

Characterization of *Salmonella* species from pork meat in Tolima, Colombia[□]

Caracterización de las especies de Salmonella en carne porcina en Tolima, Colombia

Caracterização de espécies de Salmonella a partir de carne de porco em Tolima, Colômbia

Iang S Rondón-Barragán^{1,2*}, MV, MSc; Evelyn C Arcos¹, MV; Leandro Mora-Cardona¹, MV; Clemencia Fandiño^{1,2}, Lic Bacteriology.

¹Grupo de Investigación en Inmunobiología y Patogénesis (GIP), Departamento de Sanidad Animal, Facultad de Medicina Veterinaria y Zootecnia, Universidad del Tolima, Tolima, Colombia.

²Laboratorio de Diagnóstico Veterinario, Tolima, Colombia.

(Received: March 17, 2014; accepted: May 12, 2014)

Summary

Background: *Salmonella* is a Gram-negative bacterium and the principal cause of human gastroenteritis that originates from the consumption of animal products. **Objective:** to determine serotype and antibiotic resistance of *Salmonella* spp. isolated from pork meat and environmental samples in 6 slaughterhouses and 14 butcheries in Tolima, Colombia. **Methods:** slaughterhouses and butcheries were selected depending on their slaughter capacity and compliance with good manufacturing practices. Samples (n = 507) were taken from carcasses, the environment, and fomites (i.e., surfaces of knives, hooks, floor, siphons, work surfaces, and transport trucks), then cultured in *Salmonella* selective media. Following this, the isolated *Salmonella* spp. was identified using a conventional biochemical test and genus antiserum (Poli A + Vi). The Kauffman-Whyte scheme was used for serotyping and the agar diffusion method (Kirby-Bauer) was used to determine antibiotic sensitivity. **Results:** Manhattan, Derby, Typhimurium, Javiana, Muenster, Hvittingfoss, Sinsfort, Kattbus, and Saint Paul serotypes of *Salmonella* were isolated from both pork meat and environmental samples, being Derby the most common serotype. *Salmonella* isolates showed antibiotic multiresistance mainly to tetracycline, lincomycin and nalidixic acid. **Conclusions:** several *Salmonella* serotypes are present in slaughterhouses and meat samples from butcheries, and they show similar antibiotic resistance patterns. This work represents the first report on *Salmonella* serotypes in slaughterhouses and pork meat from butcheries in Tolima, Colombia.

Keywords: antibiotic resistance, enterobacteria, isolates, serotyping.

Resumen

Antecedentes: *Salmonella* es una bacteria Gram-negativa y la principal causa de gastroenteritis en humanos transmitida por consumo de alimentos de origen animal. **Objetivo:** determinar el serotipo y la resistencia

□ To cite this article: Rondón-Barragán IS, Arcos EC, Mora-Cardona L, Fandiño C. Characterization of *Salmonella* species from pork meat in Tolima, Colombia. Rev Colomb Cienc Pecu 2015; 28:74-82.

* Corresponding author: Iang S Rondón-Barragán. Laboratorio de Diagnóstico Veterinario, Bloque 33 L105, Universidad del Tolima, Ibagué-Tolima, Colombia AA 456. E-mail: iangrondon@gmail.com

antibiótica de *Salmonella* spp. aisladas de carne porcina y muestras ambientales en 6 plantas de beneficio y 14 expendios en Tolima, Colombia. **Métodos:** las plantas de beneficio y los expendios fueron seleccionados dependiendo del volumen de animales sacrificados y el establecimiento de las buenas prácticas de manufactura. Las muestras (n = 507) fueron tomadas de las carcasas, ambiente y fômites (*i.e.* superficie de cuchillos, ganchos, piso, sifones, mesones y camiones de transporte), cultivadas en medios de cultivo selectivos para *Salmonella*. Las *Salmonella* spp., aisladas fueron identificadas mediante purnas bioquímicas convencionales y antisuero de género (Poli A + Vi). La sero-tipificación fue llevada a cabo a través del esquema Kauffman-Whyte y la sensibilidad antibiótica a través del método de difusión en agar (Kirby-Bauer). **Resultados:** fueron aislados los serotipos de *Salmonella* Manhattan, Derby, Typhimurium, Javiana, Muenster, Hvitvingfoss, Sinsfort, Kattbus y Saint Paul tanto de carne porcina como muestras ambientales, siendo el serotipo Derby el más frecuente. Los aislamientos mostraron patrones de multi-resistencia antibiótica, principalmente a tetraciclina, lincomicina y ácido nalidíxico. **Conclusiones:** diversos serotipos de *Salmonella* fueron aislados de muestras de plantas de beneficio y expendios de carne porcina y estos demostraron patrones similares de resistencia antibiótica. Este trabajo representa el primer reporte de serotipos de *Salmonella* en plantas de beneficio y expendios de carne porcina en Tolima, Colombia.

Palabras clave: aislamientos, enterobacterias, resistencia a antibióticos, serotipificación.

Resumo

Antecedentes: a *Salmonella* é uma bactéria Gram-negativa e causa principal de gastroenterite humana transmitida por consumo de produtos de origem animal. **Objetivo:** determinar o serotipo e de resistência a antibióticos de *Salmonella* spp. isolada a partir de carne de porco e amostras ambientais em 6 frigoríficos e lojas 14 açougues em Tolima, Colômbia. **Métodos:** abatedouros e açougues foram selecionados de acordo com o volume de animais sacrificados eo estabelecimento de boas práticas de manufatura. As amostras (n = 507) foram retirados de cadáveres, meio ambiente e fômites (ou seja, superfícies de facas, ganchos, piso, sifões, mésons e caminhões de transporte), cultivadas em meios de cultura de *Salmonella* seletiva e a isolada *Salmonella* spp., foram identificados usando e anti-soro de teste género bioquímica convencional (Poli A + Vi). A sorotipagem foi realizada utilizando esquema de Kauffman-Whyte e teste de sensibilidade aos antibióticos foi feito pelo método de difusão em ágar (Kirby-Bauer). **Resultados:** "o" sorotipos de *Salmonella* de Manhattan, = o surotipos de *Salmonella* Derby, Typhimurium, Javiana, Muenster, Hvitvingfoss, Sinsfort, Kattbus e Saint Paul foram isolados de ambas as carnes de porco e amostras ambientais, sendo o sorotipo Derby o mais frequente. Os isolados de *Salmonella* apresentaram padrões de multirresistência aos antibióticos, principalmente para tetraciclina, lincomicina e ácido nalidíxico. **Conclusões:** vários sorotipos de *Salmonella* estão presentes em matadouros e lojas amostras de carne de porco de talho e mostram padrões similares de resistência a antibióticos. Este trabalho representa o primeiro relato de sorotipos de *Salmonella* em abatedouros e açougues de carne de porco em Tolima, Colômbia.

Palavras chave: enterobacteria, isolamentos, resistência aos antibióticos, sorotipagem.

Introduction

Salmonellosis is the principal gastroenteritis etiology in humans associated with consumption of food from animal origin, where the most frequently isolated serovar in ill humans and pigs is *S.* Typhimurium (Torpdahl *et al.*, 2006). This pathogen is the most common cause of acute infectious gastroenteritis in Colombia (Bustos *et al.*, 2008).

In spite of the well-known role of *Samonella* as a foodborne disease (FBD), it is difficult to estimate FBD incidence due to the lack of a strict link with food (Flint *et al.*, 2005) and a number of limitations including: 1) people do not always seek medical aid

when they become infected; 2) physicians do not always request a stool culture in suspicious cases; 3) not all positive cases are reported and shared in databases; and 4) there are differences in health-care seeking behaviors among differing age groups (Kumar *et al.*, 2009; Meneses, 2010). To address these difficulties, the world health organization (WHO) developed surveillance programs for FBD such as *Salm-Surv* for salmonellosis (Petersen *et al.*, 2002) as well as sentinel sites for other bacteria including *Salmonella*, *Shigella*, and *Brucella* (Flint *et al.*, 2005).

Salmonellosis is considered a major health concern worldwide; it is estimated that 95% of these particular infections are FBDs (Xia *et al.*, 2009).

Human infections by *Salmonella* serovars have been reported in several countries, including Colombia (Ashbolt *et al.*, 2004; Durango *et al.*, 2004; Voetsch *et al.*, 2004; Vaillant *et al.*, 2005). In the United States, an estimated 56.8% of salmonellosis cases in humans might be attributable to pigs (BIOHAZ, 2012). Arguello *et al.* (2013b) demonstrated a 40.9% *Salmonella* prevalence in Danish pig herds, measured at the slaughterhouse. However, overall prevalence in Danish pork was reported to be as low as 1.2% (Alban *et al.*, 2012). Similarly, Arguello *et al.* (2012) showed 39% *Salmonella* prevalence in pig carcasses in Spain. Bolton *et al.* (2013) reported 36.8% prevalence in the UK, and Methner *et al.* (2011) reported 13.8% in Germany. Arcos *et al.* (2013) demonstrated 4.3% *Salmonella* prevalence at slaughterhouses and retail market in Tolima, Colombia.

Although *Salmonella* species have been isolated from commercial pig farms (Fierro *et al.*, unpublished data) and pork meat at slaughterhouses and butcheries in Tolima (Arcos *et al.*, 2013) limited information is available to establish a clear picture of pig health status in this region. Currently, the main risk factors associated with *Salmonella* incidence in pig farms are the lack of pest controls and sow replacement programs (Henao *et al.*, 2012). Few studies have addressed antibiotic resistance of *Salmonella* isolates from pig farms in Tolima (Fierro *et al.*, 2011).

The aim of this study was to conduct a preliminary characterization of *Salmonella* species isolated from pig carcasses and environmental samples at slaughterhouses and butcheries in Tolima.

Materials and methods

Ethical considerations

The Ethics Committee of the Research Center of Universidad del Tolima approved this study in January 16, 2011.

Population

Six slaughterhouses and 14 pork butcheries of the 32 present in Tolima were included in the study based on their routine slaughter volume and use of

good manufacturing practices (GMP). The Colombian institute for drug and food surveillance (INVIMA) supported the study. Carcasses and environmental samples were collected at the slaughterhouse after slaughter and again after delivery to the butcheries. Trucks and shop environments were also sampled. Collected samples were submitted to the Laboratorio de Diagnóstico Veterinario at Universidad del Tolima.

Sample size

Six Tolima municipalities (Chaparral, Fresno, Guamo, Ibagué, Líbano and Mariquita) were selected taking into account the number of slaughtered pigs per week (>80). Based on 0% *Salmonella* prevalence in Ibagué slaughterhouses, with a 95% confidence level and 5% expected prevalence (Pabón, 1978), sample size was calculated using the following equation (Thrusfield, 2007):

$$n = \frac{z^2 \times p \times q}{d^2}$$

Where:

z^2 : prefixed confidence coefficient (1,96² for a 95% confidence).

p: expected prevalence (in this study, 5% = 0.05).

q: 1 - p.

d: Accuracy (in this study, 5%).

$$n = \frac{(1.96)^2 \times 0.05 \times (1 - 0.05)}{(0.05)^2} = \frac{3.8416 \times 0.05 \times 0.95}{0.025} = 72.99$$

The calculated minimum number of samples was 73. A total of 507 samples were taken in this study.

Sample collection

Destructive and non-destructive sampling methods were used on the surface of pig carcasses at slaughterhouses and butcher shops. A non-destructive method was used for carcass skin with sterile swabs (3M Manufacturing Company, Saint Paul, MN, USA),

which were hydrated with buffered peptone water for initial dilution and pre-enrichment step. A 10x10 cm area was calculated in each carcass and three vertical and horizontal smears were made from cheeks, abdomen and leg. In addition, 100 g of pork meat was sampled from the abdomen and throat of each carcass. These were cut with sterile scalpels (destructive method) and placed in individual sterile and hermetic bags. Environmental samples were collected from knives, work surfaces, floors, siphons and trucks using commercial swab sponges (EnviroSponge™/HydroSponge™, Biotrace International®, South Africa). All samples were kept refrigerated until analysis.

Salmonella isolation

Salmonella species were isolated following standard international guidelines (ISO 6579, 2002). Briefly, samples were incubated in buffered peptone water as a pre-enrichment step at 37 °C for 24 hours, followed by a selective enrichment step in two media: tetrathionate broth at 37 °C (Müller-Kauffmann) and Rappaport Vassiliadis at 42 °C. Bacterial samples were cultured in SS agar (*Salmonella-Shigella*, Oxoid, Germany), XLT₄ agar (Xylose Lysine Tergitol-4, Oxoid, Germany), and XLD agar (Xylosa Lysine Desoxycholate, Oxoid, Germany). Suspected bacterial colonies were cultured in McConkey agar and Trypticase soy agar (TSA) and confirmed as *Salmonella* spp. by using Poli A-I + Vi antiserum (Difco® 222641, USA). In addition, *Salmonella* isolates were confirmed by typical biochemical tests through an API® 20E test (Biomereux, France).

Serotyping

Salmonella isolates were serotyped using the Kauffman-White scheme (Brenner, 1998) for O and H antigens with commercial antiserum (Difco, Becton, Dickinson and Company, Sparks, MD). Serotyping was done based on the antigenic description by Grimont & Weill (2007) as well as nomenclature described by Tindal *et al.* (2005) and the judicial commission of the international committee on systematics of prokaryotes (JCICSP, 2005).

Antibiotic resistance

Antibiotic resistance was assessed with the Kirby-Bauer method (agar diffusion) to determine sensitivity

against several antimicrobials (ampicillin, amoxicillin, apramycin, ciprofloxacin, chloramphenicol, cephalixin, enrofloxacin, gentamicin, kanamycin, lincomycin, nalidixic acid, neomycin, nitrofuranoine, tetracycline, and sulfametoxazole/trimethoprim). A bacterial suspension in Mueller-Hinton agar (Oxoid, Germany) was calibrated according to 0.5 McFarland scale of turbidity. The 2005 protocol of the national committee for clinical laboratory standards (NCCLS) was used to interpret bacterial growth inhibition on plate at 37 °C for 24 h.

Results

Isolation of Salmonella species

Salmonella spp. was isolated from 25 out of 507 samples (4.9%) including 421 from carcasses and 86 from environments. *Salmonella* prevalence in carcasses was 3.32% (14/421) whereas prevalence in environmental samples was 12.79% (11/86). *Salmonella* isolated from carcasses included 10 from meat (71.4%) and 4 from smears of carcass surfaces (28.6%). *Salmonella* isolated from environmental samples included 3 from knives (27.2%), 3 from hooks (27.2%), 3 from siphons (27.2%), and 2 from floors (18.4%). In summary, *Salmonella* isolates were found in meat (40%), carcass smears (16%), knives (12%), hooks (12%), siphons (12%) and floors (8%).

Serotyping

The identified *Salmonella* serotypes were *Salmonella* ser. Manhattan (2/25; 8%), *Salmonella* ser. Derby (9/25; 36%), *Salmonella* ser. Typhimurium (3/25; 12%), *Salmonella* ser. Javiana (1/25; 4%), *Salmonella* ser. Muenster (5/25; 20%), *Salmonella* ser. Hvittingfoss (2/25; 8%), *Salmonella* ser. Sinsfort (1/25; 4%), *Salmonella* ser. Kattbus (1/25; 4%), and *Salmonella* ser. Saint Paul (1/25; 4%; Table 1).

Antibiotic resistance

The majority of *Salmonella* species isolated in this study were resistant to more than 2 antibiotics (60%). Regardless of its origin, *Salmonella* isolates

showed antibiotic multi-resistance to lincomycin (25/25; 100%), tetracycline (19/25; 76%), nalidixic acid, and

neomycin (Table 1). Only one *Salmonella* isolate showed resistance to both amoxicillin and ampicillin.

Table 1. Serotypes and antibiotic resistance profiles of *Salmonella* strains (n = 25) isolated from butcher's shops (BS) and slaughterhouses (S) in Tolima, Colombia.

Source	Sample	<i>Salmonella</i> serotype	Kirby Bauer Test*	
			R	S
S1	Knife	Manhattan	10,12	1,2,3,4,5,6,7,8,9,11,13,14,15
	Hooks	Manhattan	10,12,14	1,2,3,4,5,6,7,8,9,11,13,15
	Meat (neck)	Derby	10,12,14	1,2,3,4,5,6,7,8,9,11,13,15
	Carcass swab	Derby	10,12,14	1,2,3,4,5,6,7,8,9,11,13,15
S2	Knife	Derby	10,12,14	1,2,3,4,5,6,7,8,9,11,13,15
	Hook	Derby	10,14	1,2,3,4,5,6,7,8,9,11,12,13,15
	Floor	Derby	10,14	1,2,3,4,5,6,7,8,9,11,12,13,15
	Siphon	Derby	3,8,10,14	1,2,4,5,6,7,9,11,12,13,15
BS1	Meat (leg)	Derby	10,12,14	1,2,3,4,5,6,7,8,9,11,13,15
	Carcass swab	Derby	10,14	1,2,3,4,5,6,7,8,9,11,12,13,15
S3	Knife	Derby	3,9,10,12,14	1,2,4,5,6,7,8,11,13,15
S4	Hook	Typhimurium	1,2,4,5,6,7,10,11,12,14	3,8,9,13,15
	Meat (hip)	Typhimurium	10,14	1,2,3,4,5,6,7,8,9,11,12,13,15
	Meat (neck)	Javiana	7,10,12,13	1,2,3,4,5,6,8,9,11,12,15
BS2	Carcass swab	Muenster	8,10,11,12,13,14,15	1,2,3,4,5,6,7,9
	Carcass swab	Muenster	10,11,14,15	1,2,3,4,5,6,7,8,9,12,13
BS3	Carcass swab	Hvittingfoss	10,12	1,2,3,4,5,6,7,8,9,11,13,14,15
	Carcass swab	Hvittingfoss	10	1,2,3,4,5,6,7,8,9,11,12,13,14,15
BS4	Siphon	Sinstorf	10,11	1,2,3,4,5,6,7,8,9,12,13,14,15
BS5	Carcass swab	Kattbus	10,11,14	1,2,3,4,5,6,7,8,9,12,13,15
	Siphon	Saint Paul	9,10,12,14	1,2,3,4,5,6,7,8, 11,13,15
BS6	Meat (leg)	Muenster	10,11,12,13,14,15	1,2,3,4,5,6,7,8,9
	Carcass swab	Muenster	10,11,14	1,2,3,4,5,6,7,8,9,12,13,15
	Carcass swab	Muenster	10,11	1,2,3,4,5,6,7,8,9,12,13,14,15
	Floor	Typhimurium	10,11,14	1,2,3,4,5,6,7,8,9,12,13,14,15

*R: Resistant, S: Sensitive, 1: amoxicillin, 2: ampicillin, 3: apramycin, 4: ciprofloxacin, 5: chloramphenicol, 6: cephalixin, 7: enrofloxacin, 8: gentamicin, 9: kanamycin, 10: lincomycin, 11: nalidixic acid, 12: neomycin, 13: nitrofuranoine, 14: tetracycline, 15: sulfamethoxazole/trimethoprim.

Discussion

Salmonella serotypes Derby, Typhimurium, Heidelberg, Worthington, and Mbandaka are the most

common serotypes in swine worldwide (Davies *et al.*, 1997; Mueller-Doblies *et al.*, 2013). *S.* Typhimurium and *S.* Derby are the main serotypes isolated from pigs at slaughterhouses in the European Union and

the United States (Anonymous, 2008). In this study, *S. Derby* was the main isolated serotype (36%) from pork. Similar results were reported in Italy (Piras *et al.*, 2011; 47%) and France (40.5%; Bouvet *et al.*, 2003), where *S. Typhimurium* (27%) was the second serotype in this country—it was slightly higher (36.9%) in Germany (Methner *et al.*, 2011). In contrast, studies by Yang *et al.* (2013) in China reported *S. Enteritidis* as the main serotype isolated from pork origin and they isolated only one *S. Derby* out of 31 *Salmonella* serotypes. De Busser *et al.* (2011) also reported *S. Typhimurium* as the main isolate (58.7%), whereas *S. Derby* had a prevalence of 8.3% in Belgium. Recently, Arguello *et al.* (2013b) reported 64.4% and 4.9% *S. Typhimurium* and *S. Derby* prevalence in Denmark, respectively.

Salmonella Muenster and *S. Typhimurium* were the second and third more frequent serotypes isolated in this study, respectively, which is in agreement with Prendergast *et al.* (2012) who reported several serotypes in Ireland, including *S. Typhimurium*, *S. Infantis*, *S. Derby*, *S. Virchow*, and *S. Livingstone* (two strains isolated from porcine carcass swabs could not be fully typed and therefore were referred to as *S. Unnamed*). Similarly, Botteldoorn *et al.* (2003), Bolton *et al.* (2013), Delhalle *et al.* (2009), McDowell *et al.* (2007), Meneses (2010), Arguello *et al.* (2012), Arguello *et al.* (2013a), and Mueller-Doblies *et al.* (2013) found *S. Typhimurium*, *S. Derby*, *S. Rissen*, *S. Muenster*, and *S. Javiana* in pork samples from other countries. In this study, *S. Saint Paul* was isolated in 4% of the samples (1/25), in contrast with reports by Kikvi *et al.* (2010) indicating this serotype was predominant (64.2%) in Kenya. Other serotypes such as *S. Manhattan*, *S. Javiana*, *S. Hvitvingfoss*, *S. Sinsfort*, and *S. Kattbus*, have been previously reported in Germany (Methner *et al.*, 2011). Our results indicate that the main *Salmonella* serotypes isolated from pork meat and environmental samples have similarities to those from North America and European countries, and differ from those originating in Africa.

Although some studies have shown that serotypes isolated from pig farms, slaughterhouses and those detected in infected animals are unrelated or completely different (Hurd *et al.*, 2001), there is an emerging concern that the transport method and carcass reception at butcherries could increase

the contamination rate or bacterial isolation from carcasses or environmental samples. In this regard, our study found two *Salmonella* isolates in carcasses at slaughterhouses, whereas 10 *Salmonella* isolates were detected at butcherries (Table 1), thus, although we cannot exclude the possibility of contamination during transport or carcass handling, contamination of pork carcasses seems to be more probable during handling at butcher shops given that transport trucks were negative to *Salmonella*.

Antibiotic, multi-resistant pattern by *Salmonella* isolates has been reported from pig samples worldwide (Herrera-León *et al.*, 2007; Nwachukwu *et al.*, 2010; Liu *et al.*, 2011; Yang *et al.*, 2013). In this study, tetracycline resistance was high, similar to reports of *Salmonella* isolates from pork in another countries (Aragaw *et al.*, 2007; Meneses, 2010; Nwachukwu *et al.*, 2010; Mueller-Doblies *et al.*, 2013; Xia *et al.*, 2013; Yang *et al.*, 2013). In contrast, resistance to this antibiotic was lower than 10% in other studies (Kikvi *et al.*, 2010). Similarly, all *Salmonella* isolates showed resistance to lincomycin, despite few reports describe resistance to this antibiotic (Arroyo and Arroyo 1995; Fierro *et al.*, 2011). De Geeter *et al.*, (1976) reported that the use of lincomycin in pig diets did not affect the spread of *S. Typhimurium* through the feces. In addition, high resistance to clindamycin—a lincosamide antibiotic—has been reported in *Salmonella* spp. strains (Harakeh *et al.*, 2005; Thakur and Bajaj, 2006). Crossed resistance has been demonstrated through *linF* gene expression (Achard *et al.*, 2005), which could partially explain the high resistance observed by the strains in the present study.

Antibiotic resistance by *Salmonella* isolates to nalidixic acid was also high (32%). Other researchers have reported similar results (35.8%; McDowell *et al.*, 2007). Our results appear to be higher than values reported by Mueller-Doblies *et al.* (2013), who found less than 9% *Salmonella* isolates resistant to this antibiotic in Great Britain and 2.1% in Ireland (McDowell *et al.*, 2007). In contrast, Nwachukwu *et al.* (2010) reported 87.5% resistance in Nigeria, and Yang *et al.* (2013) found 77.6% resistance to nalidixic acid in China.

Differences were also found for chloramphenicol, gentamycin, and ampicillin resistance. Values were

lower (4%) in the present study compared to those reported by Nwachukwu *et al.* (2010), Piras *et al.* (2011), Mueller-Doblies *et al.* (2013), and Yang *et al.* (2013).

Salmonella isolates were resistant to sulfamethoxazole/trimethoprim (12%). Mueller-Doblies *et al.* (2013) and Yang *et al.* (2013) reported higher resistance to both antibiotics (47.6% and 83.6%, respectively). On the other hand, *Salmonella* showed no resistance to ciprofloxacin, kanamycin, and apramycin, in contrast to what has been reported by Yang *et al.* (2003; 24.3%) and McDowell *et al.* (2007; 1.6%).

In conclusion, Derby, Muenster, and Typhimurium serotypes are the predominant *Salmonella* isolates from slaughterhouses and butcher's shops in Tolima. These serotypes were isolated from carcasses as well as from equipment used at pork butcherries. *Salmonella* isolates showed multi-resistance to various antibiotics and this finding constitutes an alert signal and an important issue that needs to be addressed by the national institute of surveillance of drugs and foods (INVIMA) which regulates the use of antimicrobial agents in the pig production chain.

Acknowledgements

This manuscript is based on the project "Determinación de la prevalencia de *Salmonella* spp. y cuantificación de factores de riesgo asociados a su presencia en carne porcina del departamento del Tolima" (2008W4497-3594), funded by contract 054/2008 CIAT/MADR, Ministerio de Agricultura y Desarrollo Rural de Colombia. The authors wish to thank the Asociación Colombiana de Porcicultores (ACP), Comité Central de Investigación and Laboratorio de Diagnóstico Veterinario, with special thanks to Luis Hernando Ortiz.

Conflicts of interest

The authors declare they have no conflicts of interest with regard to the work presented in this report.

References

- Achard A, Villers C, Pichereau V, Leclercq R. New *lnu* (c) gene conferring resistance to lincomycin by nucleotidylation in *Streptococcus agalactiae* UCN36. Antimicrob Agents Chemother 2005; 49(7):2716-2719.
- Alban L, Baptista F, Møgelmoose V, Sørensen L, Christensen H, Aabo S, Dahl J. *Salmonella* surveillance and control for finisher pigs and pork in Denmark : a case study. Food Res Int 2012; 45: 656-665.
- Anonymous. Report of the task force on zoonoses. Data collection on the analysis of the baseline survey on the prevalence of *Salmonella* in slaughter pigs, Part A. J EFSA 2008; 135:1-111.
- Aragaw K, Molla B, Muckle A, Cole L, Wilkie E, Poppe C, Kleer J, Hildebrandt G. The characterization of *Salmonella* serovars isolated from apparently healthy slaughtered pigs at Addis Ababa abattoir, Ethiopia. Prev Vet Med 2007; 82:252-261.
- Arcos E, Mora L, Fandiño L, Rondón-Barragán IS. Prevalencia de *Salmonella* spp. en carne porcina, plantas de beneficio y expendios del Tolima. Revista Orinoquia 2013; 17(1):59-68.
- Arguello H, Carvajal A, Collazos JA, García-Feliz C, Rubio P. Prevalence and serovars of *Salmonella enterica* on pig carcasses, slaughtered pigs and the environment of four Spanish slaughterhouses. Food Res Int 2012; 45:905-912.
- Arguello H, Carvajal A, Naharro G, Arcos M, Rodicio MR, Cruz M, Rubio P. Sero and genotyping of *Salmonella* in slaughter pigs, from farm to cutting plant, with a focus on the slaughter process. Int J Food Microbiol 2013a; 161:44-52.
- Arguello H, Sørensen G, Carvajal A, Baggesen DL, Rubio P, Pedersen K. Prevalence, serotypes and resistance patterns of *Salmonella* in Danish pig production. Res Vet Sci 2013b; 95(2):334-342.
- Arroyo G, Arroyo JA. Detection of *Salmonella* serotypes in edible organ meats from markets in Madrid, Spain. Food Microbiol 1995; 12:13-20.
- Ashbolt R, Dempsey K, Gregory J. Foodborne disease investigation across Australia: annual report of the OzFoodNet network, 2003. Commun Dis Intell 2004; 28:359-389.
- BIOHAZ, 2012. Scientific opinion on an estimation of the public health impact of setting a new target for the reduction of *Salmonella* in turkeys. JEFSA 10; 2616-2689.
- Bolton DJ, Ivory C, McDowell D. A study of *Salmonella* in pigs from birth to carcass: Serotypes, genotypes, antibiotic resistance and virulence profiles. Int J Food Microbiol 2013; 160:298-303.
- Botteldoorn N, Heyndrickx M, Rijpens N, Grijspeerdt K, Herman L. *Salmonella* on pig carcasses: positive pigs and cross contamination in the slaughterhouse. J Appl Microbiol 2003; 95:891-903.
- Bouvet J, Bavai C, Rossel R, Le Roux A, Montet MP, Mazuy C, Verzozy-Rozand C. Evolution of pig carcass and slaughterhouse environment contamination by *Salmonella*. Revue Méd Vét 2003; 154(12):775-779.

- Brenner FW. Modified Kaufmann-White Scheme. Centers for Disease Control and Prevention, Atlanta, GA. 1998.
- Bustos NS, Cortés LF, Domínguez CA, Mendoza LA. Medición de la carga de enfermedad en una entidad promotora de salud de Colombia año 2008 (Esp. Thesis). Universidad del Rosario. Bogotá, Colombia. 2010.
- Davies PR, Morrow WE, Jones FT, Deen J, Fedorka-Cray PJ, Harris IT. Prevalence of *Salmonella* in finishing swine raised in different production systems in North Carolina, USA. *Epidemiol Infect* 1997; 119:237-44.
- De Busser EV, Maes D, Houf K, Dewulf J, Imberechts H, Bertrand S, De Zutter L. Detection and characterization of *Salmonella* in lairage, on pig carcasses and intestines in five slaughterhouses. *J Food Microbiol* 2011; 145(1):279-86.
- De Geeter MJ, Stahl GL, Geng S. Effect of lincomycin on prevalence, duration, and quantity of *Salmonella* typhimurium excreted by swine. *Am J Vet Res* 1976; 37(5):525-9.
- Delhalle L, Saegerman C, Farnir F, Korsak N, Maes D, Messens W, De Sadeleer L, De Zutter L, Daube G. *Salmonella* surveillance and control at post-harvest in the Belgian pork meat chain. *Food Microbiol* 2009; 26:265-271.
- Durango J, Arrieta G, Mattar S. Presencia de *Salmonella* spp. en un área del Caribe colombiano: un riesgo para la salud pública. *Biomédica* 2004; 24(1):89-96.
- Fierro MA, Osorio CA, Fandiño de Rubio C, Rondón-Barragán IS. Resistencia antibiótica en *Salmonella enterica* serovar Typhimurium aisladas de granjas porcinas en el Departamento del Tolima. *Revista Orinoquia* 2011; 15(1):71-78.
- Flint JA, Van Duynhoven YT, Angulo FJ, DeLong SM, Braun P, Kirk M. Estimating the burden of acute gastroenteritis, foodborne disease, and pathogens commonly transmitted by food: an international review. *Clin Infect Dis* 2005; 41:698-704.
- Grimont PAD, Weill F. Antigenic formulae of the *Salmonella* serovars, 9th Edition. WHO Collaborating Centre for Reference and Research on *Salmonella*. Paris: Pasteur Institute. 2007 [Access date: November, 2013] URL: www.pasteur.fr/ip/portal/action/WebdriveActionEvent/oid/01s-000036-089
- Harakeh S, Yassine H, Gharios M, Barbour E, Hajjar S, El-Fadel M, Toufeili I, Tannous R. Isolation, molecular characterization and antimicrobial resistance patterns of *Salmonella* and *Escherichia coli* isolate from meat-based fast food in Lebanon. *Sci Total Environment* 2005; 341(1-3): 33-44.
- Henaó JS, Ramírez E, Rondón-Barragán I. Análisis de las Buenas Prácticas de Producción en granjas porcinas del departamento del Tolima y factores de riesgo asociados a la presencia de *Salmonella* spp. *Rev CES Med Zootec* 2012; 7(2):11-20.
- Herrera-León S, Ramiro R, Arroyo M, Díez R, Usera MA, Echeita MA. Blind comparison of traditional serotyping with three multiplex PCRs for the identification of *Salmonella* serotypes. *Res Microbiol* 2007; 158:122-127.
- Hurd HS, McKean JD, Wesley IV, Karriker LA. The effect of lairage on *Salmonella* isolation from market swine. *J Food Prot* 2001; 64:939-944.
- ISO 6579. International Organization for Standardization. Microbiology. General guidance on methods for the detection of *Salmonella*. 4th ed. Geneva, Switzerland. 2002.
- Judicial Commission of the International Committee on Systematics of Prokaryotes. The type species of the genus *Salmonella* Lignieres 1900 is *Salmonella enterica* (ex Kauffmann and Edwards 1952) Le Minor and Popoff 1987, with the type strain LT2T, and conservation of the epithet *enterica* in *Salmonella enterica* over all earlier epithets that may be applied to this species. Opinion 80. *Int J Syst Evol Micr* 2005; 55:519-520.
- Kikuvi GM, Ombui JN, Mitema ES. Serotypes and antimicrobial resistance profiles of *Salmonella* isolates from pigs at slaughter in Kenya. *J Infect Dev Ctries* 2010; 4(4):243-248.
- Kumar Y, Sharma A, Sehgal R, Kumar S. Distribution trends of *Salmonella* serovars in India (2001-2005). *Trans R Soc Trop Med Hyg* 2009; 103:390-394.
- Liu WB, Zhu X, Yu SJ, Shi X. Diversity of *Salmonella* isolates using serotyping and multilocus sequence typing. *Food Microbiol* 2011; 28:1182-1189.
- McDowell SWJ, Porter R, Madden R, Cooper B, Neill SD. *Salmonella* in slaughter pigs in Northern Ireland: prevalence and use of statistical modeling to investigate sample and abattoir effects. *Int J Food Microbiol* 2007; 118:116-125.
- Meneses YE. Identification and characterization of *Salmonella* serotypes isolated from pork and poultry from commercial sources. Dissertations & Theses in Food Science and Technology. Paper 8. 2010. [Access date: January, 2014] URL: <http://digitalcommons.unl.edu/foodscidiss/8>
- Methner U, Rammler N, Fehlhaber K, Rösler W. *Salmonella* status of pigs at slaughter: bacteriological and serological analysis. *Int J Food Microbiol* 2011; 151:15-20.
- Mueller-Doblies D, Speed K, Davies RH. A retrospective analysis of *Salmonella* serovars isolated from pigs in Great Britain between 1994 and 2010. *Prev Vet Med* 2013; 110:447- 455.
- NCCLS. CLSI/NCCLS Standard. Clinical and Laboratory Standards Institute. 2005.
- Nwachukwu NC, Orji FA, Madu CN. Antibiotic-resistance *Salmonella* species in pork on display for sale in Umuhia, Abia State, Nigeria. *Res J Agric & Biol Sci* 2010; 6(6):750-753.
- Pabón A. Aislamientos microbiológicos en la planta de beneficio de la ciudad de Ibagué, Tolima. Colombia (undergraduate thesis). Universidad del Tolima, Departamento de Sanidad Animal, 1978.
- Petersen A, Aarestrup FM, Angulo FJ, Wong S, Stohr K, Wegener HC. WHO Global Salm-Surv external quality assurance system (EQAS): an important step toward improving the quality of *Salmonella* serotyping and antimicrobial susceptibility testing worldwide. *Microb Drug Resis* 2002; 8:345-53.

- Piras F, Brown DJ, Meloni D, Mureddu A, Mazzette R. Investigation of *Salmonella enterica* in Sardinian slaughter pigs: prevalence, serotype and genotype characterization. *Int J Food Microbiol* 2011; 151:201-209.
- Prendergast DM, Grady DO, McCann A, McCabe E, Fanning S, Egan J, Fanning J, Gutierrez M. Application of PCR for rapid detection and serotyping of *Salmonella* spp. from porcine carcass swabs following enrichment in semi-solid agar. *Food Res Int* 2012; 45:993-999.
- Rosengren LB, Waldner CL, Reid-Smith RJ, Checkley SL, McFall ME, Rajic A. Antimicrobial resistance of fecal *Salmonella* spp. isolated from all phases of pig production in 20 herds in Alberta and Saskatchewan. *Can J Vet Res* 2008; 72:151-159.
- Thakur YR, Bajaj BK. Antibiotic resistance and molecular characterization of poultry isolates of *Salmonella* by RAPD-PCR. *World J Microbiol Biotech* 2006; 22(11):1177-1183.
- Thrusfield M. *Veterinary epidemiology*. 3rd ed. Oxford (UK) Blackwell Science Publisher; 2007.
- Tindall BJ, Grimont PAD, Garrity GM, Euzéby JP. Nomenclature and taxonomy of the genus *Salmonella*. *Int J Syst Evol Micr* 2005; 55:521-524.
- Torpdahl M, Sørensen G, Ethelberg S, Sandø G, Kammelgard K, Jannok Porsbo L. A regional outbreak of *S. Typhimurium* in Denmark and identification of the source using MLVA typing. *Euro Surveill* 2006; 11:134-136.
- Vaillant V, de Valk H, Baron E, Ancelle T, Colin P, Delmas MC, Dufour B, Pouillot R, Le Strat Y, Weinbreck P, Jouglu E, Desenclos JC. Foodborne infections in France. *Foodborne Pathog Dis* 2005; 2:221-232.
- Voetsch AC, Van Gilder TJ, Angulo FJ, Farley MM, Shallow S, Marcus R, Cieslak PR, Deneen VC, Tauxe RV. FoodNet estimate of the burden of illness caused by nontyphoidal *Salmonella* infections in the United States. *Clin Infect Dis* 2004; 3(38): S127-S134.
- Xia X, Zhao S, Smith A, McEvoy J, Meng J, Bhagwat A. Characterization of *Salmonella* isolates from retail foods based on serotyping, pulse field gel electrophoresis, antibiotic resistance and other phenotypic properties. *Int J Food Microbiol* 2009; 129:93-98.
- Yang B, Qiao L, Zhang X, Cui Y, Xia X, Cui S, Wang X, Meng X, Ge W, Shi X, Wang D, Meng J. Serotyping, antimicrobial susceptibility, pulse field gel electrophoresis analysis of *Salmonella* isolates from retail foods in Henan Province, China. *Food Control* 2013; 32:228-235.