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Alternative feedstuffs for swine in Colombia: what are our options? ¤

Alimentos alternativos para cerdos en Colombia: ¿qué opciones tenemos?

Alimentos alternativos para suínos na Colômbia: quais opções têm?

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Summary

Both the increasing demand of grains for food and the recent ethanol crisis have an economic impact on swine producers in many countries, including Colombia. The continuous increase in grain and corn prices push swine nutritionists everywhere to search for alternative energy feedstuffs in order to provide adequate feed to pigs. Colombia, where a variety of crops are grown, lacks effective alternative feedstuffs to replace corn, which is widely used as the main energy ingredient in common animal diets. The major limitations presented by those crops or products and their derived materials are usually their high water or high fiber contents, or both, particularly in the way they are made available from agricultural production and the food industry.

Key words: *alternative feedstuffs, byproducts, corn, feed, swine.*

Resumen

Tanto la creciente demanda de granos para la alimentación humana, como la reciente crisis generada por la producción de etanol a partir de maíz en el principal productor mundial del grano, están acorralando a los porcicultores en muchos países, incluido Colombia. Los altos precios del maíz obligan a los formuladores de alimento a buscar fuentes energéticas alternativas para alimentar los cerdos. A pesar de que en Colombia se produce una gran variedad de cosechas durante todo el año, no hay muchas alternativas para reemplazar efectivamente al maíz. Las limitaciones presentadas por los potenciales ingredientes alternativos y sus derivados son, principalmente, sus altos contenidos de agua y/o fibra.

Palabras clave: *alimentos alternativos, alimento concentrado, cerdos, maíz, subproductos.*

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Resumo

A crescente demanda de grãos para a alimentação humana, bem como a recente crise gerada pela produção de etanol a partir do milho, estão encurralando suinocultores de muitos países, incluindo a Colômbia. Os altos preços do milho obrigam os fabricantes de alimentos a buscar fontes alternativas de energia para alimentar os suínos. Apesar da Colombia produzir uma grande quantidade de colheitas durante todo o ano, não há muitas alternativas para substituir de forma efetiva o milho. As limitações apresentadas pelos potenciais ingredientes alternativos e seus derivados são, principalmente, seus altos teores de água e/ou fibra.

Palavras chave: *alimentos alternativos, alimentos balanceados, milho, subprodutos, suínos.*

Introduction

As human population grows, the demand for food continues to increase. This has been long known and is thus a somewhat predictable situation. So far, agriculture around the world has been able to cope with this demand by increasing productivity year after year. Now, however, a new variable needs to be included in the supply and demand equation of grains: ethanol. Aside from the forever-increasing demand of grains for food, such as corn, this new demand for ethanol is strongly affecting the grain markets. Nowadays grain prices, including corn, have skyrocketed in the midst of an unprecedented bio-fuel fever. In this scenario, swine nutritionists in many countries find themselves desperately looking for corn alternatives to feed pigs. In a tropical country such as Colombia, which has the capability of growing a variety of crops year-round at different elevations, one would think there are plenty alternative feedstuffs to fully or partially replace an energy ingredient such as corn. Nevertheless, in the form they are generated by the industry, those crops and their derived materials or by-products present practical limitations, including high water and/or high fiber contents.

Defining Alternative feedstuffs

Alternative feedstuffs are the crop residues or food industry byproducts not consumed by humans but are suitable for feeding pigs, transforming pigs into pork - a human-edible product. Such alternative feedstuffs are edible waste products or co-products from agriculture or the food processing, food preparation or food service industries. Examples of such industries include grain milling, brewing and distillation; baking; fruit and vegetable processing; meat, milk and egg processing; seafood processing; prepared food manufacturing; and retail food outlets. Alternative feedstuffs also include feeds not regularly fed to pigs, especially during times of low prices and/or surpluses, or during shortages of traditional feedstuffs. Alternative feedstuffs may include materials available locally that can be economical substitutes for expensive or not readily available traditional feedstuffs (Myer and Hall, 2004). Miller *et al* (1994) have proposed groupings of some potential byproducts for swine according to their primary product origin: animal (milk, meat and egg byproducts), grain (milling, baking, brewing, and distilling byproducts), sugar and starch production (cane, beet and corn molasses, and salvage candy), and vegetable materials (cull beans, roots and potato byproducts).

The suitability of an alternative feedstuff for a particular age or physiological stage of the pig depends, among many factors, on its legality of use, availability in the local market, cost (including transportation, storage, processing and labor), palatability, consistency, nutrient composition and availability, presence of potential health hazards (toxic or disease factors) or anti-nutritional factors, and potential effects on pork quality and perishability – including spoilage and rancidity (Miller *et al.*, 1994; Myer and Brendemuhl, 2001; Myer and Hall, 2004).

Searching for Alternatives to Corn: a Crucial Task

According to FAO (2004), global cereal production has been stagnating since 1996. Global cereal utilization, on the other hand, has been continuing on an upward trend and has been exceeding production by significant amounts continuously since 2000.

Several reports affirm that in the future swine production will compete directly with humans for cereal grains and high quality protein supplements (Close, 1993; Dierick *et al*, 1989; Pond, 1987). This prediction is already a reality in most countries of the developing world (Oke, 1990), where human population obtains 58% of their total caloric intake from cereal grains as compared to 28% for the developed world (Ensminger *et al*, 1990).

Among cereals, corn is an important food for the fast-growing human population. Currently in the western hemisphere, only four countries (U.S., Argentina, Paraguay and Bolivia) produce enough corn to fulfill their needs and export the excess, while nineteen other American countries show a permanent deficit in corn production (Ministerio de Agricultura y Desarrollo Rural de Colombia, 2005). Colombia (a tropical country located in northern South America) is one of those countries where the demand for corn for both human and swine populations during the last decade chronically exceeded local production of this cereal. Colombian imports of corn started to climb in 1993 when the country opened its markets to free global trade. Since that year, the country has been steadily increasing its imports of yellow corn (Figure 1), which is used for animal production, particularly to feed poultry and swine.

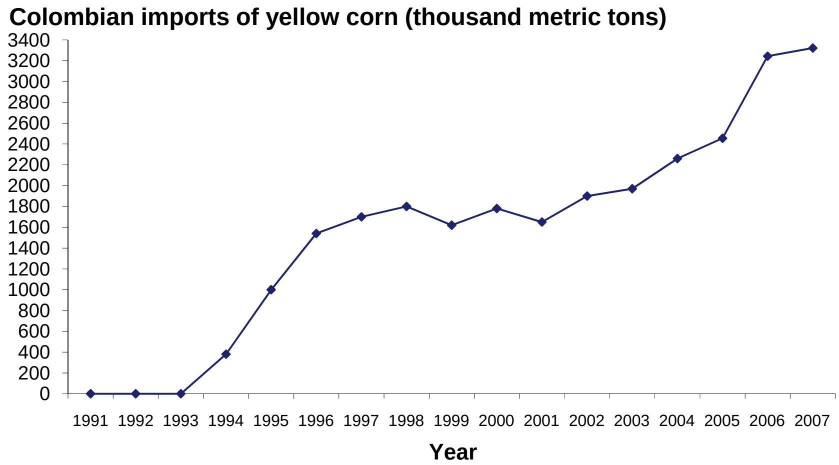

Figure 1. Colombian imports of yellow corn (adapted from Martinez and Acevedo, 2004 and from Ministerio de Agricultura y Desarrollo Rural de Colombia, 2009).

Corn imports by Colombia now account for 50.1% of the total corn consumed in the country. Since 1996, and among all the commodities imported by this country, corn ranks first in terms of total cost and volume. During 2004, Colombia imported 1,909,354 metric tons of corn (yellow and white) for a total cost of 332,085,000 USD, turning the country from a non-net importer twelve years before, into the 10th largest world importer of this cereal (FAO, 2009). These findings are interesting, taking into account that the country ranks 28th in terms of human population (42 million), has a low consumption of animal protein, and is not a meat or egg exporter. For Colombia, which is not particularly strong in animal production, the figure reflects a total dependency on foreign corn prices. The reason for the decline in local production and subsequent dependency on foreign corn is that local production is not competitive under the new global trade scheme. The magnitude of the corn deficit is similar for most Andean countries. In most Central American countries this deficit is even greater, often exceeding 90% (FAO, 2004; Ministerio de Agricultura y Desarrollo Rural de Colombia, 2005). This situation forces swine nutritionists to consider partial replacement of corn with alternatives such as grain derivatives and other materials that are in low demand as direct food sources for the human population.

Another reason for using locally-available alternative feedstuffs is the need for proper disposal of these materials. In many countries alternative feedstuffs for pigs represent not only an economic option to lower production costs, but also an environmentally-friendly approach to the disposal of the enormous amounts of organic materials in times of increasing by-product generation and landfill shortages. According to Fadel (1999), the calculated total world dry matter tonnage for about twenty types of by-product feedstuffs was almost 1 billion metric tons in 1993, and about 65% of these feedstuffs were crop residues. Over the next 20 years, this per capita tonnage will likely increase in developed countries and remain the same or slightly increase in developing countries, suggesting that byproducts will become an increasing waste problem. Thus, the role of pigs in recycling and "adding value" to many of these byproducts and wastes is becoming increasingly important as a viable waste management option.

Alternative Energy-Feedstuffs

In most swine diet formulations, ingredients that provide most of the energy (i.e., corn) usually represent the highest cost among all the dietary ingredients. This is due to the high proportion of the diet that is accounted for the energy ingredients. In a typical corn-soybean meal (corn-SBM) diet provided to growing-finishing pigs, the total cost of corn is about 50% higher than the total cost of the soybean meal used. To illustrate this, a typical corn-SBM diet for growing-finishing pigs contains between 70 to 85% corn (avg. 77.5%) and 14 to 25% soybean meal (avg. 19.5%). Using the U.S. prices reported on July 22, 2004 for both feedstuffs (Feedstuffs, 2004), i.e., \$2.24/bushel of corn (1 bushel: 54 lb for U.S. No.2 grade corn, equivalent to \$0.042/lb), and \$239/ton of soybean meal (\$0.12/lb), the corn component cost is 3.3 cents/lb of the corn-SBM mix, while the cost of SBM is 2.3 cents/lb of the total feed mix. Thus, for reasons of total cost, alternative energy feedstuffs should be considered first when thinking about partially replacing swine diets.

Nevertheless, most of the potential alternative feedstuffs available also have their own inconveniences. Table 1 presents the nutrient composition of corn, compared to several alternative feedstuffs commonly available in tropical countries. According to Myer and Brendemuhl (2001), the main disadvantages of the byproducts listed in Table 1 are:

Table 1. Nutrient composition of corn and some alternative feedstuffs (adapted from Myer and Brendemuhl, 2001).

Feedstuff	Description	Nutritional value for pigs (as fed basis)								RFV[1] vs. Corn (%)
		DM (%)	ME[2] (kcal/kg)	Protein (%)	Lysine (%)	Fat (%)	Fiber (%)	Ca (%)	P (%)	
Corn	Grain	89	3400	8.3	0.26	3.9	2.2	0.03	0.25	100
Rice	Bran, full fat	90	3000	12.5	0.60	12.0	11	0.05	1.70	70-100
	Bran, fat extracted	91	2600	14.0	0.65	1.5	13	0.10	1.40	60-80
	Polishings	90	3300	13.0	0.50	13.0	2	0.10	1.20	95-100
	Broken	89	3300	8.0	0.30	0.6	0.6	0.04	0.18	95-100
	Paddy	89	2800	9.0	0.30	2.0	10	0.05	0.25	70-80
Bananas	Ripe, whole	25	750	1.0	<0.10	0.1	0.5	0.01	0.03	20-25
	Green, whole	26	700	1.0	<0.10	0.1	0.5	0.01	0.03	15-20
Cassava	Meal	89	3300	3.0	0.10	0.5	5	0.12	0.15	95-100
	Fresh	35	1200	1.0	<0.10	0.2	1.5	0.04	0.05	30-40
Sugar cane	Molasses	80	2200	3.0	<0.10	0.1	0	0.70	0.08	60-70
	Juice	18	700	<1.0	<0.10	<0.1	2	0.20	0.05	15-25
	Stalks	25	500	1.0	<0.10	0.5	8	0.10	0.05	10-20
Potatoes	Chips or fries	90	4400	6.0	0.20	30.0	1	0.10	0.20	120-150
	Cooked flakes	92	3500	8.0	0.40	0.5	2	0.10	0.20	100
	Pulp, dried	88	2200	6.0	0.20	0.3	9	0.10	0.20	60-70
	Boiled	22	700	2.4	0.10	0.1	0.5	0.02	0.05	15-25
	Raw	20	500	2.0	0.10	0.1	0.5	0.02	0.05	10-15
Resturant food waste	Non-dried	20	800	5.0	0.20	5.0	1	0.10	0.10	15-25

[1] RFV (relative feed value): nutritional value relative to corn.
[2] Metabolizable energy.

1. Rice (*Oryza sativa*) byproducts: rice bran is a bulky, fibrous material with high potential for rancidity depending on the fat level. Rice polishings are not as bulky and fibrous as rice bran, but they also have the problem of potential rancidity. Broken rice has a high energy content, but is low in lysine. Paddy rice is highly fibrous and has a higher risk of aflatoxin contamination.
2. Bananas have a high moisture content. Whole, green bananas have a large concentration of tannins, which lowers its palatability for pigs.
3. Fresh cassava also has a high moisture content, while some varieties of the root may contain large residual concentrations of toxic cyanhydric acid in the meal.
4. Sugar cane juice has high moisture content. The stalks have the same problem and are also a bulky material.
5. Raw potatoes are high in moisture. In general, cooking improves byproduct utilization of potatoes.
6. Food waste from restaurants is not only high in moisture, but also highly variable in nutritional value; besides, using food waste to feed swine has been banned in Colombia since 2007.

As shown in Table 1, the main limitations presented by these materials in the forms they are generated by the industry- are their high water content, high fiber content, or both.

In general, most of the common energy-feedstuffs available in tropical countries make no significant protein contribution to the diet. Those feedstuffs require further processing to increase their dry matter content, thus increasing, in turn, their cost. Many non-processed feedstuffs are inexpensive because they are basically waste byproducts. It is usually the cost of transport and drying which limits their potential as economical alternatives. Drying is sometimes recommended to facilitate handling and incorporation into dry diets. Drying also concentrates the nutrients, which is necessary when feeding animals that combine a limited gastrointestinal capacity with a high growth potential.

As mentioned, digestibility of the dietary nutrients present in feedstuffs varies according to different factors, including the amount and type of fiber present in the diet (Noblet and Le-Goff, 2001; Wisemann and Cole, 1985). Crude fiber is comprised of three major fractions: cellulose, hemicellulose and lignin. These components are measured by detergent fiber analysis, which determines neutral detergent fiber (NDF) and acid detergent fiber (ADF). The NDF is the insoluble residue in a neutral detergent solution after eliminating the plant cell contents. It represents the cell wall constituents or cellulose, hemicellulose and lignin. The ADF is the residue comprised of cellulose and lignin. The difference obtained when subtracting NDF and ADF is the hemicellulose fraction of fiber.

The NDF is partially fermented in the large intestine into volatile fatty acids (VFA) such as acetic, propionic and butyric acids, also producing CO_2, H_2, CH_4, urea and heat. It is known that regardless of its source, an increase in NDF decreases energy availability and may increase fecal loss of nitrogen (Sauber and Owens, 2001). Both the old crude fiber analysis, as well as the newer detergent methods of analysis, underestimate the amount of total fiber due to their inability to recover soluble fiber components such as pectin, mucilage, gums and B-glucans (Grieshop *et al*, 2001).

In growing pigs, digestibility coefficients for dietary fiber are lower than coefficients for other nutrients. According to Noblet and Le Goff (2001), average fiber digestibility is 40 to 50%, ranging from around zero in high lignin sources (e.g., wheat straw) to between 80 and 90% in high pectin sources (e.g., sugar beet pulp and soybean hulls). Thus, the fiber digestibility depends on the ratios of lignin to pectin in feedstuffs, with lignin being indigestible, while pectin is almost completely digestible. In addition, hemicellulose is more digestible than cellulose, but both are just partially digested. It is also known that digestibility increases with body weight, so adult sows can utilize fiber better, but this utilization of fiber also depends on the botanical origin of the fiber (Noblet and Le Goff, 2001).

Thus, for a better understanding of the nutritional value of feedstuffs, the information obtained by the proximate analysis should be complemented with digestion and balance trials to assess how well those nutrients are utilized by the pig. In Table 2, digestible and metabolizable energy, as well as digestible protein results, are shown for several of the feedstuffs in Table 1.

Table 2. Digestible energy and protein for pigs in selected feedstuffs (as fed basis) (adapted from Ensminger et al., 1990).

Feedstuff	Description	Digestible energy (kcal/kg)	Metabolizable energy (kcal/kg)	Crude protein (%)	Digestible protein (%)
Corn	Grain, yellow	3338	3246	9.9	7.3
Rice	Bran, with germs	3250	2971	13	9.5
	Polishings	3713	3428	12	10.1
	Paddy, ground	3290	3107	7.5	5.1
Bananas	Fruit, dehydrated	3535	3355	3.5	1.6
	Peelings, dehydrated	3425	3240	8.6	6
Cassava	Meal, dehydrated	2923	2748	2.2	1.6
	Fresh	1127	1063	1.2	0.5
Sugarcane	Molasses, dehydrated	2663	2485	9.7	7
Potatoes	Tubers, fresh	878	830	2.2	0.7
	Tubers, boiled	918	869	2.2	1.5
	Tubers, dehydrated	3450	3261	8.1	5.6
	Peelings, fresh	882	835	2.1	1.5
Restaurant	Boiled, wet	1105	1053	3.6	2.8
food waste[1]	Boiled, dehydrated, ground	4293	4090	16.1	12.8

[1] The use of food waste to feed pigs has been declared illegal in Colombia since 2007.

Availability of alternative feedstuffs

Despite the overall shortage in corn, it is interesting to note that Colombia is an important producer and net exporter of several potential alternative feedstuffs or derivatives. In 2003, Colombia was ranked 1st worldwide as an exporter of plantains and sugar cane, and 4th as an exporter of bananas. It was also among the top 10 exporters of fresh fruits, roots and tubers and among the top 20 exporters of paddy rice (FAO, 2004). These figures mean not only that the country produces more of these staples than are required to fulfill its internal demand, but also that there is a competitive production infrastructure that is generating important amounts of materials that are potentially interesting for feeding swine. Table 3 illustrates Colombian production and world rankings among the top 20 producers of several feedstuffs.

Table 3. Colombian production of several potential alternative feedstuffs during 2005 (adapted from FAO, 2009).

Product	Colombian production (metric ton/year)	World rank
Coffee, green	682.580	4
Plantains	3.400.000	2
Avocados	185.811	4
Tropical fruits	1.150.000	5
Sugar cane	39.849.240	7
Bananas	1.600.000	10
Pineapples	419.647	12
Cassava	2.125.163	18
Potatoes	2.623.194	21
Cow milk, whole, fresh	6.770.000	21
Rice paddy	2.602.300	21

From the feedstuffs listed in Table 3, all but coffee are generally considered energy sources.

Nutritional information is available for most of the feedstuffs listed. ‘Coffee grounds’ is a material for which limited information is available. According to Ensminger *et al* (1990), and on ´as-fed´ basis, ´coffee grounds´ has 10.2% CP, equivalent to 6.1% digestible protein for pigs. It also has 74% DM, 9.3% EE, 1.2% ash, 0.09% Ca, 0.06% P, and 21.5% CF.

Rice bran: an interesting partial substitute

Rice bran is an alternative feedstuff that could be used to partially substitute for corn in temperate as well as tropical zones. It is abundant and inexpensive in many countries. According to the NRC (1998), rice bran contains 13.0% EE, 13.3% CP, 1.61% total P, and 2,040 kcal/kg of net energy, which is not too different from corn (2.395 kcal/kg).

Although richer in fat (13%) in comparison to corn (3.9%), rice bran is also richer in fiber (23.7% NDF and 13.9% ADF for rice bran versus 9.6% NDF and 2.8% ADF for corn), which makes it poorly digestible by the young pig. Because of the high fat content, it often turns rancid during storage. According to Cunha (1977), it has about 90 to 95% the feeding value of corn if used at a level not more than 20 to 30% of the diet. When used at higher levels, its relative feeding value decreases and it tends to produce ‘soft pork’ (soft carcass fat due to high concentrations of unsaturated fats), which can negatively affect the market value of pigs. Cunha (1977) also indicates that the material should be used fresh in order to prevent rancidity because this rancidity decreases palatability. As a substitute, he proposes the use of de-fatted or solvent–extracted rice bran, which has about the same feeding value as corn when fed at levels no higher than 30% of the diet, and does not produce soft pork.

Besides of its low cost, rice bran is also interesting because of its high concentration of total P. Total P in rice bran is about five times higher than in corn, and three times higher than in soybean meal, but most of it is present in the form of phytic P. About 75% of the P in rice bran is bound as phytic acid (Cromwell and Coffey, 1991). That form of P is not available and is almost completely excreted by the pig, creating an environmental concern. The low availability of P in rice bran is due to its low digestibility. In a series of trials, Jongbloed *et al* (1999) reported 14% of P digestibility for rice bran (range: 9 to 20%), 19% for corn (range: 12 to 26%), and 39% for soybean meal (range: 33 to 46%). Table 4 shows rice bran and several traditional energy feedstuffs and byproducts ranked by phytate P concentration. Among these feedstuffs, rice bran has the highest content of unavailable P, and thus it has the greatest pollution potential unless exogenous phytase is added to the diet.

Table 4. Energy feed sources and their unavailable phosphorus contents (Adapted from NRC, 1998).

Feedstuff	Phosphorus, %			
	Total	Bioavailable	Non available	Total unavailable
Rice bran	1.61	25	75	1.21
Wheat bran	1.20	29	71	0.85
Wheat middlings, < 9.5%fiber	0.93	41	59	0.55
Corn grits (hominy Feed)	0.43	14	86	0.37
Oat groats	0.41	13	87	0.36
Barley, six row	0.36	30	70	0.25
Oats	0.31	22	78	0.24
Corn	0.28	14	86	0.24
Sorghum	0.29	20	80	0.23
Wheat, soft red winter	0.39	50	50	0.20
Wheat, hard red winter	0.37	50	50	0.19
Whey, dried	0.72	97	30	0.02

Conclusion

There is not "a magic bullet" to replace corn in terms of a single alternative energy-feedstuff that fulfills all of the nutritional advantages of corn at a proper price. If we consider only the feed value (e.g. nutrient composition), there are few potential feeds and byproducts, locally produced, that could be included in swine diets. When reviewing the current literature, it is apparent that a 100% corn-based feed is ideal for optimal swine production. However, supplementing a high corn-based feed with alternative byproducts might be a solution to still achieve acceptable results. Examples include the supplementation of a corn-based diet with de-fatted or solvent-extracted rice bran, in combination with lysine-rich byproducts derived from industrial preparations of foods, or with byproducts derived from industrial ethanol production. However, more research is needed to explore alternatives to 100% corn-based animal feed, and especially combinations of corn products and nutrient dense industrial byproducts. Furthermore, when designing alternative feedstuffs for swine in Colombia, other important considerations, such as cost of dehydrating, transport, and practicability of mixing in a commercial feed at the industrial level should be taken into account. Nevertheless, if cost and market values permit it, optimal dietary compositions of feed for maximal swine production should always include the highest percentage of corn possible.

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