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SWINE PRODUCTION AND MANURE MANAGEMENT IN BRAZIL

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Strategies for Swine Manure Management in Brazil

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Brazil is the fourth larger swine producer and exporter of the world. This position was reached through significant changes in the production systems over the last 30 years. Thus, small subsistence models were replaced by larger confined animal feeding operations (10). Nonetheless, confined swine production offers major public concerns in Brazil as result of the higher amounts of waste generated in these operations. Swine manure has the potential to impact soil, air, and water resources requiring proper management, treatment and disposal. Several technologies are currently available for manure management in swine farms. However, the selection of a feasible technology should take into account not only technical and economic challenges but also particular farm characteristics. These include the number of housed animals, the available agricultural land for manure application, and the opportunities for energy and organic fertilizer production for trading or *in loco* consumption.



Although still mainly concentrated in Southern Brazil, over the last decade there is an increasing trend of expansion to Central-West region of the country (6). This will likely affect farm scales and their characteristics. For instance, a typical swine finishing operation in Southern Brazil holds 750 housed animals in less than 20 ha of the available agricultural land for manure disposal. Moreover, such farms have low manure biomass production required for effective electricity-derived biogas generation and therefore the opportunities for energy trading are scarce or not conceivable.

On the other hand, swine finishing farms located at Central-West Brazil has typically 4,500 housed animals with plenty of nearby cropland area that can be used for manure application. These

farms often have significant energy production capabilities and offer opportunities for energy trading. Needless to say, the technologies for swine manure treatment and disposal should be designed appropriately to satisfy the needs of these two different farming scenarios.

Liquid manure storage and land application is the main manure management practice in Brazil and other parts of the world due to its simplicity, low cost, and the reduction in crop production costs through the replacement of mineral fertilizers (8). The main disadvantage of such approach resides on the fact that manure transportation is not always economically sound for distances beyond a few kilometers (13). Thus, nearby agricultural land availability is limiting for the farming and productivity scale up.



With the constant economic pressure for increasing the number of housed animals, the farmer should consider alternatives manure treatment technologies to make it environmentally sustainable.

Swine manure treatment strategies are based on physical, chemical, and/or biologic processes that are able to reduce manure's pollution potential and convert them into valuable byproducts such as biomethane (i.e., heat and electricity), organic fertilizers and carbon credits (Certified Emissions Reductions – CERs) (2, 9 and 14). The economic benefits generated can then be used either locally (reducing operational costs) or sold (increasing farm revenue).

The most disseminated manure treatment technology in Brazil consists of biodigestors. The



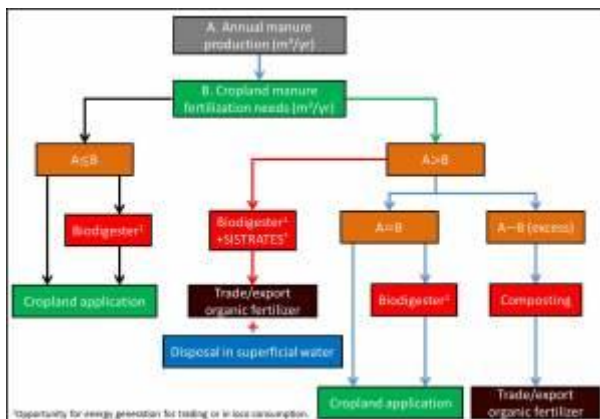
biogas produced can be used to produce energy in form of heat or electricity for *in loco* consumption or commercialization (1, 11 and 3). Swine producers can obtain additional benefits from biodigestors outcomes as soil fertilizers and diminishing atmospheric methane emissions (and carbon credits) which can be managed through certified broker companies and financial institutions. However, there are limitations in the biodigestors systems. Biodigestors offers only partial solution to manure disposal problem because N and P is not

removed from the treated effluent and cropland area is still necessary to spread these nutrients. Considering that land is not limiting to Central-West Brazil, biodigestors technology is widely adopted offering alternative economic opportunities for local agribusiness. Physical-chemical and biological strategies to remove nutrients after anaerobic digestion can be had through the use of technologies such as [SISTRATES®](#). Removing these nutrients from the effluent implies in less cropland area required for disposal. This is particularly important for those farms with area limitations.



Composting is also an alternative that has been promoted in Brazil to manage swine manure (12). During the process water loss through evaporation allows for the formation of solid material (5, 15 and 7). Likewise biodigestion, composting does not reduce the cropland area needed for manure application, nonetheless, it reduces overall volume while increasing nutrients concentration. It makes the handling of manure much easier thus reducing transportation costs and granting it's trading and exportation to distant regions with higher fertilizer demand. Composting can also potentially increase farm income through the marketing of organic-rich compound with high agronomic value.

Overall, every technology has its own potentials and limitations that must be addressed accordingly to farm characteristics and opportunities for energy or fertilizer production and trading. With this in mind, a simplified model can be used as a tool for decision making.



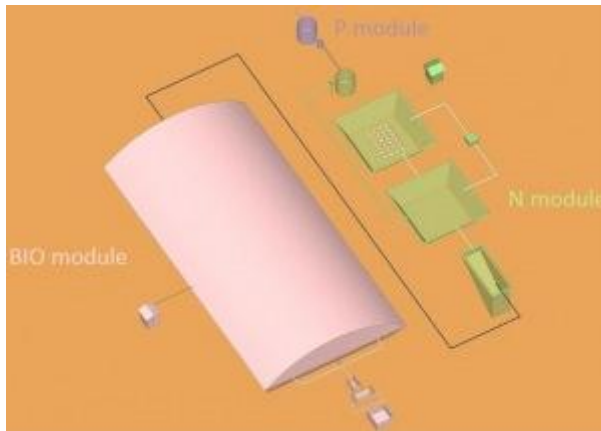
The user of this guidance should start with the evaluation of the volume of manure produced every year (A) in the swine barns, the available cropland area, and their annual fertilization needs in terms of manure volume (B). If the required cropland fertilization needs is equal or higher than the annual manure production in the farm ($A \leq B$) then manure treatment is not mandatory. In this case, cropland area is not

limiting and could be effectively used to recycle manure nutrients for crop production without significant environmental impacts.

Alternatively, the use of a biodigestors could be an interesting investment when there are opportunities for energy generation for trading or *in loco* consumption.

Most of the swine farms located in Southern Brazil have a manure production rate much higher than the soil's capacity of nutrient recycling in the available cropland area ($A > B$), thus requiring the use of alternatives remediation strategies mentioned above. For small to medium scale farms it could be interesting consider a combination of cropland application (using either neat or digested manure) assuming soil and crops ($A = B$) fertilization requirements and the use of composting for the treatment of the exceeding manure volume ($A - B$). Composting produces valuable fertilizer with interesting marketing opportunities particularly in places with intense fertilization demands.

For larger swine production scales where cropland is limiting, a combination of biodigestors and nutrients removal technology (SISTRATES[®]) should be considered. Solid-liquid separation prior



biodigestors produces low moisture manure enhancing drying processes and increasing its value as a high-quality organic fertilizer. The generated biomethane could be used for energy generation for trading or *in loco* consumption, minimizing farms demands for heat or electricity. SISTRATES[®] removes N and P from effluent and produces during the process gaseous inert N_2 and a powder $CaPO_4$ which has high agronomical value as a fertilizer, therefore retaining commercial potential. SISTRATES[®] treated effluents meets

Brazilian environmental legislations for water quality (4) and can be disposed directly in water reservoirs or streams.

Overall, the processes and technologies briefly discussed here serve to demonstrate the main swine manure management strategies recommended by Embrapa Swine and Poultry in Brazil. It should be emphasized, however, that the success of these technologies depends critically on its design and implementation focusing on farm's particular characteristics and needs. The proper manure management should ensure profitability and environmental sustainability for the swine producer and ultimately to the Brazilian society.



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The New Face of Brazilian Pig Production

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Although China still occupies a prime position in global pig production, with a production of 47 million tons, pig farming in Brazil has shown significant growth since 2004, with an increase in production of 14.6% between then and 2007. This increase in production was the highest among the pork-producing countries as can be seen in Table 1. Even so, the country's participation in world production is modest, with 3.005 million tons, occupying fourth position in the world ranking.

Table 1: World production of pork from 2004 to 2007 (thousand tons)

Country	2004	2005	2006	2007	2007/2004 (%)	2007/2004 (%)
China	47,816	50,186	51,872	47,800	-0.03%	-8.57%
European Union	21,753	21,626	21,877	22,943	1.22%	1.67%
USA	9,312	9,392	9,318	8,877	-8.07%	-1.23%
Brazil	2,620	2,708	2,943	3,005	14.69%	3.17%
Russia	1,735	1,735	1,806	1,980	8.99%	4.16%
Canada	1,936	1,928	1,898	1,890	-4.49%	-2.57%
Japan	1,272	1,265	1,247	1,260	-0.94%	1.94%
Mexico	1,150	1,195	1,200	1,200	4.35%	0.00%
Korea	1,100	1,056	1,000	1,065	-3.18%	6.50%
Taiwan	890	911	905	910	1.54%	0.50%
Other	4,019	4,215	4,298	4,581	14.23%	6.82%
World	93,804	96,127	98,504	94,678	2.02%	-3.08%

Source: USDA/ERS/ABRARS, 2008.

To make this growth possible, the Brazilian pig production chain has been constantly modernized, increasing productivity each year and improving the quality of the herds. The dominant productive profile is the partnership with large industries, with the only producer responsibility being to raise the animals, utilizing feed from the industries as well as technical assistance.



Brazil utilizes the best genetic material available in the world, has highly skilled professionals and a dynamic and efficient structure of research and development. There also exists in the country, large national and multinational companies manufacturing industrial equipment and chemicals. These factors have resulted in better productivity of the herds year by year, starting in 2004 with 19.5 finished/sow/year to 21.4 finished/sow/year in 2007.



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The competitiveness of the Brazilian production system is also the result of other factors ranging from environmental conditions to the organizational structure of production, which can be summarized as follows:

- Low cost of equipment and facilities due to a more suitable environment for the animals;
- Only in some specific microclimates, as in the Brazilian South, does the minimum temperature fall below zero, during the winter;
- High quality of the health of our herds. Brazil is the only major world pig producer that is free of PRRS, currently the most severe swine disease;
- Low cost of corn and soyabean meal in Brazil. Due to its suitability for food production, Brazil is one of the major producers and exporters of these commodities;
- Availability of labor. Although the availability of abundant and cheap labor is becoming less of a reality in Brazil, the quality of labor in the animal production and processing sectors is stressed. The shortage that began in some regions is being offset by increased productivity due to improvement in processes and increase in automation;
- Presence of strong structure to support scientific and technological developments in the country. Brazil has a National Center for Research in Pigs and Poultry linked to the Ministry of Agriculture, several universities with highly developed research areas in pigs, and an awareness of all the technological advances being made globally.

The Brazilian agribusiness has highly qualified staff and many of these professionals are qualified at Masters and PhD levels in national and international institutions.



The New Face of Brazilian Pig Production

The integration and coordination system in Brazilian pig production

In the last fifteen years the Brazilian pig production sector has been moving away from the free market (“spot”) towards coordinated models of production (Figure 1). Coordinated systems of production in Brazil can be traced back to the 1970s. At that time until the late 1980s, the system was structured as follows: there was an integration system of complete cycles similar to the other groups, a specific system for production of piglets (until the end of nursery phase) and a finishing system (from the end of nursery to slaughter).

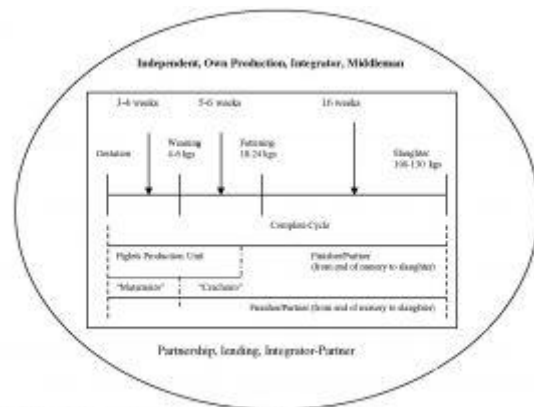


Fig. 1. Technological medium and organizational arrangements in the pig production chain.

The system of partnership had not yet been deployed and the industries were only intermediates, i.e. the industries collected the piglets from the producers and either sold them to the finishers, or finished them on their own facilities (Santos Filho et al., 1999).

From the mid-1980s, the swine industry changed this system, implementing the partnership in primary production system. This new system made the pig production process closer to the poultry production process, but this occurred only after the delivery of piglets for the terminator partner.

New segments are currently emerging within the pork production business. The producers of piglets now have their activities carried out by two new categories of producers. One group, referred to as “materneiro” is responsible for the production of piglets up to the weaning stage (up to 5–6 kg) and another, referred to as “crecheiro”, is responsible for the nursery phase (between 5–6 and 25 kg). In addition to the segmentation in the production step, there are the different organizational arrangements ranging from own production, independent production,



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middleman, partnership, lending, and partner-integrator, among others (Santos Filho et al., 1999; Miele & Waquil, 2007).



The production system within the new organizational forms of production has grown significantly in Brazil over the past 15 years. In Santa Catarina, a traditional pig producer state, it already represents over 80% of commercial slaughter. A similar picture occurs in the other states and in the new areas of expansion of the activity in the West Center, where 100% of the new investments are implemented with some form of non-traditional organization of production (mostly in partnership).



The New Face of Brazilian Pig Production

The internal and external market of Brazilian Pork

Until the 1970's pig farming was a dual purpose activity. The most important demand was the fat used for the preparation of food, followed by meat for consumption. From the 1970's onwards, it the emergence and dissemination of vegetable oil, there was less interest in the production of pigs for fat, with fat being almost completely eliminated from the diet of the Brazilian population. To cope with this change in eating habits, our pigs have undergone great genetic and technological transformation (improvements in the quality of food, health control, and facilities management), and since then have lost fat and gained lean meat.

However, these changes in genetics and production systems of pigs are not yet fully perceived by Brazilian consumers. This fact, coupled with the prejudices surrounding the effect of pork on human health (popular perception that pork is bad for health) made pork consumption in Brazil remain stagnant in the 1980's and 1990's.

Nevertheless, the 1980s, in addition to the problems just mentioned, were marked by the macroeconomic crisis in the Brazilian economy (high inflation and balance of payments deficit), that resulted in a negligible increase in the income of Brazilian consumers. Due to the problems mentioned, the market demand for pork only presented a significant growth from the mid-1990s. This was induced by a fall in the price of this product and by the actions taken by pig farmers, who, in the late 1990s created a fund for the promotion and dissemination of pork and its derivatives. The actions taken were directed towards the presentation of the product in supermarkets and to the dissemination of information on the benefits of the product through advertisements on television, in an attempt to eliminate the myths concerning pork consumption.



From 2004 to 2007 the per capita consumption of pork in Brazil showed a slight increase, from 11.9 kilograms in 2004 to 13.0 kg in 2007. In 2007, of the 3.00 million tons produced, 76% was for the domestic market and 24% was for export, demonstrating the great potential for absorption of meat by the domestic market.

In regional terms the highest per capita consumption occurs in the municipalities of the states of the South Region (Figure 3). Municipalities with intermediate consumption are located in the states of Minas Gerais, Rondônia, and part of São Paulo. The North and Northeast regions are characterized by the lowest consumption of pork.

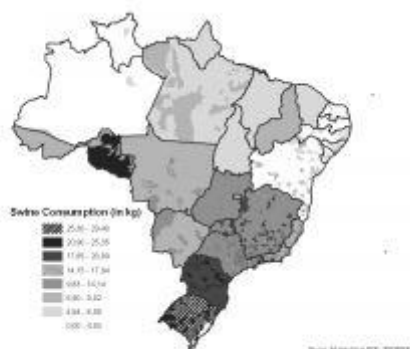


Fig. 3. Pork consumption in Brazil (Santos Filho et al., 2010)

Fonte: Adaptado de Santos Filho et al., 2010

Due to the highly competitive costs and the constant improvements made in the health of Brazilian herds, Brazilian pork and its derivatives have grown into a world market. From contributing a negligible share in the twentieth century (in 1999 exports totaled only 80 million tons), Brazil is currently the 5th largest net exporter (exports-imports), with 606 million tons of products of porcine origin,

and is below only the United States, Denmark, Spain and Canada. The major importers of Brazilian pork have remained the same for more than five years. The difficulty of the Brazilian health authorities to certify production continues to deny Brazilian pork a bigger place in the world market. What has changed is the contribution of each and in 2007 was no different, except for a decrease in the relative importance of the Russian market and a significant expansion of sales to Asian countries.

The main buyers of Brazilian pork in 2007 were Russia (45%), Hong Kong (18%), Ukraine (9%) and Singapore (5%). Worldwide, the largest importers of pork in 2007 were Japan, Russia, South Korea, United States, Mexico and Hong Kong and together were responsible for 86% of all pork consumed in the world. Thus, among the major importers, Brazil has significant sales only to Russia and Hong Kong.

Besides the factors mentioned, in recent years pig production has played new roles such as energy supply and carbon sequestration. These are functions that go beyond the boundaries of the farm and the consumer of animal protein, and give a new dimension to the domestic pig.



The New Face of Brazilian Pig Production

Social and Economic Importance

In terms of importance as an economic activity, only in the domestic market, production of pigs is responsible for a gross value of production of R\$21,714,573,739.00 (December 2007). In terms of foreign currency, this activity is coming, especially in the early years of the new century, as one of the most important in the Brazilian agribusiness. In 2007 pig production was responsible for the export of R\$ 1,232,210,000.00 (R\$ 2,490,004,184.00 for values up to December 2007), which represented that year 0.77% of total exports, 2.20% of exports of agribusiness and 3.78% of balance in the trade balance.

Besides being an activity that generates income and currencies for the national economy, pig production is extremely important for the generation of urban jobs and to support family production, with particular reference to southern Brazil. In terms of formal employment in industrial production (slaughter and processing of meat of pigs and poultry), 241,878 jobs were generated. The activity has also generated 80,431 jobs in the formal primary production of pigs. The number of formal jobs in pig production does not reflect the importance of this activity in Brazil. Rural activity in Brazil is still surrounded by a culture of low formal employment, mainly due to the fact that family production in this sector is still very dominant. Indeed, in the case of swine, especially in southern Brazil, production occurs predominantly in family properties where the figure of the owner and the staff is confused.

According to the 2006 agricultural census, 79.74% of pigs sold were from properties with total area less than 100 ha. In the case of poultry this figure was 84.59%. In Santa Catarina, which is the state with greater emphasis on the production of poultry and pigs in Brazil, this indicator was 97.28% for poultry and 91.90% in swine. Thus, the high concentration of the pig herds in properties with up to 100 hectares shows the character of family activity. Moreover, according to the agricultural census in 2006, approximately one million and four thousand farms were involved in pig production. Assuming only properties with more than 100 animals of herd (industrial or semi-industrial pig production) be taken into account, then this number drops to below 150,000 which is still a significant number.



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Studies conducted by the National Bank of Economic and Social Development (BNDES) demonstrate the great multiplier effect of meat production chains in Brazil. In this study, each



unit of direct employment generated in the slaughter and processing of meat had a multiplier power in employment of 10.3, taking into account the indirect effects and the income effects. Thus, given a direct employment of 241,878 jobs in the slaughtering and processing of poultry and pig, we can estimate a total employment of about 2,495,114 people, which includes 1,326,309 indirect jobs and 926,927 jobs generated by the income effect. As pig

production in Brazil is lower than the production of chickens (about one third), the number of jobs follows roughly the same proportion.



The New Face of Brazilian Pig Production

Corn and soyabean as factors of competitiveness in Brazilian pig production

We must not lose sight of the high added value of pig production, either upstream or downstream. Downstream, in primary production, pig farming leads to great demand for corn and soyabean meal as the feeding of pigs in Brazil is based on the consumption of these ingredients. According to estimates by Embrapa Swine and Poultry, this activity was responsible for 18% of the demand (8.46 million tons) of all the corn consumed in the country in 2007, and also a significant part of soyabean meal (2.21 million tons). Besides the sector supplier of inputs for feed, this chain also influences the sectors of transport, processing and the chemical industry.

Soyabean is an important commodity in the international market. There are no barriers related to health, and protectionist attitudes are low for this product as far as the European Economic Community and Asia are concerned. In the 2006/ 2007-crop year, the world's soyabean production was 229.4 million tons, of which the most important producing countries were the United States (86.77 million tons), Brazil (57.00 million tons), Argentina (44.00 million tons) and China (16.20 million tons). The world's largest exporters are Brazil, the United States and Argentina; the biggest importers are China, European Union, Japan, Mexico, Taiwan and Thailand. For many countries there is a positive correlation between the dependence on soyabean and soyabean meal and the production of pigs and poultry. For example, China, the European Union, Japan, Mexico and Thailand are major producers of pigs and are dependent on the import of soyabean complex. Similarly, China, European Union, Mexico, Japan and Thailand are major producers of chickens.

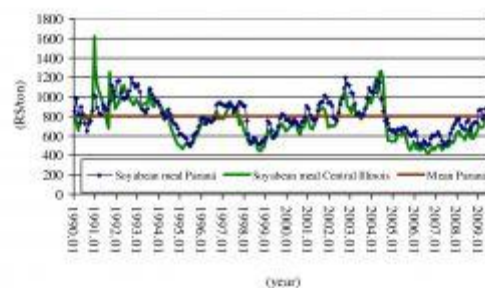


Fig. 4. Price of soybean meal in Chicago and Brazil (USDA/FEADATA, compiled by the authors)

The price of soyabeans in Brazil has a very consistent performance, always linked to the international price, as observed in other studies (Aguiar, 1994) (Figure 4). This explains why producers have confidence in this activity, as they are not hostage to a small group of buyers. The production of soyabean in Brazil showed significant annual growth of 6.07% over the last 6 years, well above the annual growth of world production, which was 3.78%. In the 2007/2008 crop year the production of soyabean in Brazil occupied an area of 20,686,800 hectares, which was equivalent to 45% of the area planted with annual crops in Brazil in the same period. Because of the availability of soyabean meal in the country and the lack of alternatives, the possibility of replacing this ingredient in animal feed is limited.

World production of corn in 2006 was approximately 692.4 million tons. The largest producers are the United States with 267.5 million tons (40.6% of world production), China with 143 million tons, Brazil with 48 million tons, the European Union with 43.9 million tons and Argentina with 21 million tons. Among the major producers, only the United States has significant exportable surpluses. Brazil is a net importer/exporter on a small scale, while China



Fig. 4. Profitability in the production of pigs in SC and corn farm price (Santos Filho et al., (2011); EMBRAPA Suínos e Aves/CONAB (2008)

is taking strides to become a major importer; Argentina has a small exportable surplus. Exports make up 83.97 million tons. The world's biggest corn exporters are the United States with 56 million tons, Argentina with 13.5 million tons, Brazil with 5 million tons and China with 4 million tons. Furthermore, the major importers are Japan (16.5 million tons), Republic of Korea (8.8 million tons), Mexico (8.0 million tons), Tunisia (6.5 million tons), Egypt (4.8 million tons), EU-25 (4.5 million tons), Syria (4.5 million tons) and Colombia (3.3 million tons).

Among the largest producers of pigs, the European Union, Japan, Mexico and the Republic of Korea are highly dependent on imported corn. Similarly, the European Union, Mexico and Japan are also major producers of chickens and dependent on imported corn.

While tied to the international price, corn has a variable behavior in the domestic market when compared to the price on the Chicago Stock Exchange (Figure 5), which is one of the factors determining the profitability of primary production of pigs. During the years of deficit in domestic production and low stocks, the domestic market price is higher than the price applied in the international market (in fact it is the price paid in the United States, plus the cost of internalization of production in the local market). The opposite occurs during periods of surplus in production and rising inventories.



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Corn production in Brazil has shown an annual growth of around 5.76%, higher than the growth of global production, which was 4.25%. Combining the two seasons in the period, the production of corn in the 2007/2008 agricultural year covers an area of 14,306,700 hectares, which is well below the potential use of 80,000,000 hectares available only in the Cerrado. In Brazil, the main substitutes for corn in the production of feed for poultry and pigs are the winter cereals, including trigoilho, triticale and germinated wheat. However, these products are of low availability, and thus have a low potential of replacing corn on a large scale in animal feed. Because of the importance of diet in the cost of pig production, and the large participation of corn and soyabean meal in the composition of the diets, an important factor for the competitiveness of Brazilian production of pigs is the production of both on national soil.

In Brazil the production of grain is concentrated in the traditional agricultural regions, south and southeast, and has been expanding since the 1980s to the Brazilian Cerrado, located in the Central West, and in some areas of the states of Maranhão, Piauí and Bahia. The Brazilian Cerrado, besides being huge, is still relatively little explored, which demonstrates the competitive potential of Brazilian pig production in terms of availability of grains.



The new face of Brazilian pig production

Challenges and prospects

The major challenges facing the pig production sector in Brazil also provide its greatest opportunities. Within Brazil, the industry has to convince the Brazilian consumer of the benefits of consuming pork-based products, and thus increasing domestic consumption of meat will be a great challenge to be pursued. On the international scene, our challenge is related to the conquest of new markets such as the European and Japanese markets. Neither can we forget the Chinese market, which will certainly be a large importer of pork, due to several factors. Among these we can mention:

- The huge growth of per capita income;
- The deficit in domestic supply sources of vegetable protein (e.g. soyabean);
- Limitation for the expansion of corn production, and
- Lack of water.

India, another country that must be considered, is beginning to show a potential for expansion of meat demand. However, in order to expand foreign markets, it is necessary to convince international consumers, especially the more demanding markets of Europe, USA and Asia, of the high health status of the national herd. The potential for sustainable growth of pig production in Brazil is huge due to:

- The availability of water, grain for feed, labor, and technology;
- Great potential for growth of domestic consumption per capita and,
- Constant improvement in the health of our herds, which is allowing us to gain new markets every year.

Moreover, the recent crisis in the grain market increases the chances of Brazil to become a major supplier of food and thus also a large global supplier of pork.



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