เอกสารทางวิชาการ

เรื่องที่ 1

การสำรวจสารตกค้างในสุกรของประเทศไทยระหว่าง พ.ศ. 2560 – 2562

Survey on Chemical Residues in Pig in Thailand during 2017-2019

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การเผยแพร่ เวบไซต์สำนักพัฒนาระบบและรับรองมาตรฐานสินค้าปศุสัตว์

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ABSTRACT

The objectives of survey on chemical residues in pig in Thailand is to study residue of drugs, contaminants and chemicals used in pig farm and to find the cause of residue in non-compliant pig products , feed and water samples in pig farm. In the study, the samples were collected from both farm and slaughterhouse level. Then, the samples were sent to analyze at the official laboratory under Department of Livestock Development. The results of residue analysis in pig have to be collected and analyzed in order to know the country status and to support the export of live pigs and pig products. The sampling plan and distribution as well as chemical residues to be analyzed are based on European Union regulations. Analytical methods, depending on substance being examined, include LC-MS/MS, LC-MS ion trap, HPLC, HPLC-UV, HPLC-FLD, GC-ECD, GC-MS, ICP-MS, Direct Mercury Analyzer, ICP-OES and GC-HRMS. Chemical residues of group A and group B being analyzed, and matrices of choice for each substance are in accordance with EU Regulations. Maximum Residue Limits (MRLs) are decided based on international and national standards. In 2017, 3,313 samples were collected, 1,949 samples were from farms and 1,364 samples were from slaughterhouses. There were 2 non-compliant samples with the detection of gentamycin (70.18 ppb) in muscle, nitrofuran metabolite (furazolidone (AOZ), 2.24 ppb) in muscle. In 2018, 3,299 samples were collected, 1,949 and 1,350 samples were from farms and slaughterhouses, respectively. There were 2 non-compliant samples with sulphonamide (sulfamethazine (SMZ), 1837.17 ppb) in muscle and doxycycline (58.3 ppb) in muscle. In 2019, 2,784 samples were collected, 1,449 and 1,335 samples were from farms and slaughterhouses, respectively. Among them 2 non-compliant samples were found with 0.91 ppb of nitrofuran metabolite (AOZ) in muscle and 17.17 ppb of chloramphenicol in feed. Each non-compliant case was investigated and followed-up; restriction may be applied in some cases. Investigation results were discussed.

Keyword: residue, pig farm, pig slaughterhouse

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การสำรวจสารตกค้างในสุกรของประเทศไทยระหว่าง พ.ศ. 2560 – 2562

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บทคัดย่อ

การสำรวจสารตกค้างในสุกรของประเทศไทยมีวัตถุประสงค์เพื่อศึกษาการตกค้างของยา สารปนเปื้อน และสารเคมีที่ใช้ในฟาร์มสุกร รวมทั้งหาสาเหตุของการพบสารตกค้างเกินมาตรฐานด้วยวิธีการศึกษาดังนี้ เก็บตัวอย่างที่ฟาร์มสุกรและโรงฆ่าสุกร โดยตัวอย่างจะถูกส่งตรวจวิเคราะห์ที่ห้องปฏิบัติการกรมปศุสัตว์ การสำรวจสารตกค้างในสุกรมีความจำเป็นต้องรวบรวมและวิเคราะห์เพื่อทราบสภาวะของประทศ และเพื่อเป็นการสนับสนุนการเปิดตลาดส่งออกสุกรและผลิตภัณฑ์ แผนเฝ้าระวังสารตกค้างในสุกรมีการออกแบบให้สอดคล้องตามกฎระเบียบของสหภาพยุโรป วิธีการตรวจวิเคราะห์สารตกค้างจะขึ้นกับชนิดสารที่ทำการตรวจวิเคราะห์ ซึ่งประกอบด้วย LC-MS/MS, LC-MS ion trap, HPLC, HPLC-UV, HPLC-FLD, GC-ECD, GC-MS, ICP-MS, Direct Mercury Analyzer, ICP-OES และ GC-HRMS ค่าปริมาณสารตกค้างสูงสุด (Maximum Residue Limits, MRLs) พิจารณาตามมาตรฐานระหว่างประเทศ ประเทศคู่ค้าและประเทศไทย ในปี พ.ศ. 2560 มีการเก็บตัวอย่างในสุกรทั้งหมด 3,313 ตัวอย่าง แบ่งเป็นตัวอย่างที่เก็บจากฟาร์ม 1,949 ตัวอย่างและจากโรงฆ่า 1,364 ตัวอย่าง พบสารตกค้างเกินเกณฑ์มาตรฐาน 2 ตัวอย่าง ได้แก่ gentamycin ปริมาณ 70.18 ไมโครกรัมต่อกิโลกรัมในกล้ามเนื้อสุกร และเมตาโบไลท์ของ nitrofuran ชนิด furazolidone (AOZ) ปริมาณ 2.24 ไมโครกรัมต่อกิโลกรัมในกล้ามเนื้อสุกร ในปี พ.ศ. 2561 มีการเก็บตัวอย่างในสุกรทั้งหมด 3,299 ตัวอย่าง แบ่งเป็นตัวอย่างที่เก็บจากฟาร์ม 1,949 ตัวอย่างและจากโรงฆ่า 1,350 ตัวอย่าง พบสารตกค้างเกินเกณฑ์มาตรฐาน 2 ตัวอย่าง ได้แก่ เมตาโบไลท์ของ sulphonamide ชนิด sulfamethazine (SMZ) ปริมาณ 1,837.17 ไมโครกรัมต่อกิโลกรัมในกล้ามเนื้อสุกรและ doxycycline ปริมาณ 58.3 ไมโครกรัมต่อกิโลกรัมในกล้ามเนื้อสุกร ในปี พ.ศ. 2562 มีการเก็บตัวอย่างในสุกรทั้งหมด 2,784 ตัวอย่าง แบ่งเป็นตัวอย่างที่เก็บจากฟาร์ม 1,449 ตัวอย่างและจากโรงฆ่า 1,335 ตัวอย่าง พบสารตกค้างเกินเกณฑ์มาตรฐาน 2 ตัวอย่าง ได้แก่ เมตาโบไลท์ของ nitrofuran ชนิด furazolidone (AOZ) ปริมาณ 0.91 ไมโครกรัมต่อกิโลกรัมในกล้ามเนื้อสุกร และchloramphenicol ปริมาณ 17.17 ไมโครกรัมต่อกิโลกรัมในอาหารสุกร ทั้งนี้เมื่อพบสารตกค้างเกินมาตรฐานจะมีการสอบสวนและติดตามรวมถึงดำเนินการกับผู้ประกอบการตามมาตรการ ผลการสอบสวนกรณีพบสารตกค้างเกินมาตรฐานทุกรายได้สรุปไว้ในรายงานนี้

คำสำคัญ: สารตกค้าง ฟาร์มสุกร โรงฆ่าสุกร

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Introduction

Department of Livestock Development (DLD), Thailand, is the Competent Authority (CA) responsible for Residue Monitoring Plan (RMP) in livestock products including poultry, pig, honey, egg and quail egg. The DLD launched the RMP in 2003 based on Commission Directive 96/23/EC dated 29 May 1996 (European Community, 1996), in order to ensure food safety of livestock products for export and domestic market. The Directive divides chemical residues into 2 groups; Group A is banned substance with "Zero tolerance" and Group B is veterinary drug or contaminant, allowed to be detected within Maximum Residue Limits (MRLs). The Directive also provides different list of chemical residues, sample size and sample distribution, required to be monitored in deferent species. List of monitored chemical residues can be adjusted based on the findings of the year before. If chemical residue is detected or found over the MRL, DLD officials will carry out case investigation, visit the farm and advice on prudent use of chemical and drug, as well as follow-up on the case until the problem solved. If wrong doing is found, legal actions will be applied to the farm, the veterinarian or the company, in accordance with relevant laws such as Feed Quality Act B.E. 2558 (A.C. 2013) or Slaughtering and Meat Sale Act B.E. 2559 (A.C. 2014).

From 2019, African Swine Fever (ASF) outbreaks in many countries have caused major global pork shortage. Therefore, there were demands to import live pigs and pork from Thailand. National residue monitoring program by competent authority is one key requirement to be considered by importing countries. The results of the survey on chemical residues in pig in Thailand during 2017-2019 become important data to be compiled, analyzed and published. Findings from DLD's RMP in pig will serve as national reference, contributed to food safety and consumer protection domestically and internationally, confidence building for trade partners, as well as promoting export of livestock product from Thailand.

Materials and Methods

Sample size and sample distribution

Sample size was calculated based on number of pigs being slaughtered each year as described in Commission Directive 96/23/EC (European Community, 1996). Place to collect samples for each chemical group, either at the slaughterhouse or the farm, was recommended in the same Directive. Type of sample or matrix (muscle, liver, lung, fat, feed or water) to be collected depended on nature of the substance and recommendation for each reference method. Sample distribution was designed by the authors to cover all regions of the country, in proportion with pig production in the area, to cover all chemical groups in different times of the year.

Sample collection and handling

Samples from farms and local slaughterhouses were collected by staffs from provincial livestock offices throughout Thailand, while samples from export slaughterhouses were collected by veterinarian-in-charge at the slaughterhouses. Samples were taken in accordance with the guideline (Buranathai C., 2017). All samples under Residue Monitoring Program of Livestock Products (RMP) were sent to Bureau of Quality Control of Livestock Product (BQCLP), the official laboratory under Department of Livestock Development, Thailand

Analytical Methods

Bureau of Quality Control of Livestock Product (BQCLP) analyzed the samples using reference methods or in-house methods. Most of the methods are ISO 17025 accreditation or have been validated. Analytical methods for chemical residue in different matrices and detection limits are summarized in Table1.

Maximum Residue Limits (MRLs)

Maximum Residue Limits (MRLs) are adopted based on

- Notification of Thai Ministry of Public Health Notification "Prescribed standards for some chemical contaminations in foods and veterinary drugs residues in foods"
- Notification of Department of Livestock Development "Prescribed residue standards for livestock product"
- Codex Alimentarius Commission "Maximum residue limits (MRLs) and risk management recommendations (RMRs) for residues of veterinary drug in food"
- Japan Positive List System "Positive List System for Agricultural Chemical Residues in Foods"
- Europion Union Regulation No. 396/2005 of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin
- Europion Union Regulation No. 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs
- Europion Union Regulation No. 37/2010 of 22 December 2009 on pharmacologically active substances and their classification regarding maximum residue limits in foodstuffs of animal origin
- Europion Union Regulation No. 1259/2011 of 2 December 2011 amending Regulation (EC) No 1881/2006 as regards maximum levels for dioxins, dioxin-like PCBs and non dioxin-like PCBs in foodstuffs
- Europion Union Regulation No.1275/2013 of 6 December 2013 amending Annex I to Directive 2002/32/EC of the European Parliament and of the Council as regards maximum levels for arsenic, cadmium, lead, nitrites, volatile mustard oil and harmful botanical impurities

- Europion Union Recommendation No. 2016/1319 of 29 July 2016 amending Recommendation 2006/576/EC as regards deoxynivalenol, zearalenone and ochratoxin A in pet food
- Europion Union Regulation No. 2018/73 of 16 January 2018 amending Annexes II and III to Regulation (EC) No. 396/2005 of the European Parliament and of the Council as regards maximum residue levels for mercury compounds in or on certain products

  (Maximum Residue Limits (MRLs) or Maximum Levels (MLs) are summarized in Table 1)

Table 1 Analytical methods applied by Bureau of Quality Control of Livestock Product (BQCLP) and Maximum Residue Limits (MRLs) or Maximum Levels (MLs) for pig tissues, drinking water and feed

Group of Substances	Residue	Matrix analysed	Method	Detection limit (µg/kg or µg/L)	Maximum Residue Limits (MRLs)/ Maximum Levels (MLs) (µg/kg or µg/L)
A1	**Stilbenes**	Muscle	LC-MS/MS		Not detected
	Diethylstilbestrol			0.10	
	Dienestrol			0.13	
	Hexestrol			0.08	
	Diethylstilbestrol	Feed		15	
A5	**Beta agonist**	Liver , Lung	LC-MS/MS		Not detected
	Clenbuterol			0.10	
	Salbutamol			0.06	
	Ractopamine			0.07	
	Clenbuterol	Drinking water	LC-MS ion trap	0.08	
	Salbutamol			0.14	
	Ractopamine			0.10	
	Clenbuterol	Feed	LC-MS/MS	20	
	Salbutamol			20	
	Ractopamine			20	
A6	**Chloramphenicol**	Muscle	LC-MS/MS	0.05	Not detected
		Feed		2	
	Nitrofurans	Muscle	LC-MS/MS		Not detected
	Nitrofurantoin metabolite (AHD)			0.10	
	Furaltadone metabolite (AMOZ)			0.10	
	Furazolidone metabolite (AOZ)			0.10	
	Nitrofurazone metabolite (SEM)			0.10	
	Nitrofurantoin (NFT)	Drinking water		0.0218	
	Furaltadone (FTD)			0.0041	
	Furazolidone (FZD)			0.0158	
	Nitrofurazone (NFZ)			0.0112	
	Nitroimidazoles	Feed	LC-MS/MS		Not detected
	Dimetridazole (DMZ)			20	
	Metronidazole (MNZ)			20	
	Ronidazole (RNZ)			20	
B1	**Tetracyclines**	Muscle	LC-MS/MS		MRL=100 (Sum of 4 drugs) or 50 for Doxycycline
	Oxytetracycline (OTC)			17.84	
	Tetracycline (TTC)			15.19	
	Chlortetracycline (CTC)			16.41	
	Doxycycline (DC)			9.64	
	Oxytetracycline (OTC)	Feed	HPLC-UV	300	Not detected
	Chlortetracycline (CTC)			500	
	Doxycycline (DC)			500	

Note: -Group of substance as defined in Council Directive 96/23/EC
-Feed for pig in finishing stage

Group of Substances	Residue	Matrix analysed	Method	Detection limit (µg/kg or µg/L)	Maximum Residue Limits (MRLs)/ Maximum Levels (MLs) (µg/kg or µg/L)
B1	**Macrolides**				
	Tylosin A	Muscle	LC-MS/MS	17	MRL=100
	Erythromycin A			25	MRL=50
	Tilmicosin			25	MRL=10
	Tylosin	Feed		20	Not detected
	Lincomycin				
	Lincomycin	Muscle		18	MRL=100
	Sulphonamides	Muscle	HPLC-UV	5.66	MRL=100
		Feed	LC-MS/MS	15	Not detected
	Fluoroquinolone				
	Enrofloxacin (EFX)	Muscle	LC-MS/MS	3.52	100 (Sum of 2 drugs) or 50 for Enrofloxacin
	Ciprofloxacin (CFX)			3.59	
	Enrofloxacin (EFX)	Feed		25	Not detected
	Ciprofloxacin (CFX)				
	Beta-lactams				
	Ampicillin	Muscle	LC-MS/MS	2.75	MRL=50
	Amoxycillin			2.76	MRL=40
	Benzyl penicillin			1.78	MRL=50
	Aminoglycosides				
	Neomycin	Muscle	LC-MS/MS	62.5	MRL=500
	Gentamycin			19.8	MRL=50
	Streptomicin			41.7	MRL=500
	Dihydrostreptomicin			30.4	MRL=500
	Carbadox &Olaquindox metabolites				
	QCA	Liver	LC-MS/MS	3.5	Not detected
	MQCA	Muscle		2.5	
	Carbadox	Feed		12	
	Olaquindox			20	
B2a	**Anthelmintics**				
	Ivermectin	Liver	HPLC-FLD	10	MRL=20
B2c	**Pyrethroids**				
	Bifenthrin	Fat	GC-ECD	5	MRL = 3,000
	Cypermethrin			5	MRL = 2,000
	Cyfluthrin			5	MRL = 200
	Cis-Deltamethrin			5	MRL = 10
	Fenvalerate			5	MRL = 10
	Lambda-Cyhalothrin			5	MRL = 10
	Permethrin			5	MRL = 50
B3a	**OCPs:**				
	Aldrin & Dieldrin	Fat	GC-ECD	3	MRL = 200
	Heptachlor & Heptachlor epoxide			3	MRL = 200
	Total Chlordane			3	MRL = 50
	Total DDT			3	MRL = 1,000
	BHC - alpha			3	MRL =10
	BHC - beta			3	MRL =10
	Lindane			3	MRL = 10
	Endrin			3	MRL = 50
	HCB			3	MRL = 10
	PCBs:				
	Sum of PCB 28, 52, 101, 138, 153 and 180			3	ML = 40

Note: -Group of substance as defined in Council Directive 96/23/EC
-Feed for pig in finishing stage

Group of Substances	Residue	Matrix analysed	Method	Detection limit (µg/kg or µg/L)	Maximum Residue Limits (MRLs)/ Maximum Levels (MLs) (µg/kg or µg/L)
B3a	**OCPs:** Heptachlor	Feed	GC-MS	10	*LOQ = 20
	Aldrin			10	*LOQ = 20
	Aldrin			10	*LOQ = 20
	Heptachlor epoxide			10	*LOQ = 20
	alpha-Endosulfan			10	*LOQ = 20
	beta-Endosulfan			10	*LOQ = 20
	Dieldrin			10	*LOQ = 20
	Endrin			10	*LOQ = 20
	Endrin aldehyde			10	*LOQ = 20
	Endosulfan sulfate			10	*LOQ = 20
	4,4'-DDE			10	*LOQ = 20
	4,4'-DDD			10	*LOQ = 20
	4,4'-DDT			50	*LOQ = 167
	PCB 28			50	*LOQ = 167
	PCB 52			50	*LOQ = 167
	PCB 81			50	*LOQ = 167
	PCB 153			50	*LOQ = 167
B3c	**Heavy metal** Arsenic	Muscle	ICP-MS	2	ML = 500
	Cadmium		ICP-MS	2	ML = 50
	Lead		ICP-MS	7	ML = 100
	Mercury	Liver	Direct Mercury Analyzer	1.3	MRL = 20
	Arsenic	Liver	ICP-MS	5	ML = 1000
	Cadmium		ICP-MS	5	ML = 500
	Lead		ICP-MS	20	ML = 500
	Mercury	Muscle	Direct Mercury Analyzer	1.4	MRL =10
	Cadmium	Feed	ICP-OES	60	ML= 500
B3d	**Mycotoxin** Aflatoxin B1	Liver	HPLC-FLD	0.25	*LOD = 0.25
	Aflatoxin B2			0.25	*LOD = 0.25
	Aflatoxin G1			0.25	*LOD = 0.25
	Aflatoxin G2			0.25	*LOD = 0.25
	Zearalenone	Feed	HPLC	100	ML = 250
B3f	Dioxin	Liver	GC-HRMS	0.01 pg/g fat	ML = 4.5 pg/g fat
		Fat		0.5 pg/g fat	ML = 1.0 pg/g fat

Note: - Group of substance as defined in Council Directive 96/23/EC
- Feed for pig in finishing stage
- *No established MRL

*Investigation of non-compliant case*s

Investigation team carries out investigation on non-compliant cases and follow-up measures in collaboration with staffs from regional and provincial livestock offices, tracing back to the farm of origin as well as feed mill. Follow-up samples such as feed, water, or chemical used in the farm are collected for laboratory analysis. Samples of animal tissues, such as muscle, liver, will be taken from the same farm for the next 2 production cycles. Protocol for investigation and follow-up is available in officer's guideline (Buranathai C., 2017).

Results

Results of RMPs 2017-2019

In 2017, 3,313 samples were collected, 1,949 and 1,364 samples were from farms and slaughterhouses, respectively. There were 2 non-compliant samples with the detection of gentamycin (70.18 ppb) in muscle and nitrofuran metabolite (AOZ, 2.24 ppb) in muscle.

In 2018, 3,299 samples were collected, 1,949 and 1,350 samples were from farms and slaughterhouses, respectively. There were 2 non-compliant samples with sulphonamide (SMZ, 1837.17 ppb) in muscle and doxycycline (58.3 ppb) in muscle.

In 2019, 2,784 samples were collected, 1,449 and 1,335 samples were from farms and slaughterhouses, respectively. Among them 2 non-compliant samples were found with 0.91 ppb of Nitrofuran metabolite (AOZ) in muscle and 17.17 ppb of chloramphenicol in feed.

(The 2017-2019 RMP results are shown in Table 2 and percentage of non-compliant samples are shown in Figure 1)

Table 2A Results of residue monitoring plan in pig from pig farm during 2017-2019

1.Samples collected from pig farms								
Group of substances	**Kind of substances**	**matrix**	**2017**		**2018**		**2019**	
			Number of samples	**results**	**Number of samples**	**results**	**Number of samples**	**results**
A1	Stilbenes	Feed	50	C	50	C	50	C
A5	Beta agonist	Drinking water, Feed	800	C	800	C	400	C
A6	Chloramphenicol	Feed	100	C	100	C	100	NC (17.17 ppb)
A6	Nitrofurans	Drinking water	200	C	200	C	100	C
A6	Nitroimidazoles	Feed	60	C	60	C	60	C
B1	Tetracyclines	Feed	206	C	206	C	206	C
B1	Macrolides	Feed	50	C	50	C	50	C
B1	Sulfonamides	Feed	106	C	106	C	106	C
B1	Fluoroquinolones	Feed	81	C	81	C	81	C
B1	Carbadox and Olaquindox	Feed	97	C	97	C	97	C
B3a	Organochlorine compound including PCB	Feed	50	C	50	C	50	C
B3c	Heavy metal -Cadmium	Feed	50	C	50	C	50	C
B3d	Mycotoxin -Zearalenone	Feed	99	C	99	C	99	C

Note : C = Compliant

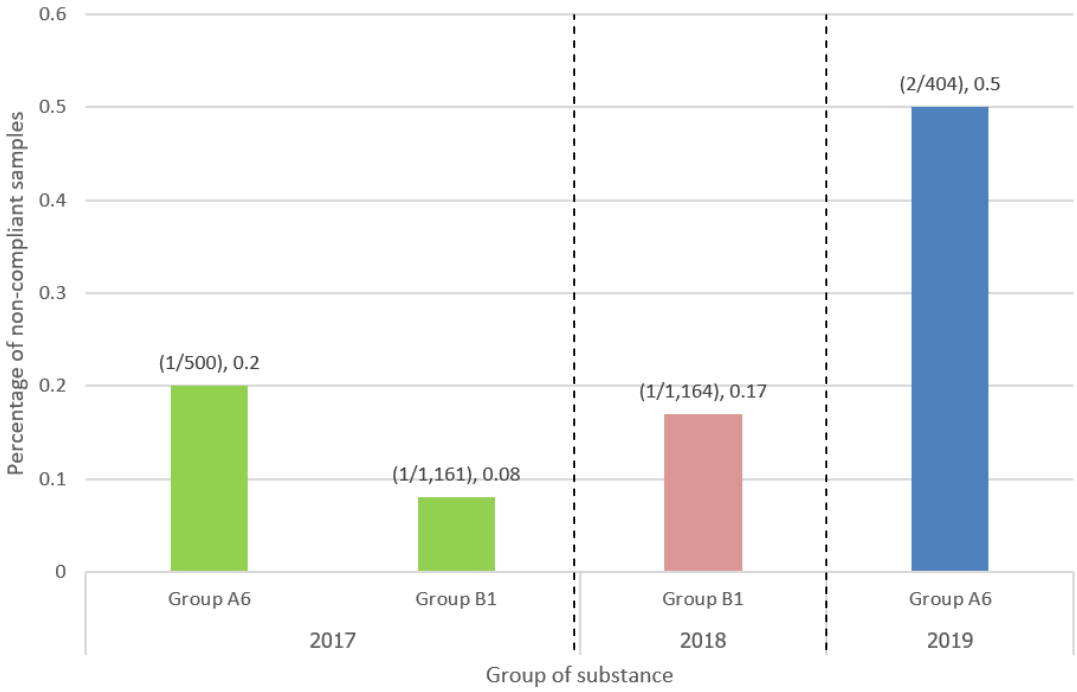
NC= Non-compliant

Table 2B Results of residue monitoring plan in pig from pig slaughterhouse during 2017-2019

2.Samples collected from pig slaughterhouses								
Group of substances	**Kind of substances**	**matrix**	**2017**		**2018**		**2019**	
			Number of samples	**results**	**Number of samples**	**results**	**Number of samples**	**results**
A1	Stilbenes	Muscle	50	C	50	C	50	C
A5	Beta agonist	Liver, Lung	110	C	110	C	110	C
A6	Chloramphenicol	Muscle	40	C	40	C	40	C
A6	Nitrofurans metabolites	Muscle	100	NC (AOZ=2.24ppb)	100	C	104	NC (AOZ=0.91ppb)
B1	Tetracyclines	Muscle	100	C	100	NC (Doxycycline= 58.3 ppb)	93	C
B1	Macrolides	Muscle	50	C	50	C	51	C
B1	Sulfonamides metabolite	Muscle	238	C	238	NC (SMZ= 70.18 ppb)	238	C
B1	Fluoroquinolones	Muscle	53	C	53	C	53	C
B1	Beta-lactams	Muscle	30	C	30	C	30	C
B1	Aminoglycosides	Muscle	100	NC (Gentamycin= 70.18 ppb)	103	C	104	C
B1	Carbadox and Olaquindox metabolites	Liver, Muscle	50	C	50	C	50	C
B2a	Ivermectin	Liver	30	C	30	C	30	C
B2c	Pyrethroids	Fat	80	C	80	C	80	C
B3a	Organochlorine compound including PCB	Fat	80	C	80	C	80	C
B3c	Heavy metal -Arsenic -Cadmium -Lead	Liver	50	C	50	C	50	C
B3c	Heavy metal -Mercury	Liver	99	C	99	C	99	C
B3d	Mycotoxin -Aflatoxin B1 -Aflatoxin B2 -Aflatoxin G1 -Aflatoxin G2	Liver	50	C	50	C	50	C
B3f	Dioxin	Liver, Fat	54	C	37	C	23	C

Note : C = Compliant
NC= Non-compliant

Figure 1 Percentage of non-compliant samples from residue monitoring plan in pig in Thailand during 2017 - 2019



Investigation and follow-up of non-compliant cases

For the three years being studied (2017-2019) six non-complied cases were detected. Investigation team as well as staffs from regional and provincial livestock offices conducted investigation in every case. Investigation summary and results of follow-up samples during 2017-2019 are presented in Table 3.

As for group A, there were two non-compliant samples of nitrofuran in muscle, and one case of chloramphenicol in feed. Investigation of both nitrofuran cases were inconclusive due to poor information record at the local slaughterhouse of one case, and no indicative evidence in the other case. Similarly, investigation of chloramphenicol in feed was also inconclusive. However, monitoring of the residues for the next 2 crops of these premises showed complied results.

For group B, there were three non-compliant samples. Residues of gentamycin (B1), SMZ (sulphonamide group (B1) and doxycycline (B1) were detected in muscle samples. The gentamycin case was caused by over-dose injection of gentamycin. SMZ (metabolite of sulfonamide) residue was caused by insufficient withdrawal period. In both cases medicine were given to the animals without prescription from the farm veterinarians. Both farms were given official warnings, and were monitored. The monitoring results were complied. Doxycycline case in muscle was caused by cross-contamination of medicated feed to finishing feed at the farm. The farm has been improving its feeding practice, and no more non-compliance of doxycycline in muscle has been detected.

Table 3 Investigation summary and results of follow-up samples during 2017-2019

No	Date Collect sample	Date Report	Matrix	Substance	Results (ppb)	MRLs (ppb)	Sample collector	Investigation Result	Follow-up samples/ Results	Follow-up 2 crops
Non – compliant samples 2017										
1	27-Mar-17	17-Apr-17	Muscle	Gentamycin	70.18	50	Veterinary In charge of slaughterhouse	Overdose injection of gentamycin	NA	No non-compliant level of gentamycin were detected in the muscle samples from the next 2 crops
2	2-Jun-17	23-Jun-17	Muscle	Nitrofuran metabolite (AOZ)	2.24	ND	Saraburi Provincial Livestock Officer	Inconclusive	Water and feed taken from the farm were negative for residues.	No residues were detected in the muscle samples from the next 2 crops.
Non – compliant samples 2018										
1	5-Jul-18	1-Aug-18	Muscle	Sulphonamide metabolite (SMZ)	1,837.17	100	Ratchaburi Provincial Livestock Officer	Farm worker gave drug to the pig without prescription from farm veterinarian.	NA	NA
2	14-Aug-18	19-Oct-18	Muscle	Doxycycline	58.3	50	Veterinary In charge of slaughterhouse	Suspected the cross contamination of medicated feed in the finishing feed at the farm	Sample of finishing feed was collected (feed for pig weight > 80 kg untill slaughter). Doxycycline of 2.67 ppm was found.	No non-compliant level of doxycycline were detected in the muscle samples from the next 2 crops
Non – compliant samples 2019										
1	21-Jun-19	25-Jul-19	Muscle	Nitrofuran metabolites (AOZ)	0.91	ND	Chiangmai Provincial Livestock Officer	The pig was kept for some days at the slaughterhouse, investigation team suspected that medicine was given to the pig at the slaughterhouse.	Water and feed taken from the slaughterhouse were negative for residues.	NA
2	10-Oct-19	2-Nov -19	Feed	Chloramphenicol	17.17	ND	Nakorn pathom Provincial Livestock Officer	Inconclusive	NA	No residues were detected in feed samples from the next 2 crops.

ND = Not Detected NA = Not Available

Discussions and Conclusions

From our survey on Chemical Residues in Pig in Thailand during 2017-2019, where substances in groups A1, A5, A6, B1, B2a, B2c, B3a, B3c, B3d and B3f were monitored, with matrices and sample size in accordance with Council Directive 96/23/EC, there were 6 non-compliant samples, 5 in muscle and 1 in feed. Every case was investigated by the appointed team together with staffs from regional and provincial livestock offices.

Monitoring of group A substance, nitrofurans (A6) which is a banned substance according to Ministry of Agriculture and Cooperative Notification on Substances Prohibited in Animal Feed B.E. 2559 (2016) and Ministry of Public Health Notification on Prescribed standards for some chemical contaminations in foods (2nd Edition) B.E.2549 (2006) was detected the most among non-complied samples. Furazolidone (AOZ), a metabolite of nitrofurans (A6) was detected in 2 from 6 non-complied cases. However, source of the problem of both cases were inconclusive because the residue was not detected in the follow-up samples (water and feed). Chloramphenicol residue was detected in one feed sample. Investigation was carried out but the result was inconclusive. All of premises in this group were monitored for at least two production cycles, all follow-up samples were complied.

Monitoring of residues of veterinary drugs and contaminants program detected three non-compliant muscle samples. Residues of gentamycin (B1), SMZ (sulphonamide group (B1) and doxycycline (B1) were detected in muscle samples. These three cases had similar problem, inadequate farm management. After being warned, instructed or suspended, the three farms improved their practice. As a result follow-up samples were all complied with the regulations.

When compared with chemical residue situation in pig in the EU (European Food Safety Authority, 2019 and 2020) some interesting information was observed especially for residue in A6, B1 and B3c groups. In 2017, percentage of A6 non-compliant sample (0.2%) in pig in Thailand were higher than in the EU which was 0.02%. On the other hand, for antibacterial substance (B1), there was only 0.08% non-compliant sample in Thailand while there was 0.3% non-compliant samples in the EU. In 2018, B1 non-compliant sample in Thailand was 0.17% which was slightly higher than percentage of B1 non-compliant sample in the EU (0.11%). In addition, there was no non-compliant sample of B3c during 2017-2018 in Thailand while the percentages of B3c non-compliant sample in EU was 4.2 % in 2017 and 2.37% in 2018.

Our results indicate that banned substances are still illegally used in swine farms. Investigation results of non-compliant case of banned substances are often inconclusive due to operator's refusion of using prohibited substance, no concrete evidence on the day being investigated, and negative results derived from follow-up samples. For non-compliance caused by veterinary drugs, cause of the problem was identified in every case,

so that the corrective action could be done precisely. Although investigation may not be able to identify the direct cause of every case; being investigated, visited, advised and monitored by competent authority have big impact on improvement of farm management. As a result, none of the same premises have been detected with non-compliant again (information up to January 2021). Monitoring of chemical residues, investigation and follow-up action are key of success to prevent the use of banned substances and improper use of veterinary drugs.

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