# PHYSICAL STRUCTURE, SANITARY-HYGIENIC PRACTICES AND MICROBIOLOGICAL PARAMETERS OF PORK SLAUGHTERHOUSES IN THE STATE OF PARAIBA, BRAZIL

Valquíria C. da S. Ferreira[1], Terezinha D. D. Martins[2] and Sinara P. Fragoso[1*]

1Post-Graduate Program Food Science and Technology, UFPB, João Pessoa, Paraíba, Brazil. 2 Department of Agriculture, UFPB, Bananeiras, Paraíba, Brazil

*sinarafragoso@hotmail.com

**Abstract – The physical structure, sanitary-hygienic practices and microbiological parameters of pork slaughterhouses were assessed. Five slaughterhouses in the state of Paraíba, Brazil, were inspected, using a checklist and were classified into group I (low risk), II (intermediate risk) and III (high risk). The microorganisms investigated were: total and faecal coliforms (in water); total and faecal coliforms, mesophilic aerobic bacteria, *Staphylococcus aureus* (in carcasses, handlers' hands and knives), and presence of *Salmonella sp*. (only in carcasses). All the slaughterhouses were classified in Group III (high risk). Although there are differences between slaughterhouses and collection points contamination levels above permitted levels for all analyses were observed, *Salmonella* was present in 12% of carcasses evaluated. Contamination of water and knives suggested cross-contamination. The high levels of microbiological contamination of water, carcasses, knives and handlers' hands compromise the food safety of pork.**

## I. INTRODUCTION

In Brazil, about 34.3 million heads of pigs are officially slaughtered. From this total, 29.1 million are monitored through the Federal Inspection Service (SIF) and the others (5.2 million) are submitted to other certifications that keep decreasing in recent years [1]. In turn, the production of pigs in northeastern Brazil is aimed at local consumption, with animals being slaughtered concomitant with other species in small local slaughterhouses.

In recent years, there has been an increasing interest in the pork market in Northeast Brazil. The increase in purchasing power (income) and the fact that this region has the second largest population (53 million) in the country have been identified as major factors to raise the domestic per capita pork consumption, with positive impact on the chain production. Considering these aspects, issues related to food quality and safety must be considered.

According to Alban et al. [2], the fundamental principle to control microbial contamination in pork carcasses is based on hygienic and sanitary processes during slaughter and technologies and procedures used in order to minimize the microbial load of the final product.

Studies recently carried out indicate that the slaughterhouse environment contributes to the contamination of pork carcasses. According to Buncic et al, [3] and Bello et al. [4] during slaughter, not only pork carcasses are infected with *Salmonella*, but cross-contamination of the environment and other animals also occur, indicating inefficient hygienic practices. In turn, high total and faecal coliform, mesophilic aerobic bacteria and *Staphylococcus aureus* counts are indicators of poor hygiene practices in pork slaughterhouses, being responsible for numerous reported cases of food poisoning in humans [5]. Thus, the aim of this study was to evaluate the physical structure, sanitary-hygienic practices and microbiological parameters of pork slaughterhouses in the state of Paraiba, Brazil.

## II. MATERIALS AND METHODS

The survey was conducted in five slaughterhouses in the state of Paraiba, (identified as A, B, C, D and E) selected according to the proximity of the largest pork production region. In each slaughterhouse, slaughter was carried out overnight during three times a week, with a production of 20 head of pigs / day of slaughter.

To evaluate the physical structure and sanitary-hygienic practices of slaughterhouses, an in loco inspection was performed during the slaughter of animals, using a checklist adapted from Matsubara [6] taking the Ministério da Agricultura Pecuária e Abastecimento (MAPA) recommendations [7][8][9] and the Ministry of Health [10][11]. The 81 attributes were rated as yes (Y) or no (N) and according to the percentage compliance with the requirements of each item, the slaughterhouses were classified into group I (low risk), II (intermediate risk) and III (high risk) when they met from 76 to 100%, 51 to 75% and below 50% of attributes, respectively. Slaughterhouses were visited three times. On the last visit, sampling was conducted for microbiological analysis.

Microbial analysis was performed on four types of samples: supply water of slaughterhouses, surface of pork carcasses, handler's hands and knives used in the slaughter of pigs. Microorganisms investigated

were: total and faecal coliforms (in water); total and faecal coliforms, mesophilic aerobic bacteria and *Staphylococcus aureus* (in carcasses, handler's hands and knives) and *Salmonella* research was performed only in pork carcasses.

Samples were collected 90 minutes after slaughter. At each slaughterhouse, five samples of carcass, handler's hand and knives were collected, totaling fifteen samples, with exception of supply water. Samples were collected from the surface of carcasses, inner face of the handler's left hand and from both sides of knives used during slaughter. Supply water was collected at three points in the slaughter area using sterile containers.

To collect each sample, a pair of sterile swabs was used. The surface previously delimited with (50 $cm^2$) per collection point was rubbed with the aid of swabs with ten replicates in the horizontal direction and ten in the vertical direction. Then, they were placed in flasks containing 10 mL of sterile phosphate buffered saline, in accordance with recommendations of ISO 17604 [12].

The values of total and faecal coliforms (MPN/mL) were obtained by searching a table for the number of positive tubes. Mesophilic aerobic bacteria and *Staphylococcus aureus* counts were expressed in CFU/$cm^2$ after correction by its dilution factor to yield counts as colony forming units per 50 $cm^2$. *Salmonella* was presented as positive percentage for the number of samples. According to methodology of the American Publication Health Association (APHA) [13].

For microbiological counts, except for *Salmonella*, a completely randomized design (CRD) with five treatments and five replicates was used. The statistical interpretation of data was performed using analysis of variance (ANOVA) followed by Tukey's mean test ($p > 0.05$). The SAS statistical software version 8.2 was used.

## III. RESULTS AND DISCUSSION

**Physical structure and sanitary-hygienic practices of slaughterhouses**. Several irregularities in pigsties and surroundings were observed, and only 20% of slaughterhouses met the current legislation (Table 1). In 60% of slaughterhouses, pigs had no health certificate. All slaughterhouses were provided of arrival and selection pigsties, and about 80% of them adopt water diet and fasting in the pre-slaughter period. The arrival of pigs in the slaughter line without performing ante-mortem inspection, rest and water diet, as observed during inspections, it is not approved by [7].

In the overall evaluation of the checklist (Table 1), slaughterhouses reached 20.8% of compliance, on average. According to the classification criterion, all slaughterhouses were in group III, which provides high risk to the safety of meat, and should adopt more effective regulations to improve the current situation. According to Alban et al. [2] despite having common goal, the control system of microorganisms of each slaughterhouse must seek unique solutions suitable to each specific case.

Table 1. Conformity percentage of attributes from the checklists of five slaughterhouses of the state of Paraíba, Brazil.

| Blocs/attributes | SLAUGHTERHOUSES | | | | | | |
|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | CS | C % |
| Characterization of slaughterhouses | 6.3 | 9.4 | 6.3 | 7.8 | 4.7 | 22 | 31.4 |
| Swinery and attachments | 1.6 | 4.7 | 4.7 | 6.3 | 4.7 | 14 | 20.0 |
| Stunning and bleeding | 3.1 | 3.1 | 6.3 | 3.1 | 3.1 | 12 | 17.1 |
| Slaughter room – dirty zone | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 10 | 14.3 |
| Slaughter room – clean zone | 1.6 | 3.1 | 1.6 | 4.7 | 0.0 | 07 | 10.0 |
| Refrigeration setup and meat transport | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Hygiene of Employees | 0.0 | 0.0 | 0.0 | 1.6 | 0.0 | 01 | 14 |
| Changing rooms and toilets | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 05 | 7.1 |
| SOP[1] control | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Waste and garbage | 0.0 | 1.6 | 0.0 | 1.6 | 0.0 | 02 | 2.9 |
| Total score | 17.3 | 26.6 | 23.6 | 29.8 | 17.2 | 73 | - |
| Group[2] | III | III | III | III | III | - | - |

[1]SOP: Standard Operating Procedures; [2] Group = I (low risk), II (intermediate risk) and III (high risk). CS= Conformity Sun; C=Conformity

**Microbiological Analyses.** The results of total and faecal coliform, mesophilic aerobic bacteria, *Staphylococcus aureus*, and *Salmonella* counts are shown in Table 2. The lowest average values for these microorganisms were observed for slaughterhouse A: 1.64 ± 0.68 log MPN/$cm^2$ for total coliform and 1.44 ± 0.45 log MPN/$cm^2$ for the faecal coliform. In contrast, slaughterhouses B, C and D showed the highest counts, with no

statistically significant ($p < 0.05$) difference between them (Table 2). Matsubara et al. [6] evaluated half-carcasses of porks in a slaughterhouse under federal inspection in São Paulo, Brazil, and found values of 1.93, 1.92 and 2.15 log CFU/cm$^2$ of total coliforms for leg, chest and chin, respectively, which were similar to those found in slaughterhouse A.

For the mesophilic aerobic bacteria count, statistical difference ($p<0.05$) was observed between treatments, with higher mean values being obtained for slaughterhouses E, 5.13 ±0.78 log CFU/cm$^2$), D (4.50 ± 0.80 log CFU/cm$^2$) and A (4.49 ± 0.80 log CFU/cm$^2$) (Table 2). The high counts found are directly related to unfavorable sanitary-hygienic conditions found in slaughterhouses, which may indicate high contamination levels. It was observed that stunning, bleeding and evisceration of animals, in most of slaughterhouses, were performed directly on the ground or concrete floor.

The *Staphylococcus aureus* counts were higher ($p> 0.05$) in samples from slaughterhouse C, and samples from slaughterhouses B and D and between A and E were similar (Table 2). These values are greater than 1.39 ± 1.03 log CFU/cm$^2$ found by Lima et al. [14] evaluating pork carcasses after evisceration and sawing.

Table 2. Count ($log_{10}$) of total and faecal coliforms, mesophilic aerobic bacteria, *Staphylococcus aureus* and percentage of positive samples for *Salmonella*, according to the samples obtained from five slaughterhouses of the state of Paraíba, Brazil

| Slaughter houses | Microorganisms | | | | |
|---|---|---|---|---|---|
| | Total coliforms[1] | Faecal coliforms[1] | Mesophilic aerobic bacteria[2] | *Staphylo-coccus aureus*[2] | *Salmonella* (n/p)[3] |
| A | $1.64^{c}$±0.7 | $1.44^{c}$±0.5 | $4.49^{ab}$±0.8 | $3.19^{c}$±0.7 | 05/01 |
| B | $3.02^{a}$±0.7 | $2.82^{a}$±0.8 | $4.01^{b}$±0.9 | $4.87^{b}$±0.8 | 05/00 |
| C | $3.39^{a}$±0.6 | $3.11^{a}$±0.9 | $3.96^{b}$±0.7 | $5.75^{a}$±0.6 | 05/01 |
| D | $3.02^{a}$±0.7 | $2.51^{ab}$±0.8 | $4.50^{a}$±0.8 | $4.84^{b}$±0.8 | 05/00 |
| E | $2.55^{b}$±0.6 | $2.09^{b}$±0.8 | $5.13^{a}$±0.8 | $3.61^{c}$±0.5 | 05/01 |

Means followed by same letters in each column do not differ statistically ($p < 0.05$) by Tukey test.
[1]MPN = Most Probable Number; [2]CFU = Colony-Forming Unit; [3]n/p = number/positive number.

*Salmonella* was present in 12% of the 25 samples (Table 2), in slaughterhouses A, C and E, *Salmonella* was found in one of the five carcasses analyzed. Carrasco et al. [15] detected the occurrence of *Salmonella* in 24% of pork carcasses in slaughterhouses from Santa Catarina, Brazil, and according to the authors, contamination in the waiting rooms was the most important source of infection.

The result of the most probable number for total coliforms showed no difference ($p <0.05$) between samples with the lowest values (1.88 ± 0.46 log CFU/cm$^2$) for the supply water of slaughterhouses (Table 3). Samulak et al. [16] found an increased contamination of bovine carcasses by *E. coli* after the use of non-potable water, and do not recommend its use for hygienic practices and standard operations in slaughterhouses.

Table 3. Count ($log_{10}$) of total and fecal coliforms, mesophilic aerobic bacteria, *Staphylococcus aureus* according to the sample types.

| Samples types | Microorganisms | | | |
|---|---|---|---|---|
| | Total coliforms[1] | Faecal coliform[1] | Mesophilic aerobic bacteria[2] | *Staphylo-coccus aureus*[2] |
| Water | $1.88^{c}$±0.4 | $1.76^{b}$±0.5 | UN[3] | UN[3] |
| Carcass | $2.83^{ab}$±1.0 | $2.46^{a}$±1.0 | $4.20^{b}$±1.0 | $4.40^{ab}$±1.2 |
| Knife | $3.17^{a}$±0.9 | $2.65^{a}$±1.1 | $4.96^{a}$±1.2 | $4.80^{a}$±1.5 |
| Hands | $2.68^{b}$±1.0 | $2.46^{a}$±1.1 | $4.15^{b}$±1.1 | $4.16^{b}$±1.3 |

Means followed by same letters in each column do not differ statistically ($p > 0.05$) by Tukey test.
[1] MPN/cm$^2$ = Most Probable Number/cm$^2$; [2]CFU/cm$^2$ = Colony-Forming Unit/cm$^2$; [3]UN = Unrealized.

In the faecal coliform counts, carcasses, knives and handlers' hands were more contaminated ($p<0.05$) than water (Table 3). All values found, except for the handlers' hands, were below those found by Samulak et al. [16] in evisceration table (4.80 log CFU/cm$^2$), handlers' hand (< 2.48 log CFU/cm$^2$), pork carcasses after washing (< 2.48 log CFU/cm$^2$) and supply water (3.00 log CFU/cm$^2$). However, contamination by faecal coliforms was higher than values reported by Matsubara [6], who found average values of 1.57, 1.51 and 1.79 log CFU/cm$^2$, respectively, for leg, chest and chin. In turn, the value of 1.76 ± 0.53 log CFU/cm$^2$ for water does not meet recommendations of Ordinance No. 518/04 of the Ministry of Health [11] and [17] which establish the absence of faecal coliforms.

The mesophilic aerobic bacteria counts for knives (4.96 log CFU/cm$^2$) was higher than those found for carcasses (4.20 log CFU/cm$^2$) and handlers (4.15 log CFU/cm$^2$) (Table 3). In pork carcasses, RDC 12/01 of ANVISA [10] does not establish standards for aerobic mesophilic bacteria counts, but the European legislation [18] establishes values of 4.0 log CFU/cm$^2$. Samulak et al. [16] found counts of 3.94, 3.15 and <2.0 log CFU/cm$^2$ in evisceration table, carcasses and handler's hands,

respectively, in slaughterhouse under State Inspection in the State of Paraná, Brazil.

With respect to *Staphylococcus aureus* counts differences were found ($p<0.05$) between sample types (Table 3). These values were higher than those found by Lima et al. [14] in pork carcasses after evisceration and sawing (1.39 ± 1.03 log CFU/cm$^2$) and by Samulak et al. [16] in evisceration table (3.48 log CFU/cm$^2$), carcasses (3.18 log CFU/cm$^2$) and handler's hands (<2.0 log CFU/cm$^2$).

## IV. CONCLUSION

According to current laws, the slaughterhouses surveyed showed poor physical structure and hygiene practices. The high levels of microbiological contamination of water, carcasses, knives and handlers' hands compromise the food safety of pork.

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