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Diagnosis of Microbiological Contamination Risks in Frankfurt Type Sausage, Virginia Ham and Dried Salted Pork

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Abstract : The objective of this study was to diagnose the risks of microbiological contamination in 3 meet products: Frankfurt type sausage, Virginia ham and dried salted pork, made in the meat processing plant at the University of Guadalajara. The influence from the physical infrastructure of the plant was evaluated such as the type and number of handlers, number of people present when the handling was carried out, as well as the time of manipulation and storage in refrigeration, the environmental conditions in processing areas and refrigeration and water from the municipal source (used to wash hands), equipment and utensils. Meat products with various preparation processes were chosen, individual microbiological tests for *Salmonella*, *Escherichia coli* and *Staphylococcus aureus* were made. The 90 point sanitary questionnaire was used to verify sanitation for physical risks in the processing plant. The results were analyzed using the EpiInfo® 2002 data base. There was a significant effect ($p<0.05$) between independent variables, number of people coming in per day, and time of refrigeration with *S. aureus* present in the sampled food. Using standard comparison we observed that 100% of the products had some kind of microorganism. The installations complied entirely with the 90 point questionnaire by 23.08%, partially by 42.31% and was incompliant by 34.62%.

Key words: Contamination, meat, pork products, *salmonella, escherichia coli, staphylococcus aureus*

INTRODUCTION

Foods in general provide essential nutrients that humans need, whether from animal or a vegetable source, they furnish proteins, carbohydrates, fats, vitamins and minerals. Those that meet said requirements in the best possible manner are considered good and nutritious, it is necessary to habitually ingest various types of food. However, we also need to consider factors such as contamination, the absence or presence of substances that can negatively affect the consumer (Jay, 1982; Dao and Yen, 2006).

Out of all foods, meat is one of the most perishable due to the fact that meat can develop various types of microorganisms. Meat processing provides us with diverse product formulas with a longer shelf life than unprocessed meat itself (Korkeala and Makela, 1989; Fernandez, 2000; Van Gerwen and Gorris, 2004).

Application of hygienic and healthy practices while processing food significantly reduces risk of intoxicating the consumer population, the same for product loss, protection against contamination, and contributing to a quality presentation (Fernandez, 2000). Quality control (including non-toxicity) of foods, as we generally understand it today, can be defined as stored foods that are sold to the public, the objective being to protect the population against health risks and consumer fraud (NOM-122-SSA1-1994; Cahill and Jouve, 2004).

Risks of contamination of products made in the meat processing plant at the South University Center, can be increased due to pathogenic environmental agents such as *Salmonella*, *Staphylococcus aureus* and *Escherichia coli*, which are commonly found in processing plants, personnel handling food or by cross contamination (Dao and Yen, 2006).

The objective of this study was to identify the risks of microbiological contamination caused by pathogenic environmental agents previously mentioned in Frankfurt

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type sausage, Virginia ham and dried salted pork at the meat processing plant at the University of Guadalajara according to the Official Mexican Standard NOM-122-SSA1-1994.

MATERIALS AND METHODS

This research was carried out at the meat processing plant (2005) and at the microbiology laboratory at the University of Guadalajara, South Univ. Center, located in Guzman, Zapotlan el Grande, Jalisco, Mexico.

Determining pathogenic agents in the Frankfurt type sausage, Virginia ham (smoked ham) and dried salted pork were carried out by closely following Official Mexican health standards.

- *Salmonella* sp. detection was carried out using NOM-114-SSA1-1994, Goods and services.
- *Staphylococcus aureus* detection was carried out using NOM-115-SSA1-1994, Goods and services.
- *Escherichia coli* detection was carried out using NOM-006-SSA1-2002, Goods and services.
- Fungal and yeast counts were taken using NOM-111-SSA1-1994, Goods and services.
- Total coliform organisms were detected using NOM-112-SSA1-1994, Goods and services.
- Aerobic mesophilic bacteria were detected using NOM-092-SSA1-1994, Goods and services.
- In order to establish the maximum limit of microorganisms permitted in products we used the Official Mexican Standard NOM-122-SSA1-1994 Goods and services. Meat products. Cured and cooked meat products, and cured- emulsified and cooked meat. Health specifications.
- The Official Mexican Standard NOM-093-SSA-1994 was used to verify warehouse handling and personnel hygiene, and in order to establish the maximum in live surfaces we used NOM-093-SSA-1994. Goods and services. Hygiene and health practice in food preparation that is offered in establishments.
- Another standard that was used a base for comparison is Good Hygiene Practices (GHPs) for personnel, equipment, utensils and the very infrastructure of the building was NOM-120-SSA-1994. Goods and services. Health and hygiene practice for food, non alcoholic and alcoholic beverage processing.

Dependent variables in this study were:

- *Salmonella* sp.
- *Escherichia coli.*
- *Staphylococcus aureus*
- Fungal and yeast count
- Aerobic mesophilic bacteria count

The independent variables were the handlers:

- Constant handlers (fulltime workers)
- Student handlers.
- Student brigade handlers.

In order to control the handler variable, the variants were studied. Time exposed to manipulation.

- Refrigeration temperature / time / number of hours in cold room
- Number of persons entering shop per day.
- Quality of water
- Quality of air in the processing area and cold chamber.

The samples were taken randomly from each product lot weekly, for a period of five weeks; the samples were sent to the before mentioned microbiological laboratory, so that required pathogenic (*Salmonella* sp., *S. aureus* and *E. coli*), aerobic mesophilic bacteria, fungal and yeast analysis could be completed.

For comparison we used the Official Mexican standard NOM-122-SSA1-1994. Goods and services. Meat products, cured and cooked meat products, and emulsified and cooked meats. Health specifications.

Random samples were taken from two workers hands in the following activity classifications: Fulltime workers, student handlers, student brigade handlers. Microbiological test are made to determine the Total Coliform Organisms (TCO) and Mesophilic Aerobic Bacteria (MAB) count. Testing was also done on air quality in the cold chamber, as well as in the processing area during activities; MAB was collected in the same manor in these areas. A water sample was taken at the same time from the Municipal water supply each week, TCO were identified, the Most Probable Number (MPN) technique was applied.

Results were captured in the EpiInfo (1996) data base and were analyzed with the same program. The quantitative variables were analyzed by measuring the central tendency and dispersion (average, medium tendency and mode, standard deviation and variance), in addition to absolute and relative frequency. In order to prove microbiological non-toxicity of the finished products, the Pearson linear regression correlation test was run with a statistically significant probability of 0.05.

RESULTS AND DISCUSSION

Bacteria count for handlers: Significantly different amounts of mesophilic aerobic bacteria among the three categories of handlers, brigade handlers and student handlers were found. Out of the three, the student handlers had the highest recorded ufc/surface number, they showed 8,600 ufc/surface, this being higher than the NOM-093-SSA1-1994 standard reference which establishes <3000 ufc/surface as the maximum limit, in the standards appendix B, health specifications, second subparagraph of the microbiological specifications regarding live and inert surfaces. A sample measuring 1,630 ufc/surface on the hands of a brigade handler was also observed; said numbers of colonies are permitted by the standard. The full time workers measured 30 ufc/surface in the highest example.

The total coliform organism samples taken from the workers hands indicate that 80% of the samples had a 0 ufc/surface, where handlers from the three categories participated; positive results were found on two occasions, where a student handler was found with a 40 ufc/surface on his hands in the first week, which is not permitted according to the NOM-093-SSA1-1994 reference; another handler was found positive with 4 ufc/surface, which is permitted and inside the limits of this standard reference.

Aerobic mesophilic pathogen count in the processing area: The environmental sample from the processing area was tested for MAB, the largest ufc/plate numbers were represented in the 1st, 4th and 5th week, (64, 46 and 99, respectively), which indicates that as the tests advanced in time, stronger air current continued to build with larger number of personnel in the building.

Sixty percent of the samples taken in the cold chamber showed a 0 ufc/plate reading in the first three weeks of samples, but not in the 4th, which registered a 2 ufc/plate reading, and the 5th week we observed a 7 ufc/plate reading, our observation showed that as time passed the ufc/plate readings increased, we also attributed a larger amount of raw product, entrails and unprocessed pork skin, and an even larger number of recordings in the cold chamber. One hundred percent of the samples taken from the Municipal water supply were within the maximum limits of the Official Mexican Standard NOM-127-SSA1-1994.

Pathogenic food count: One hundred percent of the 15 food samples taken tested negative for *Salmonella* sp. and *E. coli*, not so in the case of *S. aureus*. We found 9 out of 15 samples had *S. aureus*, which corresponds to 60%, 6 out of the 15 samples had zero presence of *S. aureus*, representing 40% of our findings. Also, 100% of the samples had traces of fungal and yeast, all of which were outside the norm, since the maximum limit of the standard is <10 ufc g^{-1} (Table 1).

Presence of *Staphylococcus aureus* according to maximum limits permitted in the Official Mexican Standard NOM-122-SSA1-1994 Goods and Services. Meat products. Cured and cooked meat products and cured-emulsified and cooked meat. Health specifications.

The following products were not within the standard: Frankfurt type sausage registered 22100 ufc g^{-1} in the 5th week; the Virginia ham was outside the norm only in the first week at 490 ufc g^{-1}; and dried salted pork was outside the norm in the fifth week of this study, with 600 ufc g^{-1}, this ufc g^{-1} number indicates that production of *Staphylococcus* toxins allows for possible intoxication or death to the consumer.

Salmonella sp. in meat and derivatives is unacceptable, according to what has been established in General Health Regulations Governing Health Related Activity, Establishments, Products and Services; based on HACCP information, *Salmonella* sp. presence, proliferation or survival in said products is defined as a danger that produces illness in the consumer (Secretariat of Public Health, 1993).

The results obtained from the MAB count found presence in 100% of the food samples analyzed. With the smallest amount of ufc g^{-1} in salted dried pork, followed by Frankfurt type sausage with larger numbers of ufc g^{-1} in Virginia ham, with a notable increase in the number of ufc g^{-1} as time advanced, which are attributed to stronger air currents in the processing area and a larger number of people present while handling the product. A sample of sausage was found outside the norm in the fifth week at a 376,000 ufc g^{-1}; Official Mexican Standard NOM-122-SSA1-1994 stipulates the norm at <100,000 ufc g^{-1}, a Virginia ham sample had a count of 4'140,000 ufc g^{-1} in the first week, where as the rest of the samples were found inside the norm of <100,000 ufc g^{-1} (Table 2).

The handler variable was tested using the Chi-square test, finding traces of *Staphylococcus aureus*, fungal and yeast in the food samples proving that the handlers were directly responsible for the presence of

Table 1: Pathogens presence in food

Pathogenic presence in food	Number of samples	Absence percentage	Presence percentage
Salmonella sp.	15	100%	-
Escherichia coli	15	100%	-
Staphylococcus aureus	15	40%	60%

Source: Laboratory recordings

Table 2: mesophilic aerobic bacteria count in food

Sample number	Meat product	ufc/25 gr sample	Percentage	Number of weeks
1	Sausage	470	6.7	1
1	Virginia ham	4'140000	6.7	1
1	Dried salted pork	130	6.7	1
1	Sausage	480	6.7	2
1	Virginia ham	200	6.7	2
1	Dried salted pork	90	6.7	2
1	Sausage	680	6.7	3
1	Virginia ham	380	6.7	3
1	Dried salted pork	270	6.7	3
1	Sausage	590	6.7	4
1	Virginia ham	15500	6.7	4
1	Dried salted pork	300	6.7	4
1	Sausage	376000	6.7	5
1	Virginia ham	16500	6.7	5
1	Dried salted pork	180	6.7	5
15			100.0%	

Staphylococcus aureus, fungal and yeast ($p<0.05$). Therefore, the same test was used on the handler variable in relation to the presence of MAB in food samples, and we found the handler to be directly responsible for the presence of MAB ($p<0.05$).

Numbers reported on MAB in the air in different areas of a meat processing plant, varied between 0.95 and 2.48 $\log^{10}$ ufc/0.028 $m^{.3}$ The environmental sample plays an important role in contamination of processed products, since they may not have adequate conditions suitable for packing aseptically.

The multiple linear regression results between the independent variables: handler, number of people, refrigeration time and handling time, and the dependent variable *Staphylococcus aureus* presence in food samples was $p = 0.944$, $p = 0.018$, $p = 0.006$ and $p = 0.713$, respectively, this indicates a significant effect between the independent variables (number of persons entering per day and refrigeration time), with the dependent variable regarding *Staphylococcus aureus* presence in food samples, with no effect between the independent variables (handler and handling time) on *S. aureus* presence in food samples. This corroborates the correlation between the variables, the result was $r = 0.67$, indicating an important correlation between the variables. The results of the multiple lineal regression between independent variables: handler, number of people, refrigeration and handling time, and the dependent MAB sample was the same at $p = 0.527$, $p = 0.557$, $p = 0.236$ and $p = 0.955$, respectively, which indicates that there was no effect between the independent variables on the dependent variable. This corroborates the correlation between variables with results at $r = 0.20$, indicating a weak relation between the variables.

In a study made by Mendez (2002), the microbiologic quality of Vienna sausage was determined before and after giving a handling course for processing plants, evaluating the product in and outside the plant (sales) in the city of Chihuahua, the microbiologic quality of Vienna sausage and cooked ham was also evaluated from 6 supermarkets, warehouses and points of sale in Juarez, Chihuahua, then the study was divided in two stages. The first stage had two evaluations, before (sample 1) and after giving a handling course (sample 2) on hygienic handling, based on Good Manufacturing Practices. In stage two, the authors evaluated cooked sausage handing in supermarkets, warehouses and points of sale. The microbiological results were verified according to the Official Mexican Standards 22-SSA1-1994 and 145-SSA1-1995. In the first stage, 100% of the samples inside the plant were inside regulation; while the samples obtained outside the plant, did not meet regulation standards by 25% for mesophilic microorganisms and 8.33% for coliform organisms, and 20.83% for *Staphylococcus aureus*. Second stage results were outside standard regulation, respectively for sausage and ham, supermarket (41.6 and 0%), warehouse (62.5 and 6.17%) and points of sale (61.91 and 57.14%) for mesophilic microorganisms. In supermarkets (4.17 and 0%), warehouse (8.33 and 0%) and points of sale (7.14 and 52.38%) for coliform organisms. In supermarkets (4.17 and 0%), warehouse (4.14 and 0%) and points of sale (7.14 and 71.43%) for *S. aureus*. The results reported in the second stage agree with the present investigation, given the fact that both studies report elevated levels of contamination from *S. aureus*. Which means that sanitary handling of the products during its commercialization does not exist; this irresponsibility is reflected during the sale, principally regarding cooked ham, since it involves more handling with the use of slicer's, which must be regulated under a health and hygiene program.

The National Public Health Institute reported that isolated *Salmonella* cases for food poisoning, 51% corresponds to prepared foods, 23% meat products (products derived from meat such as: ham, longaniza, chorizo. Headcheese, known as queso de puerco, etc.), 22% meat (ground beef, chicken, fish), 3% milk products 1% eggs (fresh and powdered). On the other hand, Carrera *et al*. (1998) in a study made in Cuba, reported a sample equivalent to 1,738 semi-finished meat products, 7.51% were outside the norm in reference to *Staphylococcus aureus* number and proportion; situated only under pastry products; however the same study a semi-finished meat product sample recorded 2, 615, 11.01% of the samples were contaminated with *Salmonella* spp. The before mentioned results differ from what was found in our investigation, given that we found 0% *Salmonella* spp. and *Staphylococcus aureus*, in 60% of samples evaluated. The variations in the results are

consequent of the process, since this investigation was carried out with Good Handling and Hygiene for *Salmonella* sp.; however, we did see deficiencies in *Staphylococcus aureus* control. In connection to the before mentioned, it is important to mention that the origin of products modify the measure of bacterial contamination, that is to say, bacterial quantity tends to vary from one processing plant to another or one company to another.

CONCLUSION

The levels of pathogenic contamination in meat products signal high risk for consumer health, caused by poor hygienic conditions and lack of sanitary control.

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