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Sustainable company producing pigs, sheep and lemons

Empresa sustentable de producción de cerdos, ovinos y limones

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ABSTRACT

The pig industry, bound by sanitary requirements, has been in need of finding a way out of solid waste, produced in its normal operation, the so-called pig dung or pig slurry, an available food resource. Several technologies have been developed over the years to solve this problem by physical, chemical and biological means; as solids separation, drying, fermentation, silage, etc. The process of fermentation in barrels may be feasible to use. On the floor the pig slurry was deposited, adding water to reach 60% humidity and 10% sorghum to accelerate the fermentation process, then this product is deposited in 200 liter plastic drums, which were covered with nylon and this fixed around the barrel with a rubber or plastic spring to avoid oxygenation. In the minimum fermentation process it is 25 days, during which the pig slurry loses the smell of pig. In a stirrer, the pig dung is added together with the stubble and other ingredients, obtaining the balanced food. Water is treated in optional lagoons. The company is considered sustainable by recycling water, using sheep droppings as fertilizer and/or building bricks, and using fermented slurry as sheep feed. The pig slurry is an economic, palatable and nutritional food for sheep, which makes it an excellent quality food.

Keywords: recycled, food, water, fertilizer.

RESUMEN

La industria porcina, obligada por los requisitos sanitarios, se ha visto en la necesidad de buscar una salida a los desechos sólidos, producidos en su operación normal, la denominada cerdaza, un recurso alimenticio disponible. A través de los años se han desarrollado diversas tecnologías tendientes a solucionar este problema por medios físicos, químicos y biológicos; como separación de sólidos, secado, fermentación, ensilado, etc. El proceso de fermentado en tambos puede ser factible su uso. En el piso se depositó la cerdaza, agregándole agua hasta alcanzar un 60% de humedad y un 10% de sorgo para acelerar al proceso de fermentación, después es depositado este producto en tambos de plásticos de 200 litros, los cuales fueron tapados con nylon y éste fijado alrededor del tambo con un hule o resorte de plástico para evitar la oxigenación. En el proceso de fermentación mínimo es de 25 días, durante el cual la cerdaza pierde el olor a cerdo. En una revolvedora se agrega la cerdaza junto con el rastrojo y otros ingredientes, obteniendo el alimento balanceado. El agua se trata en lagunas facultativas. La empresa se considera sustentable al reciclar el agua, usar el excremento de ovinos como abono y/o en la construcción de ladrillos, y usar la cerdaza fermentada como alimento para ovinos. La cerdaza es un alimento económico, palatable y nutricional para los ovinos, lo cual hace que sea un alimento de excelente calidad.

Palabras clave: reciclado, alimento, agua y abono.

INTRODUCTION

The pig industry as well as the poultry industry, forced by sanitary requirements, has found it necessary to look for an outlet for solid waste, produced in its normal operation, the so-called pig slurry and poultry manure; available food resources. All these factors have been combined for the appearance of fattening projects in stabling, initially as a way of disposing of waste from the farm, and later as a productive activity with its own identity (Sosa, 2006).

At a global level, the generation of large quantities of excreta is a problem due to its high potential of nutrients that contaminate the environment, and can be an obstacle in the future development of the animal industry; however, manure can be used as food. Ruminants have been identified as ideal animals for recycling manure. In Mexico, poultry manure is marketed at the foot of the farm, or in large warehouses where buyers go to transport it to consumption centers. It is estimated that 200 to 300 g of dry matter per kg of feed, or 700 to 800 g of dry matter per chicken produced, or 550 g of dry matter per kg of chicken, and finally 9.6 ton of dry matter per 1000 kg of meat. This last data would represent an estimated 1.2 million tons produced annually by 1,461 million chickens (Munguía-Xóchihua *et al*., 2019).

The inclusion of pig excrement in the sheep diet helps solve the problem of environmental pollution and reduces sheep production costs, due to the substitution of high-cost traditional ingredients for non-conventional ingredients such as excrement (Castrillón *et al*., 2002).

The advantage of pig excrement is its availability throughout the year. Recently Canton *et al* (2005) concluded in a digestion and metabolism test that fresh pig excreta is a valuable source of nitrogen for sheep. In this sense, pig excreta are an appropriate and safe ingredient in diets for fattening sheep; this is shown in the study by Padilla *et al* (2000), who fed high levels of pig excreta to finished sheep; weight gain or carcass characteristics were not affected, and levels of copper in the liver were normal.

It is also important to note that by comparing the toxicity of manure from different animals and using a microtoxic test, it was shown that pig manure was three times less toxic than poultry manure (Gupta and Kely, 1990).

The main problem caused by excreta is chemical contamination, due to the excretion of large amounts of nitrogen (in the form of nitrates), phosphorus and potassium (Mariscal, 2007). It is estimated that under commercial production conditions, the phosphorus consumed is excreted in varying proportions, since a sow excretes about 75%; weaned piglets 38% and supply pigs 63%. The phosphorus excretion pathway is mainly fecal. Regarding nitrogen, the proportion excreted for the same categories of animals was 76, 46 and 67% respectively, and this is excreted mainly via the urinary tract.

The pollution generated by a pig farm affects the microenvironment (the farm itself) and the environment in general. With regard to the microenvironment, it has been seen that exposure to the gases produced (ammonia, hydrogen sulphide, methane and carbon dioxide), represent direct risks to the health of workers and exploitation pigs. This is because ammonia is irritating, so it tends to cause discomfort in pigs; confirming a decrease (from 12 to 30%) in the daily weight gain of pigs housed, in places with increasing concentrations of ammonia (50, 100 and 150 ppm). Ammonia comes from excreted nitrogen, mainly in the urine (85%) and in the feces (15%); its volatilization rate depends on the relationship between the ammonium and ammonia ions, which depends on the pH of the excreta (Mariscal, 2007).

On a global level, a fundamental problem of pig farms is the generation of large quantities of excreta; which, due to their high nutrient potential, pollutes the environment and can be the main obstacle in the future development of the animal industry (Mackie *et al*., 1998). Approximate calculations indicate that in Mexico, more than 1,860 tons of pig manure per day are originated (considering number of heads and age of the animal) (Cervantes et al., 2007).

Manure can be used as food. Ruminants have been designated as the ideal animals to recycle pig manure, due to their ability to use non-protein nitrogen, digest cellulose and use high levels of nucleic acids (Smith, 1976; Smith and Wheeler, 1979; Arndt *et al*., 1979). The pig slurry is the food not digested by the digestive system of the pig and enriched with the intestinal flora, which makes it an excellent quality food to be used in the preparation of diets for sheep.

Also remember that in Mexico there is a deficit of almost 40,000 tons each year of sheep meat. These missing tons are imported from New Zealand, Chile and Australia (Martínez *et al*., 2011); therefore, the production of this species is important.

Chemical composition of the pig slurry

The pig slurry is the food not digested by the digestive system of the pig and enriched with the intestinal flora, which makes it an excellent quality food to be used in the preparation of diets for sheep.

In Table 1, a comparison of protein and fat is made between pig slurry, corn and sorghum. In table 2, the nutrient content of the pig excreta (% dry basis) is observed. The pig slurry has more than 20% crude protein and a digestibility greater than 40%.

Table 1. Comparison of the crude protein and crude fat content of the pig slurry, corn and sorghum (% on dry basis)

	Pig slurry	Corn	Sorghum
Crude protein	21.2	8	9
Crude fat	6.3	4	2

Table 2. Nutrient content of pig excreta (% on a dry basis)

Total digestible nutrients	48
Crude protein	24
Crude fibre	15
Calcium	2.7
Phosphorus	2.1
Potassium	1.3

Copper in sheep

Foods and salts prepared for poultry and pigs may have excess copper, which eliminates the animals in the feces in amounts up to 700 ppm. The sheep are very sensitive to excess copper in the diet, they begin to be poisoned from 20 ppm; recommending to include in your diet a maximum of 25% of excreta; however, in this livestock company, contrary to the scientific prevention indicated, for three years they have fed their sheep with a diet that includes 60% and silage pig slurry respectively, with satisfactory productive results. Copper destroys the red blood cells, and the urine of the animals is very dark and foamy brown. Most animals die a couple of days after the intoxication has occurred (Tórtora, 2002). Sheep are more sensitive to high levels of Cu in the diet, than any other species of zootechnical interest (Fontenot *et al*., 1971; NRC, 1980); although other authors have only found problems in young sheep (Deshck *et al*., 1998).

In the case of goats, the literature usually indicates more frequently cases of Cu deficiency, and may be evidence that this species tolerates better high levels of Cu than sheep and cattle (Meschy, 2000). In ruminants, copper is stored primarily in the liver and also in the kidneys, heart, lungs, pancreas and spleen. Body reserves serve for about five months, providing the necessary Cu when a deficiency occurs (Mufarrege, 2003).

Copper can cause toxic effects on the wool, when more than 25 ppm of the element is ingested. Once ingested in the ration, assimilable Cu can be reduced by excesses of molybdenum, sulfur and iron; and also by some other antagonists such as cadmium, zinc and silver (Mufarrege, 2003). Copper poisoning has been widely documented in the ovine species, being a common chapter in any treaty of sheep disease (Jensen and Swift, 1982; Henderson, 1990; Sharman and Angus, 1991); highlighting in all of them the high susceptibility of this species.

The sustainable project

The management of excreta is the main problem of the pig, since at present and due to the sanitary legislation, the producer cannot get rid of the excreta as they did it traditionally; throwing them at the ravines, streams and other bodies of water; therefore, the producer is obliged to get rid of excreta in an ecological way, which does not pollute the environment.

Several technologies have been developed over the years to solve this problem, by physical, chemical and biological means; as separation of solids, drying, fermentation, silage, etc., some with advantages and disadvantages over others. Since drying it in the

sun pollutes the environment and a large cement board is required. The pressing method requires equipment, which is often expensive. The process of fermentation in barrels may be feasible to use.

The fermented pig dung use project, arises from the need that all pig farmers have to treat wastewater according to the norm established by the National Water Commission. Before this project, the pens were washed with water, and the amount of 40,000 liters/day was discharged into the Ixtlán River.

The objective of the sustainable project was to stop contaminating the environment with water and pig manure, reduce water consumption to 70%, reuse water, treating it and using it to irrigate a lemon orchard, and finally use the pig slurry as fodder for sheep consumption.

MATERIAL AND METHODS

Location

The company producing pigs and sheep La Sidra, is located at km 3 of the free highway Ixtlán de Río-Guadalajara; in Ixtlán del Río, Nayarit, Mexico; between the parallels 20° 50' and 21° 13' of Latitude North and the meridians 104° 12'and 104° 28' of West Longitude; with an altitude between 400 and 2,300 meters above sea level; the temperature is 18-26 °C; precipitation 800-1 000 mm. The predominant climate is warm subhumid with rains in summer, of lower humidity (68.73%) warm; subhumid with rains in summer, of lower humidity (25.28%); temperate subhumid with rains in summer, of higher humidity (5.46%), and temperate subhumid with rains in summer, of medium humidity (0.53%). The company is circulated with brick wall and galvanized mesh, drowned in cement; It has several warehouses: maternity pigs, gestation pigs, weaning and fattening pigs, gestation and maternity sheep, weaning and fattening of sheep, food cellar, food preparation area, fermentation area, office, pharmacy, orchard of lemons , sewage treatment plant and parking.

Animals and excreta

The company has permanent 110 bellies of pigs of Landrace race, Yorkshire, Pietrain and their crosses; and 400 bellies of Dorper, Pelibuey, Katahdin one and their crosses; in addition, the offspring of the two species are completed on the same farm, see figure 3. Apply a breeding program for the two species continuously; it also has the recommended preventive program for each species. On the other hand, it applies the biosafety standards, recommended by SAGARPA.

The project of the company

The project begins with its own resources and an animal health support from SAGARPA, through the State Livestock Development and Protection Committee. The support was 50% for the wastewater treatment plant; it is started by a family group, consisting of 3 women and 1 man.

Water use

In the pens with cement floor, firstly, the pig dung with shovel and wheelbarrow was collected, and it was taken to the silage area; the pens were then washed with recycled water, which came from optional lagoons, see figure 1.

Figure 1. Facultative lagoons

Process and use of pig slurry production

To the pig slurry already in the floor, water was added until reaching 60% of humidity and 10% of sorghum to accelerate the fermentation process. This product is then deposited in 200 liter plastic barrels, which were covered with nylon and this one fixed around the barrel with a rubber or plastic spring to avoid oxygenation. In the minimum fermentation process it is 25 days, during which the pig dung loses the smell of pig and lowers the amount of CFU of bacteria. In a stirrer add the pig slurry, ground stubble without corn and other ingredients; getting balanced food. The pig slurry was included in maintenance, pregnancy, 60% lactation (with 9.52% crude protein, see proximal analysis in table 3), development and fattening of 20% sheep; obtaining an excellent productive behavior in each of the stages, see figure 2.

Table 3. Proximal analysis of the diet for pregnant sheep (% dry basis)

Humidity	8.19
Crude protein	9.52
Fats	3.68
Crude fiber	20.42
Ashes	15.73

Source: Analysis in Nuevlab S.A. of C.V. Guadalajara Jalisco, Mexico. 24/04/2019.

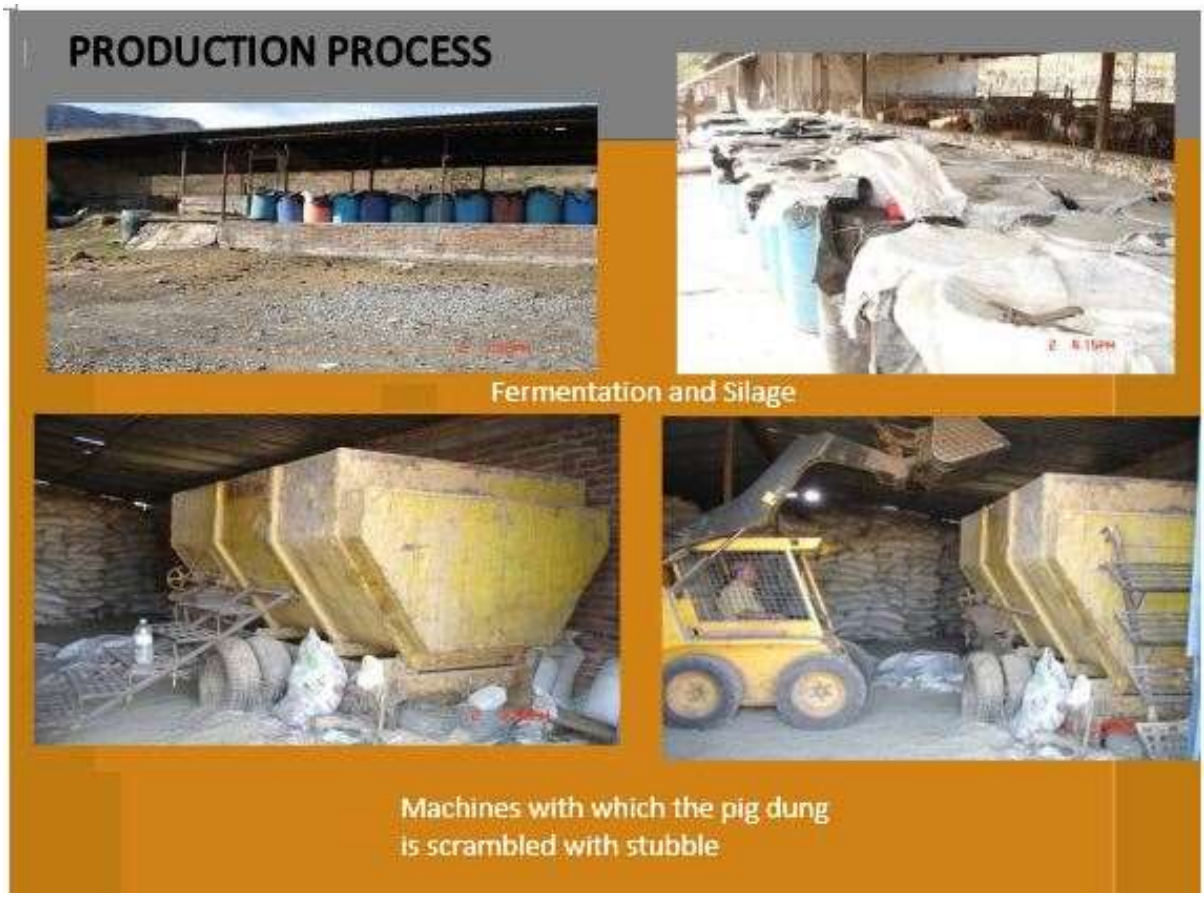

Figure 2. Silage and/or fermentation of the pig slurry, in addition to the inclusion in the stirrer

RESULTS AND DISCUSSION

The farm with 110 pig bellies and 400 sheep bellies, plus their growing and fattening offspring, produce a ton of pig slurry and another one of sheep slurry. With the implementation of the use of the pig slurry as feed for sheep, the change in the management of excrement, recycling and good water management, in the pig farm only 12,000 L are used, of which 4000 are residual and were treated to be used as irrigation of a lemon orchard. With this project, a second approved project was achieved to build and equip a plant for the production of balanced food, to improve milling, mixing and make the most efficient food, see figure 1.

There are studies where they report the expense of water, for example, Chao *et al*., (2012) reported, a cleaning water expense per animal and per day of 26 L; which is directly influenced by the system used for this work that consists of pressurized water, but it is also customary to bathe the animals daily, all this makes this expense excessive. While Taiganides *et al*. (1996) reports 9.2 L, but much less than that reported by Sánchez *et al*. (1995), 50 L and Juantorena *et al*. (2000), which was 60 to 80 L per day for pigs fattening

100 kilograms in weight, and similar to that reported by Venotti *et al*. (2002), which was 25 L.

It is recommended to try to use the least amount of water in the cleaning of the corrals, not to bathe the animals daily and only when it is necessary and in the places that can be applied to drag the excrements with lazy, and later to use the water under pressure, only the necessary one, Chao *et al*., (2012).

Table 4 shows the proximal chemical analysis of the fermented pig slurry on a dry basis. The pig slurry-fed sheep were kept in excellent body condition, with a prolificacy of 1.5 lambs/womb/year and an average live weight of 3.5 kg/lamb.

Impacts (social, economic and environmental)

Social

There are 10 permanent jobs.

Indirectly, farmers in the region benefit, buying their stubble and sorghum, which receive a better price and security in the sale of their product.

Economic

The waste is used within the farm to provide a considerable economic income. The grain is replaced with the pig slurry, saving 146 tons per year, with a saving of $ 438,000.00.

With the sheep manure it has an income of $ 48,000.00 annually.

With the sale of the lemon it has an income of $ 25,000.00 annually.

With water savings, the consumption of electric energy is reduced by 70%, which represents $ 12,000.00 per year.

Environmental

Water consumption was reduced from 40,000 liters to 12,000 liters per day.

100% of wastewater discharges to the river was reduced.

Table 4. Proximal chemical analysis of fermented pig slurry dry base,%.

Crude protein	21.2
Dry matter	38.5
Crude fat	6.3
Crude fiber	18.1
Total ashes	13.6
E.L.N.	40.8
E. M. Mcal/kg	2.28

Sustainability

The pig slurry is used as food for sheep, and the sheep slurry is used in the brickyards as a binder to improve the quality of the brick and as an organic fertilizer. Water is treated in facultative lagoons, where enzymes are added to help the cleaning process. The treated water comes out with the quality for irrigation use of the lemon orchard. Therefore, everything is reused and making the process 100% sustainable, see figure 3.

CONCLUSION

The company is considered sustainable by recycling water, using fermented pig slurry as sheep feed and using sheep droppings as fertilizer and/or brick building. The pig slurry is an economic, palatable and nutritional food for sheep, which makes it an excellent quality food.

Figure 3. Pigs, lemons, bricks and sheep eating food.

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