byproducts which fed to finishers could reduce the level of *Salmonella* infection (Van der Wolf *et al*, 1999). Also the results of Kranker *et al*, (2001) demonstrate that dry feed for sow has a significant effect on seroprevalence (meat juice at slaughterhouse).

In the Netherlands, Berend *et al*. (1998) reported that the application of GMP principles from farm to cutting / retail could reduce *Salmonella* contamination of pig and pork by 50-60%. If pigs were bred under 'specific pathogen free' (SPF) conditions, the prevalence of contaminated carcasses and pork could be reduced 95%. Borch *et al*. (1996) investigated the foodborne pathogen along the slaughter line indicating that slaughter pigs were a major source of *Campylobacter* spp., *Salmonella* spp and *Y. enterocolitica* contamination. These bacteria can be used as indicator for the success of GMP; they suggested that CPs or CCPs for specific stage during slaughtering and dressing should be serving as guidance. A study of D'Aoust (2001) in the United States, the preliminary results indicated that after implementation of HACCP in pig and poultry plants, the *Salmonella* prevalence were reduced in the food supply to a certain animals.

Moreover, Van der Gaag *et al*, (2002) recommended that *Salmonella* control program should be done at all stages in the pig production line (breeding through consumers) with the combination of seven intervention points,

- Reduce the sow prevalence by used of acidified feed in the farm
- Logistic slaughtering
- Decontamination of carcasses
- Extensive hygiene at slaughterhouse and farm origin,
- Purchased of certified *Salmonella* free piglets in the finishing stage
- Informing consumers in storing of pork meat
- Informing consumers in preparing of pork meat