UDC636

Print ISSN 1450-9156
Online ISSN 2217-7140

# BIOTECHNOLOGY IN ANIMAL HUSBANDRY

**CONTENTS**



**VOL 31, 4**
Founder and publisher
**INSTITUTE FOR ANIMAL HUSBANDRY**
**11080 Belgrade-Zemun**
**Belgrade 2015**

Journal for the Improvement of Animal Husbandry

**UDC636**

**Print ISSN 1450-9156**
**Online ISSN 2217-7140**

# BIOTECHNOLOGY IN ANIMAL HUSBANDRY

Belgrade - Zemun 2015

Biotechnology in Animal Husbandry 31 (4), p 441-575, 2015 ISSN 1450-9156
Publisher: Institute for Animal Husbandry, Belgrade-Zemun UDC 636



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**According to CEON bibliometrical analysis citation in SCI index 212, in ISI 9, impact factor (2 and 5) of journal in 2012: 0,667 and 0,467, - M51 category**

Annual subscription: for individuals -500 RSD, for organizations 1200 RSD, -foreign subscriptions 20 EUR. Bank account Institut za stočarstvo, Beograd-Zemun 105-1073-11 Aik banka Niš Filijala Beograd.

Journal is published in four issues annually, circulation 100 copies.

The publication of this journal is sponsored by the Ministry of Education and Science of the Republic of Serbia.
Printed: "Mladost birošped", Novi Beograd, St. Bulevar AVNOJ-a 12, tel. 381 11 2601-506

Biotechnology in Animal Husbandry 31 (4), p 457-466 , 2015 ISSN 1450-9156
Publisher: Institute for Animal Husbandry, Belgrade-Zemun UDC 636.09'64
DOI: 10.2298/BAH1504457V

# IDENTIFICATION OF RISK FACTORS FOR *SALMONELLA* SPP. IN PIGS AND CONTROL MEASURES DURING MANAGEMENT AND TRANSPORT OF ANIMALS

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Review paper

**Abstract:** Pigs and pork meat products are common source of human salmonellosis. Salmonella can enter the food chain at any point such as the livestock feed, via the on-farm production site, at the slaughterhouse or packing plant, as well as during manufacturing, processing and retailing of food, or through catering and food preparation at home. The understanding of epidemiology of *Salmonella* sp. at all stages of production chain is of crucial importance. The production of „Salmonella free pigs“ would reduce the risk for the occurrence of human infections Also, production of „Salmonella free pigs“ is difficult to achieve due to a number of practical and financial reasons. However, serological status of particular pig farm can be determined based on the analysis of blood- or meat juice samples taken from slaughtered pigs. This procedure enables the identification of Salmonella free farms“. The basic actions for preventing salmonellosis in humans should involve the following: preventing the entrance of Salmonella to the farm, reducing the number of infected animals and preventing the spread of the infection. The best way to prevent the disease is to keep the infection away from the farm. In order to successfully resolve the problem of human salmonellosis associated with infected pork meat or meat products, control measures need to be simultaneously implemented at all levels of meat production chain.

**Key words**: salmonellosis, pigs, risk factors, control measures

## Introduction

*Salmonella* spp. is considered one of the leading food borne pathogens that for humans. The sources of infection include infected animals, contaminated food, stables, equipment, manure, rodents, etc. The term salmonellosis describes a range of different forms of infection. The most common form of infection is the carrier

status, where the carrier does not show any symptoms of the disease. Such carrier-animals are of importance for breeding of animals intended for meat production because they can serve as infection reservoirs that facilitate disease spreading via animal excreta and thus can cause the contamination of final product.

Pigs and pork meat products are very often the source of human salmonellosis. Salmonella can enter the food chain at any phase of meat production process - feeding or animals on the farm, in the slaughter house, during packaging of meat products or even during preparation of food in the households (*Stojanov et. al., 2005).* Contamination of pork meat can be reduced by decreasing the contamination at the level of primary production. Proper understanding of Salmonella epidemiology within the entire production chain is the prerequisite for successful implementation of such measures (*Vidić et al., 2014a*). A whole range of studies worldwide have addressed the epidemiology of salmonellosis in pigs. Pork meat and products are an important source of salmonellosis in humans. Precise determination of exact number of cases is difficult to accomplish even in developed countries. The estimated rate of human salmonellosis associated with pork meat and related products in Denmark and Netherlands range between 10 and 15% (*Berends et al. 1998*).

Production of „Salmonella free pigs“ is highly complex and intricate for many practical and financial reasons. However, determination of serological status of the pig farm is feasible and is based on the analysis of blood or meat juice samples collected from slaughtered pigs. This procedure enables identification of a „Salmonella free farms“. The control models for pig salmonellosis differ from country to country; however, all of them include strict control of feed and its components as well as bacteriological and serological monitoring of certain percentage of animals (piglets, sows and fatlings) in defined time frames (*Davis and Funk, 1999*). In order to successfully resolve the problem of human salmonellosis associated with consumption of infected pork meat or meat products, simultaneous implementation of appropriate control measures at all levels of meat production chain is necessary.

In most of EU countries, programs for control and continuous examination are applied throughout all stages of pig production chain at the national level. In Denmark for example, application of defined control programs resulted in significant reduction of salmonellosis rate in pigs, which has dropped from 3.5% in 1993 to 0.7% in 2000, and to even 0.4% in 2014. Such a decreasing tendency is also associated with the reduced incidence of salmonellosis in humans, which was for the same period reduced ten times on annual level (*Mousing et al. 1997, Berends et al. 1998).* In our country, the analysis was performed applying ELISA test and the presence of Salmonella infection was confirmed on the pig farms. The study encompassed 628 blood serum samples of fatlings from 5 different farms. Positive findings for Salmonella were obtained in 46.5% animals, for the cut off at 10%. The S/P value ranged between 0.25 and 3.147 (*Grgić et al. 2004.*). Analysis

of 256 serum samples from sows and boars using ELISA test revealed positive finding in 25.9% animals (*Vidić et al., 2008b*).

# Risk factors

## Feed

Feed and feed components can be contaminated with Salmonella and as such can represent a potential source of salmonellosis. Large amounts of feed mixture are produced on a daily basis and they are transported and stored for the purpose of pig breeding. Even very low rates of contamination with Salmonella pose substantial risk of infection for many farms. The processes of control and decontamination, such as heat treatment, can be applied at this level to avoid the contamination of feed mixtures. However, according to the research done in Denmark, there are no significant differences in the level of pig infection with *S. enetericae* at the end of fattening period, depending on weather the pigs were fed with pelleted or unpelleted food. *Davies and Wrey* (1997) have found a very high level of contamination with Salmonella on the cooling equipment inside the manufacturing building, on the fresh feces of wild birds collected in the warehouse and the crane for unloading in some mills. This strongly indicates that the contact of final products with infection reservoirs (birds, rats, etc.) must be prevented as well as their potential contamination in the transportation trucks (*Fedorka-Cray, et al., 1997*), warehouses, and mills, which have to be safe and secured.

## Epidemiology of Salmonella during pre-harvest stage

Basic goals of control strategies and epidemiology of salmonellosis include prevention of infection introduction into the farm and its transmission and maintenance as well. Farms are not closed systems - constant intake of feed and introduction of new animals represent the potential source of infection as was reported in several studies on the risk factors for salmonellosis (*Dahl et al., 1997; Kljajić et al., 2006*). Besides these two potential entry portals for Salmonella infection, there are many more, some of which have already been confirmed and some are still hypothetical. Based on potential risks and sources of salmonellosis, a number of preventive and control options have been suggested. Feed mixtures treated with heath can help in prevention of salmonellosis in serologically negative herds, but this measure cannot help much in herds where salmonellosis is already present. A range of studies reported on protective effects of feed with low pH (in form of added organic acid, whey or fermented additives) against Salmonella infections (*van der Wolf et al., 2001; Dahl et al., 1999).*

Control of birds, flies and rodents is necessary in pigsties and warehouses but also keeping small animals, such as cats and dogs, out of the facility. Avoiding transmission of bacteria by dust and aerosol inside the facilities and prevention of

contact with infected wild animals is of crucial importance. Appropriate hygienic measures should be provided inside the facilities and drains. Purchase of new animals should be done from the certified and Salmonella free herds. New animals should be quarantined and subjected to relevant health monitoring. The purchase of animals should be performed from limited number of farms. Through washing and disinfection in line with predefined procedures has to be performed at every turnover and movement of animals on the farm. Sanitary rooms and facilities for hand washing as well as changing rooms must also comply with standard operative procedures in order to avoid spreading of Salmonella and other pathogens.

In cases when Salmonella has already been present in pig herd, acidification of feed mixture or even drinking water by adding organic acids or whey was included into the control program. The changes in feeding strategy can help to reduce the exposure to Salmonella and increase resistance to pig infection *(van der Wolf et al., 2001; Dahl et al., 1999*). Application of highly placed pens and partitions can be useful for preventing infection spreading between boxes and buildings. Moreover, a separate facility for keeping sick animals should be planed *(Pedersen, 1997).* Application of only one single control measure is not effective enough to prevent Salmonella infection, reduce the level of infection or to eliminate the infection from the herd (*Kljajić et al 2010a*). Each farm has to define relevant measures and strategies based on the realistic actual situation on the farm and potential successes of all actions has to be objectively assessed and based on combination of measures to be applied, depending on practical and economic factors. Multifactorial infection such as salmonellosis requires a complex approach to identify the procedures to be defined and applied between farms, within the farm itself and to an individual animal on the farm (*Vidić et. al., 2014b*).

## Epidemiology of Salmonella during shipping and transportation of animals

Pigs infected with Salmonella have a subclinical form of the disease and only occasionally shed Salmonella in the feces. Stressful conditions can intensify the bacterial shedding in carrier animals and increase the susceptibility to Salmonella infection in animals, which were not infected before (*Williams and Newell, 1970*). During transportation, the pigs are exposed to many stress factors such as noise, smell, mixing with other pigs that were not in the same object, high density of pigs in a small area, duration of transportation, temperature changes and other ambient changes (*Warriss et al., 1992*). Consequently, transportation and manipulation can significantly influence and increase the number of pigs that are shedding Salmonella at the moment of entry to the farm (*Williams and Newell, 1970; Berends et al., 1996; Rajkowski et al., 1998*). Salmonella-negative pigs can be exposed to infection during transportation in a vehicle that has not been

adequately cleaned and disinfected after transportation of Salmonella-positive animals. Contaminated trucks present a potential source of infection also for other farms and slaughterhouses.

After transportation to the slaughterhouse, pigs are usually kept in a lairage before slaughtering. The period spent in a lairage is variable and influences the level of pig infection. The waiting area at the slaughterhouse allows pigs to recover from stress caused by transportation and manipulation of animals. Many of the same stress factors related to transportation are also present during waiting period and the number of pigs which excrete Salmonella is increased also depending on the time spent in the waiting areas (*Morgan et al, 1987b).* Further on, this space or hall is usually cleaned only at the end of the day and represents a potential source of infection for Salmonella negative or weakly infected pigs. Those pigs can easily pick up Salmonella from other pigs or from the environment by oral or nasal intake or even through skin. The longer the time that pigs spend in the waiting area the higher the possibility of contamination and ending up as positive trunks (*Morgan et al., 1987a*).

In order to avoid spreading of infection during transportation or waiting period, appropriate control measures should be taken. Mixing of animals from different farms should be avoided and pigs should be treated as quietly and gently as possible (*Williams et al., 1970, Warriss et al., 1992).* If possible, groups of pigs should be delivered directly to the slaughterhouse in separated trucks (*Morgan et al. 1987b*). Trucks should be cleaned and disinfected between different transports. (*Rajkowski et al., 1998, Swanenburg et al., 2001a*). Waiting time should be as minimal as possible at least for the pigs that are Salmonella negative without mixing animals with other herds (*Morgan et al., 1987b, Swanenburg et al., 2001b*). Pigs should be kept in smaller groups of less than 15 animals and waiting space should be cleaned between different groups of pigs and at the end of slaughtering (*Morgan et al., 1987a, Berends et al., 1998).* Procedures for cleaning and disinfection should undergo constant visual and bacteriological control (*Morgan et al., 1987a, Swanenburg et al., 2001b).*

## Control measures

There are three basic strategies to fight against salmonellosis: preventing Salmonella to enter the farm, reducing the number of infected animals and stopping the spread of the disease.

### Prevention of entering Salmonella on the farm

The best way to prevent the disease is to prevent the entrance of the pathogen into the farm (*Kljajić et al., 2008*). Purchase of the pigs should be done

from only one or only few herds that are Salmonella-free. Vehicles must be thoroughly cleaned and disinfected before shipping the pigs for further transportation. Before introducing the newly purchased pigs into the farm, quarantine has to be provided. The entrance to the farm should be strictly controlled. Vehicles and trucks should not enter the farm and the shipping of animals and feed should be done in front of the farm entrance. If the vehicles have to enter into the farm, appropriate disinfection should be performed. Dead animals should be disposed into a secured container, which is regularly disinfected. No other animals should be allowed to go near the pigs of warehouse for feed. Dogs and cats are not welcome to pig farm, especially cats which carry particularly high risk. Rodents have to be under control, nets should be mounted on all entrances and openings and all dishes with feed should be covered. Rodents, birds or cats must have no access to warehouses (*Kljajić et al., 2010b*).

Pigs should be separated from other production animals if there are any. The risk from foxes, birds and other pests should be reduced by collecting dead animals immediately as well as the remains after farrowing. Feeding dishes should be covered and there should be solid fences around the objects in the open air. If objects are close to the roads that people use, they should be at least 5m away with a double fence. All machines and equipment should be cleaned and disinfected both before entering and leaving the farm. Unemployed persons must have no access on the farm or, if their presence is necessary only with protective clothes. Feed and water must be purchased from reliable warehouses and public water supply. If this is not possible, disinfection of water should be done.

Salmonella can be transmitted from pigs to humans, so toilets and bathrooms for personnel are needed on the farm. All workers on the farm have to wash their hands every time they work with a different group of pigs.

## Reduction of the number of infected animals and prevention of disease spreading

If Salmonella is present on the farm, the infection will most probably spread across the farm, wherever there is contamination with pig feces and liquid manure. The microorganism will die very soon if the environment is dry, clean (no organic matter), warm and disinfected. Places where Salmonella can persist are dirty dishes, dust and cobweb, corners and wall cracks, taps, tools and machines, dirty boots, clothes, warehouses, feed containers, contaminated roads. Thorough cleaning is of utmost importance because the disinfectants are ineffective on dirty surfaces. The ideal strategy is all in – all out. Facilities that are filled with animals all the time cannot be cleaned in a proper way. However, if the facilities are empty for one-two weeks before the next round of pigs, the infection risk can be reduced applying thorough cleaning and disinfection procedure. Everyday work on the farm

should always start from the youngest pigs and then proceed to older groups. Farrowing facilities should be done first. The facilities for housing of sick animals must be cleaned as last. The golden rule is not to mix pigs of different age (*Vidić et al., 2008a*). If there are any pigs smaller and weaker than the others, it might suggest that they are infected and may be a carrier of Salmonella. Pools for boot disinfection should be positioned near every pigsty.

The choice of feed used on the farm can contribute to protection from salmonellosis and retention of Salmonella in the intestinal tract (*Stojanov et. al., 2005*). Pelleted food is the worst solution, that is, feeding powdered meal should prevail. The meals should be based on barley and not wheat, with some addition of organic acids. Liquid meal, especially fermented one is the best option in the control of salmonellosis. This strategy proved effective in Denmark, Netherlands and UK. Water acidification can be of use with low costs, but it appropriate cleaning of the water system is the prerequisite for a successful outcome

The level of stress has to be reduced to the minimum. Pigs must have enough space, especially near feeding place. Water dishes have to work properly and there has to be enough space for lying.

The use of antibiotics is forbidden in the control of salmonellosis. Antimicrobial drugs do not help in reducing the level of infection and can even increase the rate of shedding of Salmonella, prolong the period of excretion and contribute to the development of resistance to antibiotic treatment. Antibiotics can be used only in sick animals, which is rare in pigs. Vaccines are not an easy option and they are not the usual choice for pigs. However, if nothing else gives results, the use of vaccine can be considered. Vaccines made of Salmonella strains originating from the observed herd usually have not been appropriately tested and thus cannot be used as replacement for other measures, such as cleaning and disinfection. Vaccines administered during the period before slaughter can cause a positive finding during testing of the meat juice.

## Acknowledgments

The presented work is a part of the research done in the project TR31071, TR31084 granted by the Serbian Ministry of Education and Science.

## Faktori rizika kod salmoneloze svinja i mere kontrole u procesu proizvodnje i transporta životinja

*B. Vidić, S. Savić, N. Prica*

## Rezime

Svinje i proizvodi od svinjskog mesa su često izvor humanih slučajeva salmoneloze. Salmonela može ući u lanac hrane na bilo kojoj tački lanca, od ishrane životinja, proizvodnje na farmi, na klanici ili pakeraju, tokom proizvodnje, prerade proizvoda, u snabdevanju i pripremi hrane u domaćinstvu. Razumevanje epidemiologije salmoneloza u svim fazama proizvodnog lanca je od presudnog značaja. Proizvodnja svinja slobodnih od *Salmonella* spp. redukovala bi rizik za nastajanja i javljanje ove zoonoze kod ljudi. Proizvodnja svinja slobodnih od salmonela teško je izovodljiva iz praktičnih i finansijskih razloga. Međutim, realno je moguće utvrditi serološki status farme svinja baziran na rezultatima pregleda krvi ili mesnog soka uzetog od zaklanih svinja. Ovim postupkom definišu se farme «slobodne od salmonela». Osnovni pravci delovanja su: sprečavanje unosa salmonela na farmu i smanjivanje broja inficiranih jedinki na farmi i zaustavljanje njenog širenja. Najbolji način za prevenciju bolesti je sprečavanje ulaska na farmu. Kako bi efikasno rešavali problem salmoneloze kod ljudi, čiji je uzrok svinjsko meso ili proizvodi, potrebno je da se uvedu mere kontrole istovremeno na svim nivoima u lancu proizvodnje.

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Received 4 November 2015; accepted for publication 5 December 2015