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Production of Hog Meat under the Concepts of Clean Technology

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Abstract: The hog meat is the most produced and consumed in the entire world. Parallel, due to hog feces and to the residues begotten by cold stores, pollution has been a major problem, faced by both developed and under development countries, especially, under intensive production. Governments, industries and researchers have gathered in order to minimize the problem of pollution generated from this activity. The southern region of Brazil is the main producer of hogs, in addition to such position we find the reality of the water's quality in the major producer cities. The high consume of water for each processed hog and the effect of the creation of these, with the generation of feces and the elimination of compounds with high ammonia concentration and the consequent result on the atmosphere and waters, does not suit with the current tendencies for environmental and social management. The result of such production may contribute to a loss of life quality. In a general way, big and small producers are searching for an effective strategy for the minimization of pollution, maintaining the market. The majority of strategies converge for the utilization of the potential from the pollutant itself, valuation of the hog, minimizing residues during the process, consequently reducing the environmental impact. The present study features production of hog's meat processing under the concepts of clean technology, doing a presentation of the involved steps, suggesting procedures for a minimization of residues, valuation of raw materials and generation of new products.

Key words: Hogs, residues, clean technology

Introduction

Meat is commonly defined as being constituted by animal tissues as a rule, the muscular tissue used as food. For broad concepts, it is usually adopted the term in the plural form meats taking into consideration also the innards. Not only are included in this definition the products in their natural form, but the same products at processed form. In general terms, meats can be subdivided into red meats and white meats (Pardi *et al*., 1994).

Formerly, the hog was raised with a goal of producing pig lard, besides the meat production itself, where the hog was evaluated by the amount of lard it produced. Even the bigger industries, that used to explore this kind of business, they gave up such practice (Girotto, 2002). The changes in the customers profile brought benefits to themselves, according to the supply of lean meat in consequence of the low fat percentage the animal presents. In the search of a higher content of lean meat, in the year of 1996 it was introduced in Brazil the ultra-light hog, result of ten years of study and selection genetic development, done by the Pig Improvement Company (PIC), in Germany. There, this whole process is conduced to provide a higher output of noble cuttings such as loin and leg (Pereira, 2000).

The growth in the sector of industrialized hog meat has surpassed other types of meat all over the world in the last twenty-five years, as much in developed countries as in countries under development. According to data from the ABCS (Brazilian Association of Swine Producers), Brazilian hog herd has reached about 38.3 million hogs in the year 2004, with a production of 24.7 thousand pigs and a medium consume of 12.6 kilos per inhabitant. In terms of exportation, the mark in the year 2005 was of 625 thousand tons, mainly to Russia and Hong Kong.

In the meantime, all producers know the problems caused by pollution, since the raising process where there is a high emission of odors, due to the accumulation of feces and urine, until the industrialization, where the is an enormous liberation of both liquid and solid residues.

Santa Catarina State has leaded a great part of the investments that Brazil has made searching for development in the field. However its agro-industrial position brought also negative effects on the environment. Although to present a diversified food sector, however among the industries that cause more worry under an environmental point of view are the hog industries (Amante, 1997).

The aggravation of the environmental issue in the greatest hog producer centers, like the West part of Santa Catarina, results from the great volume of effluents, which are generated by properties and by the lack of agricultural areas suitable to their utilization as fertilizers. Many producers, besides the fact of being considered small owners of lands, generate volumes of effluents above the support capacity of utilization in the property, which many times, without treatment, end up being thrown away at nature, begetting pollution and putting in risk the sustainability of the system (Perdomo *et al*., 1999).

In slaughterhouses and in meat product factories, the residues are frequently of high volume and these represent a serious problem, for their high content of organic matter they contain. The elevated Biochemical Oxygen Demand (BOD) from liquid residues produces unpleasant odors that spread themselves along the neighborhoods, having repercussions, even in the own scope of the industry (Pardi *et al*., 1994; Perdomo, 2003).

Besides, the not treated residues end up acting as proliferation centers of insects and of infectious agents. The reservoir of residues from meat processing establishments contains: blood, fats, excrements and substances of the stomachs of animals, residues that are prominent from the fabrication of fats and from the cleaning of floors, equipment and utensils and also, possibly the latrine sewer. Such residues, if thrown directly at water courses, cause critical problems of pollution, imposing severe damages to both flora and fauna.

Nowadays the most used forms of treatment in such cases are still the end-of-pipe technologies. The most common methods of treatment include steps such as: sieving, consolidation, chemical precipitation and biological processes (activated mud, stabilization lagoons, etc.).

Then, this study has as general goal, to structure a model of environmental management to the industries of this field, trying to collaborate for the minimization of the begotten residues during the whole production process, since the raising stage until the dispatch of industrialized meat, taking into account the concepts of clean technology. Under the point of view of clean technology, there must have a maximization of raw material utilization and a consequent reduction on the operations of residues' treatment.

Production

According to recent data from the FAO (Food and Agriculture Organization of the United Nations) and the ABIPEC (Brazilian Association of the Producing and Exporting Swine Industry), the major producer and consumer of hogs is China, producing in the year 2004 the amount of approximately 47,210 thousand tons, followed by European Union with and the United States with 21,614 and 9,312 thousand tons, respectively. Brazil occupies the forth position with 2,950 thousand tons. The global production was around 100,917 thousand animals. In terms of global export, United States and Canada have together reached 1,766.6 thousand tons. Among the importing countries, Japan is responsible for 1,195.6 thousand tons (FAO/ABIPECS).

Santa Catarina State is the major hog meat Brazilian producer. The majority of slaughterhouses and hog processing is located in the Western and Northern regions of this State (ICEPA, 1995). Brazilian hog meat is not yet the most popular of the country, but is successful in Russia and in Hong Kong. According to ABIPECS, in 2006 (January/May) these both countries were responsible for 70% of the acquisitions from exported Brazilian hog meat.

The considerable growth in the production, is associated to the problem of begotten residues, taking into consideration, mainly, the excrements generated on the raising stage and the high consume of water during the processing stage, which is close to 1,200 L per animal. Three hundred liters are used in the slaughter room, 400 L in other internal rooms and 500 L are destined to the external rooms (Braile amd Cavalcanti, 1979).

Processing

Here is described all the process for hog's meat production, from the breeding stage to the final industrialized products, schematized in Fig. 1, as reported by Fonseca (2000) in a case study.

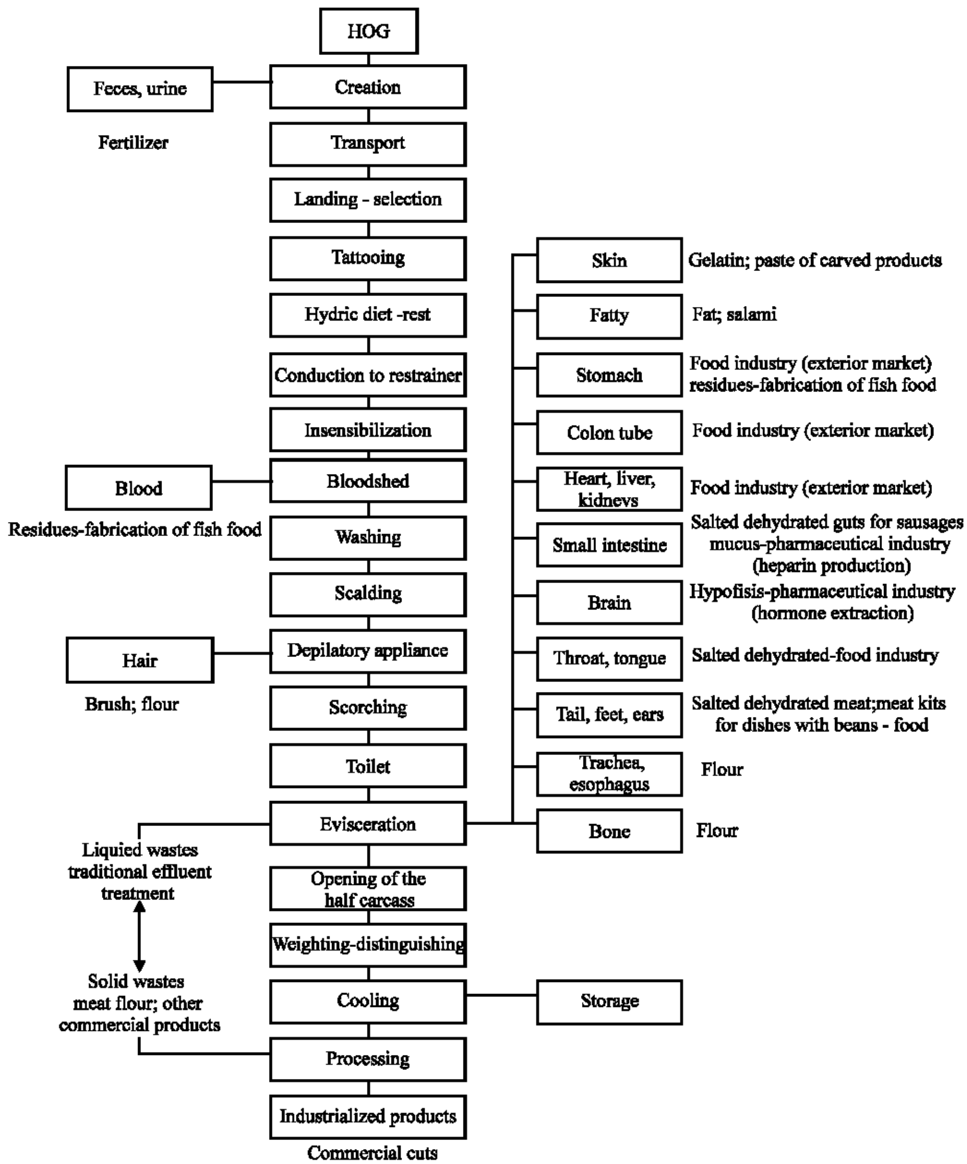

Fig. 1: Production of hog meat in Brazil

The hogs arrive at the fridge via road through trucks of one or two floors. When they get down from the vehicles, the hogs are meant for a pigsty of arrival and selection, where portions are formed and those animals that are sick or fractured are discarded. The healthy animals are weighted, marked with a number on the loin by a tattooist and meant for the killing pigsties. There, the animals go through a resting period, which is convenient. The given time for resting, fast and hydro-diet varies from 6 to 8 h. Such period can be diminished to 2 h, for the hogs that belonged to places close to industries.

After the resting time, the animal is directed to a restrainer, placed at the industrial block in the beginning of the corridor that connects to the pigsties block.

The insensitivity process is done through an electric appliance with two electrodes that are put behind the ears, hitting the brain. Afterwards, the animal is suspended by a hook locked in one of its back paws and transported to the bloodshed room. It begins in front of the room of the person in charge of the bloodshed process. There is a big drain inside the room, where blood runs through, going to a huge boiler and afterwards is put in casks.

The scalding is done right in the entrance of the bloodshed room. The bath occurs at the first part of the scalding tunnel, through showers and rubber beaters, with the intent of removing the excessive blood of the bloodshed and any dirt from the carcass. The intent of this bath is to loosen the bristles, which will facilitate their removal by the depilatory appliance.

The depilation is done with a machine that removes the bristles. Next step is the scorching, which is done manually through flamethrowers, linked to gas cylinders. The intent of such operation is the burning of the excessive bristles that were not removed by the depilatory appliance and by the manual cleaning, facilitating a final cleaning. In this final step, cut out with a knife are the remaining scorching bristles and other kinds of dirt.

The loosening and closing of the colon tube are done through a manual pneumatic pistol, which liberates the colon tube from the other tissues and automatically twists the colon tube in order to avoid contamination. After the closing of the colon tube, the following step is the removal of the penis of the male animals.

Right after the opening of the carcass on a special platform, both uterus and ovary are removed and put in a recipient meant for the clean zone of the gut room, where are cleaned, frozen and meant for export. In case of pregnant uterus, these have as destination the grease room. The opening of the double chin is done through a cut behind the ears until the joint, which will make the tongue stay adhered to the carcass only through the respiratory system organs.

Next step after the inspection of both double chin and head is the evisceration of the white innards, like stomach and intestine and from the red innards, like liver, heart and lungs. The pancreas is removed and put in a tray with ice and meant for the production of insulin. The sawing of the carcass is done with a saw, dividing the animal into half carcasses. The kidneys are not separated from the carcass until their inspection line, in which the capsule is incurred and the kidney is removed. The fat of the abdominal cavity is removed from the carcass after a kidneys' inspection.

After all those steps, the carcass passes through a last bath before being weighted and distinguished; the last bath is similar to the one that separates dirty zone from clean zone. Then, it is time for weighting and distinguishing the carcasses, such procedure occurs in a place away from the slaughter room. The shaping of the modern pig characterizes for well-developed muscular masses, long, large and deep body, with a tendency to proportionally advantage the back quarter in relation to the front quarter. In its distinguishing what interests are: the utilization of the meat, taking into account the relation meat - fat - bones; the percentage relation of each of the most valuable cuts considering the weight of the carcass; the thickness of the crackling, the length of carcass, leg and of the loin.

As the process of distinguishing is over, the carcasses get to the pre-shocking continuous tunnel, passing then to the chamber of temperature equalization, ending up in the cut room.

Dirty Zone

It is the area that receives the innards from the bloodshed room. At first, stomach, small intestine and colon tube are separated. The stomach is liberated from the small intestine, separated from the oments and emptied. Then it is sent to the clean zone of the gut room. The small intestine is separated from other innards and it is subjected to a mechanical process that promotes the moving away of the mucus and sub-mucus regions that are sold to laboratories for the fabrication of heparin. In the colon tube, there is a process of removal of fat excesses and intestinal content and then it is turned again and meant for the clean zone of the gut room.

Clean Zone

Stomach residues are meant for the fabrication of fish food. The stomach and the colon tube go through the same process of preparation and after the final cleaning, they are considered ready to be frozen and exported. In the clean zone, the small intestine goes to calibration, where the diameters of guts are determined. They are immediately put together into bundles and are salted. Then, they are dislocated to the fabrication of several types of pork sausages.

Small Innards Section

There is the reception of the following organs: heart, liver, kidneys, trachea, esophagus, diaphragm, throat and tongue. Heart, kidneys and the liver without the bile are cleaned and meant for freezing. The trachea is ripped apart from the esophagus and meant for the grease room. Throat is separated and salted, ending up stocked up in the salting chamber to dehydrate and conserve the meat. Esophagus is liberated from the trachea, the mucous region is removed and meant for the grease room. The muscular layer is used for the fabrication of carved products, right after a pre-cooking process. Tongue is cleaned, selected and meant for the salting process. The skin is classified in A and B types. The first is cooked for 45 min and bagged, so it can be meant for the fabrication of gelatin. B type passes through a pre-cooking process and is used on the paste of carved products.

Head Section

The head arrives at the bloodshed room via continuous elevator. There occurs the removal of the mask, which goes for the external small innards section. The jaw is separated inside a machine, with the goal of facilitating the removal of meat from the head.

Skull is removed to the extraction of brain and hypofisis. The brain is meant for industrialization and hypofisis is commercialized to laboratories and for hormone extraction.

External Small Innards Section (Tail, Feet, Ears)

From the mask coming from the head, is removed the medium ear, which is meant for the grease room. The mask with ears is meant for salting process. Feet are centrifuged for the removal of any dirt and so, are meant for the salting process.

Clean Technology

In the majority of hog meat processor companies, sub products and both solid and liquid residues end up in the grease room and in effluent treatment units. Countries under development are traditional clients of the end-of-pipe technologies from developed countries. Taking this reality into account, environmental problems and procedures to solve such, follow the same way. Clean technology concepts and procedures need to be transferred to under development countries (Amante, 1997).

Nevertheless, when clean technology is transferred from a place to another, there are some key points to be considered. First one is the efficiency of the transference itself, i.e. the adaptation of the social and economical conditions in order to implement it inside the country or the receiving organization. Next step is the efficiency of process, i.e., the extension of absorption (by the final receptor) of the main steps of knowledge - a characteristic of capacity of the technology transference process.

Under a global point of view, in both developed and under development countries, not taking into consideration their industrial sector, all industries are involved with the question of environmental protection. However, countries under development are great producers of food and of significant volumes of organic residues. In addition, production and demand of processed foods have increased largely in the last years, so industries have begotten a higher amount of solid and liquid residues. Under development countries have increased food production, while developed countries, in a general way, stabilize their production.

Having hog meat production as goal, each raiser must have a rational program of fecal material control, aiming for its adequate utilization to avoid damages caused by pollution. According to the environmental legislation, the producer may be criminally charged for eventual damages s/he caused to the environment and to the health of man and/or animals (Seganfredo, 2000, 2002; Perdomo, 2003).

Due to the high international value of this food, residues (since the raising until the processing of the meat) have been a major worry of governments, industries and researchers. Studies have demonstrated that these residues, according to their own characteristics, can have potential application (Cañizares *et al*., 1993).

The program must follow demands and specific characteristics of each raiser. Planning, production, collection, storage, treatment, distribution and the correct utilization of feces in their solid, liquid or paste form, must be taken into account. The perfect knowledge of each of these components is fundamental for the success and sustainability of the system (Perdomo, 1999), to avoid the common remedial strategies to remove pollutant from environment (Kao *et al*., 2003). Furthermore, the use of centralized units facilitates the management and valorization of the residues.

Hog cultivation produces a great amount of nitrogen rich feces and other nutrients that, if thrown directly at watercourses, provoke pollution of great magnitude. The use of liquid feces begotten on hog cultivation raising processes, as source of nitrogen for compost heap of agricultural residues, has been identified as promising alternative for the destination of these pollutant residues. The total nitrogen content of agricultural residues is low, being situated around 10 to 15 g kg^{-1}, while in hog feces these contents reach from 40 to 50 g kg^{-1} on dry material (Sediyama *et al*., 2000). According to Lindner (1999) the pollutant capacity of a hog is in average 3.5 times the value produced by a human. Manipulation of dietary protein and nonstarch polysaccharide is important to control swine manure emissions. While CO_2 and CH_4 emissions increase with lower dietary protein, manure from high-protein diets has higher sulfur concentration and pH (Clark *et al*., 2005).

The use of organic residues as fertilizer has increased along the years, becoming a matter of great contribution in the issue of environmental preservation. Hog feces as organic fertilizer is the fastest, efficient and economical way for the improvement of physical, chemical and biological soil conditions, improvement of agricultural production and environmental pollution control (Scherer and Baldissera, 1994; Perdomo *et al*., 1999). The use of hog dung was reported, i.e. as a source of nitrogen for cultures such as corn and beans (Scherer and Castilhos, 1994). However is important to establish a right dosage and correct period of application, because nutrients, as nitrogen, are not always in their assimilated form, and. the capacity of soil storage varies, as well as the extraction of nutrients by plants (Perdomo *et al*., 1999). The determination of density for the feces makes possible an estimation of its nutrients composition and the calculation of an adequate dose to be used in any cultivation (Miranda *et al*., 1999). This way their use should comply with the necessary cares with dosage and type of soil (Bhamidimarri, 1991; Kao, 1993; Ong *et al*., 1993) because the utilization of excrements in unbalanced form may present toxicity to soil (Gupta and Kelly, 1990).

Seed germination techniques are reasonable to evaluate the phytotoxicity of hog feces in different stages of compost heap (Tiquia and Tam, 1998). Furthermore, many solutions for the problem of organic charge found in the hog residues were reported. The use of phitasis in the animal food i.e. reduces in 30% the phosphate in the excrements and the combination of synthetic amino acids and feeding systems in multi-steps, reduces the elimination of nitrate in about 20% (Evans, 1995). The cultivation of cianobacteria *Spirulina* free and immobilized for the treatment of these residues allows to remove the excessive nutrients (phosphorus and ammonia) with the additional advantage on the generation of *Spirulina*, micro seaweeds of high commercial value as diet supplement or other technologic purposes and reduction of pollution (Cañizares *et al*., 1993). Another alternative reported for these hog creation residues was the use as substrate to the cultivation of yeasts, which allows obtaining a considerable BOD from the effluents (Hong *et al*., 1991).

Excrement utilization as a fertilizer must only be undertaken when material is stored for enough time to destroy or reduce to an impracticability state the potential pathogens in it by compost heap. This can mean storage of material for plenty of months before its spreading and the application of such only when there is no probability of rain (Hooda *et al*., 2000). The spreading of ground is recommended in order to limit moist content upon hog residues, supplying a less favorable environment to the multiplication of Salmonella (Carr *et al*., 1995). Moreover, the contamination via air of pigsties for slaughter units by bacteria and fungi is mainly due to irregular and infrequent cleaning, high elevated density of hogs, to the no separation of soil wastes and to the accumulation of water (Chang *et al*., 2001).

Water can be removed from slurry by evaporation, through the application of waste heat from a power plant or from other processes. Apart from obtaining a concentrate with an obviously higher nutrient concentration than the original slurry, another objective is to obtain clean water as condensate. Anaerobic digestion presents clear advantages: it provides a fraction of the required energy and it removes organic matter, preventing its volatilisation in the evaporation process and providing higher quality condensates. According to Bonmati *et al*., (2003) these advantages make this combined treatment strategy economically more feasible than the evaporation process alone. On the other hand, the use of solar and wind energies to concentrate hog feces was also suggested because air exhaustion's heat from pigsties is an effective and cheaper source of heat, allowing that more than 1,000 kg m^2 be evaporated annually, revealing a promising potential for combined natural drying to the use of recovered heat through stoves. However, Pieters and Rommans (2000) affirm that technical and economical optimizations are required to make from such technique a valuable alternative for the treatment of organic hog residues.

Integrated systems were also reported in the treatment/utilization of hog excrement. The use of the obtained residue after the extraction of sugar juice from the stem of sweet potato mixed with hog feces provides a fertilizer adequate to the use for soil corrections on agriculture (Negro *et al*., 1999). An integrated system for hog fecal treatment using anaerobic digestion, nitrification and denitrification allowed the removal of 90% of the BOD and the reduction of the nitrogen content (Font *et al*. 1997).

A treatment system of hog residues, investigating the control of odors potential, by using sub products and water reuse was proposed, where solid residues were treated and stabilized through anaerobic process, while the liquid portion was anaerobically digested by aeration and sedimentation. The treated effluent was used for irrigation of pastures without any odor problem, with the additional possibility of reusing biogas as energy and mud, as fertilizer (Yang and Gan, 1998).

Tiquia and Tam (2000) studied fertilization from hog feces (a mixture of hog manure partially decomposed and sawdust with pig mud established in the bottom of the sedimentation of primary treatment tank) onwards, evaluating it as a way to reduce the waste volume and to produce a stable correction of organic soil. Sawdust was related as ideal for the preparation of compost heap, due to its capacity of absorbing humidity (Bhamidimarri and Pandey, 1996).

Yang and Wang (1999) investigated the impact of integrating an intermittent unit of aeration for the treatment of a combination of liquid excrement raw and concentrated, anaerobically treated obtaining a high effectiveness in the treatment of BOD and total-nitrogen (TN). The economical evaluation of the hog residual treatment system confirmed that the utilization of biogas and digested mud is essential for the benefit or profit of operating this treatment system. Integrating the intermittent unit of aeration in the hog residual treatment system supplied cost reduction of energy consume and the reutilization of the treated liquid residue without causing deterioration of environmental quality, including on processed plants from limited areas.

Sediyama *et al.* (2000) evaluated the concentration of nutrients from seven different compounds produced with sugar cane pulp, napier grass, coffee straw and hog feces in liquid form. Each compound was produced with one or more vegetable residues associated to hog feces, which had as goals: the incorporation of decomposing microorganisms and the moistening of the stacks material. The utilization of hog feces in the compost heap of organic residues resulted into fertilizer production of high fertilizing value.

The exceeding dejections that had not been used as organic fertilizer are generally treated in stabilization lagoons with the aim of degrade the residual organic material (Oliveira *et al*., 2003). In anaerobic lagoon sludge from swine production, sterols are an organic fraction of sludge that are resistant to bacterial degradation. In the case of fresh manure, fatty acids could represent a potential source of energy via the manufacture of biodiesel fuel, if efficient means for their extraction and transesterification can be devised (Loughrin and Szogi, 2006).

In resume, the adoption of a system that adequates and maximizes the use as fertilizer to the reality of each property and the treatment of the effluent excess according the Environmental Legislation is one of the most logical paths for the resolution of problems. However, the necessary investments for its feasibility, as simple as they may seem, are not always compatible with the financial capacity of ordinary raisers (Perdomo, 1999).

From the meat processing, blood can be used for human consuming, since it is under veterinary inspection on the originating animal's sanity (Cross and Overby, 1988). These exceeding parts of the slaughter have had practical use on studies of organ replacement. Furthermore, the liberated iodine from the treatment of hog meat industry effluents by flocking-flotation and/or activated mud has been studied as a potential constituent for animal food (Franzen *et al*., 1995).

Among other application for hogs residues, Kent *et al*. (2000) studied reforestation of tropical forest plots with liquid residues of hog creations, being filled with vegetation in less than half of the usual time.

Conclusions

The use of clean technologies does not make impracticable the hog raising activity (Seganfredo, 2002). As presented here, it is perceivable that the clean technology utilization is being of great value at food industries and hog farms, where the begotten residues are highly pollutant. This way, there is an increasing need of services that fit to their reality, so that they can minimize and make a better use of their own generated residues. For the producer, the difficulty presents is the initial investment for the installation of the system, what unfortunately few producers could carry out. This, however, it could be solved with the government participations, considering the interests of the State in economic, social and environmental aspects. Considering that the hog raising is a business with diverse benefited segments that have in common the dependence of the environment quality, the division of the costs for the dejections treatment will adjust the interests of producers, agro-industries, suppliers, consumers and government, while manager of the interests of the citizens, in which is included the environment preservation. This review, under the concept of clean technologies, tried to offer some options so that these technologies may contribute with the improvement of the current environmental global situation.

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