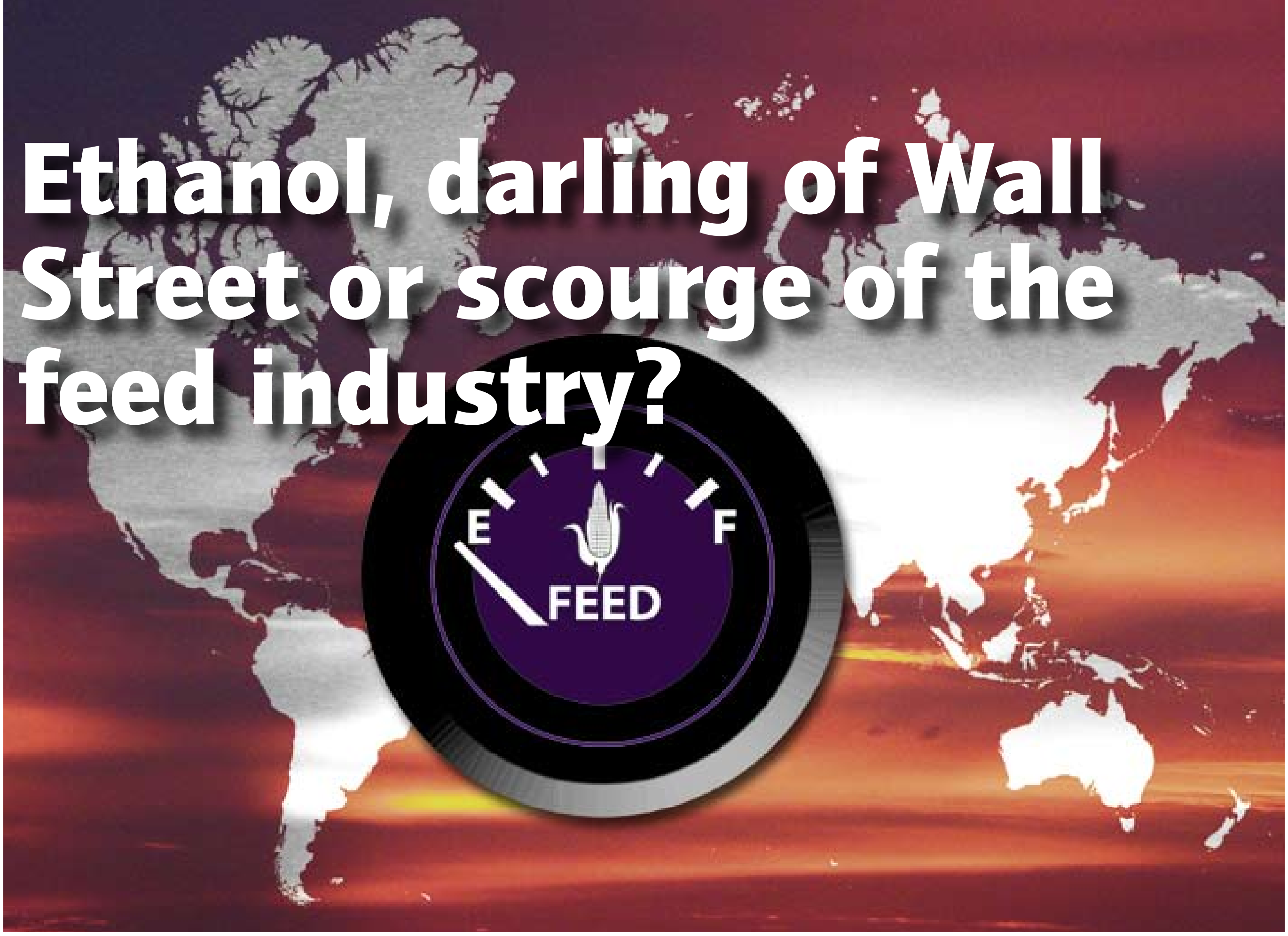
Ethanol, darling of Wall Street or scourge of the feed industry?



The hype around biofuels was a topical issue at the International Feed Expo (IPE) in Atlanta in January. US President Bush also emphasised in his "State of the Union" address the necessity to become less dependent on oil imports for fuel requirements. A shift in markets is to be expected. Being a brewer by education and thus a fermentation specialist, T. Pearse Lyons, president and founder of Alltech, is in the position to judge the current debate on the use of valuable raw materials for food, feed or fuel.

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To understand the ethanol industry is to understand the world. Driven by the 2002 Kyoto Protocol, where some 40 industrialised countries agreed to cut carbon dioxide emission back to or below (8%) that of 1990 in an effort to slow global warming, ethanol is now the darling of Wall Street, but possibly the scourge of the feed industry. Key factors, other than the environment, continue to drive interest in ethanol, namely reducing dependence on imported oil and increasing opportunities for farmers.

In 2003, the 15 member European Union adopted its biofuels directive to replace gasoline (and diesel) with biofuels; however, it was largely ignored. The move to alternative fuels has now taken on a new life, spurred by oil prices and political events in oil rich areas of the Middle East, Nigeria and Venezuela.

The US ethanol industry - long overshadowed by the use of the oil industry's MTBE as an oxygenate (reduces engine knocking) - has also found new life with the ban on the carcinogenic MTBE and a presidential directive on biofuels, where President Bush states 30% of our fuels should be biofuels by 2030.

History repeats

Interestingly, a similar "crisis" in 1980 led to the formation of Alltech. At that time, ethanol production in the US was about 175 million gallons. In that year, Alltech published a book for fuel alcohol production titled "A Step to Energy Independence". The book predicted that ethanol production in the US might meet 1.8 billion gallons by 1985 with a further 1 billion gallons in Brazil. More than 2,680 plants were anticipated in the US and "my corn field is my oil field" became the industry's mantra. Even then it was suggested that a simplistic conversion of corn (predominately maize) into ethanol and distiller's grain was not the way forward. Corn needed to be value-added, then and now.

While the gasohol industry stalled in the mid 1980s due to low oil prices ($10/barrel), lack of environmental concerns and an oil industry with its own oxygenate, ethanol production continued to grow in both N. America and Brazil. Flex cars were designed to use either ethanol or gasoline, or any combination of the two.

Three Es

Twenty-five years later, political instability in oil-producing nations (coupled with high energy prices) is renewing interest in ethanol, and the paradigm has shifted again. By July 2006, Ethanol Producer magazine announced that there were more than 100 plants in North America in operation or under construction. Ethanol had arrived, they declared, and had become a public policy driven by three Es: Energy security, Environmental protection and Economic security for rural America (Miller, 2006). Meanwhile, world petroleum consumption continues to rise and is expected to reach 1.3 million barrels per day in 2006 and 1.8 million barrels in 2007. But, the

Figure 1 – Breakdown of grain into ethanol, CO2 and DDGS

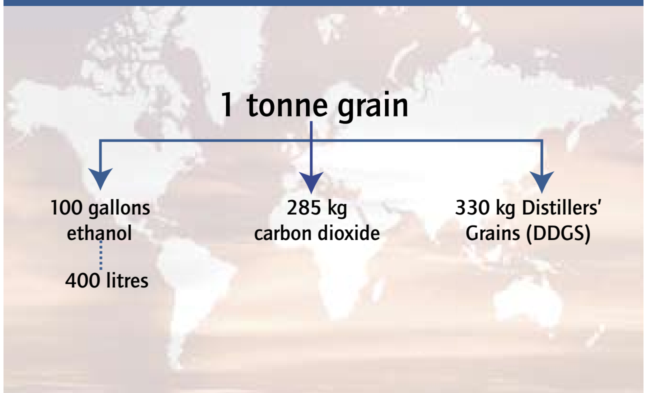

Figure 2 – Grains requirements for inclusion of 10% ethanol in US gasoline

Total US Gasoline

Consumption	140 billion gallons
Government replacement target	10% ethanol inclusion by 2010
Ethanol required	14 billion gallons for target
Cereal (corn)	140 million tonnes required
% of current US harvest	52%
DDGS produced	47 million tonnes

proven reserves are not increasing and political situations can alter the balance (already thin, at 1.1 million to 1.3 million barrels per day) between supply and demand at any time.

Corn as an oil replacer

What are the consequences for our industry? Is ethanol a saviour or a threat? Whatever the answer, we need to understand the implications. To do so, we must understand some key facts (*Figures 1 and 2*). One tonne of corn produces approximately 100 gallons of pure ethanol and 330 kg of a protein-fibre called Distiller's Dried Grains with Solubles (DDGS). The US government's target for 2010 is to replace 10% of US gasoline (approximately 14 billion gallons) with ethanol. This means consuming 52% of the current grain crop, producing approximately 47 million tonnes of DDGS.

In 2006, the US produced about 6 billion gallons (18 million tonnes) of ethanol, less than half of the 2010 target. Brazil produced approximately 5 billion tonnes, using sugar cane as a raw material with effectively no by-products. Brazil produces approximately 19% of the world's sugar supply, half of which is converted to ethanol, which is two-thirds the cost of ethanol in the US.

Effect on the feed industry

What then are the implications for the feed industry? Could global grain consumption exceed production as it did in 2005? (*Figure 3*) Will world grain stocks continue to fall from the current level of 270 million tonnes, the lowest in 25 years? Are we in danger of running out of raw materials such as maize, barley, wheat or sugar? Do we need to look to alternative raw materials? Do we need to secure our own raw materials in a future where competition for feed, food and fuel exists?

To answer these questions we must consider where the people are, where they will be, what raw materials we use today and what raw materials we may have to use in the future. What technology is available and do we adopt it fast enough?

Population and meat consumption

Today's world population is 6.1 billion people. This is expected to increase to 7 billion by 2010. More than 80% of the people live outside the European Union, North America and South America. Furthermore, the growth is coming primarily from Asia. China predicts a population of 1.5 billion by 2030. India, with its awakening economy, is expected to grow to 1.3 billion by 2010, while Asia as a whole will represent some 70% of the world's population by 2010. North America's mere 300 million people or the European Union's 465 million are small in comparison.

A stark comparison exists when looking at meat consumption in developed countries versus developing countries. In the US, meat consumption is almost 120 kg per person per year. In China, meat consumption is a mere 50 kg, however, is expected to increase to 70 kg by 2030. India is a distant 10 kg. Even in the area of eggs - a key protein for underdeveloped countries - there is great disparity. Globally, egg consumption is approximately 120 eggs per person - rising in the US (up 6.4%) and Asia (up 7%) and declining in the EU (down 7%) and Russia (down 20%).

Furthermore, as income rises, so does protein consumption. Each 10 kg increase in meat consumption per capita for 1 billion people equates to 40 million extra tonnes of feed needed to produce those meat animals. For China alone this would mean as much feed as the world currently produces.

Relative feed production declines

According to a survey by the International Feed Industry Federation, the world feed production is approximately 618 million tonnes. This level of compound feed is primarily produced at the source of the raw materials and also where meat consumption is the highest. Global feed production was 82 kg per person in 1980 and increased to 96 kg per person in 2004. The high was 105 kg per person in 1995. Clearly, feed production has not kept pace with population growth.

When analysed in terms of feed per million people, regionally the outlook is even more alarming: the US produces 0.81 million tonnes of feed per million people; Canada produces 0.60 million tonnes. China, on the other hand, produces only 0.07 and India a miniscule 0.01 million tonnes per inhabitant. Should these countries move toward feed sufficiency or more meat consumption, a major movement in terms of grain production or grain importation will have to occur. Where would the grain come from? Do we have enough? What other raw materials could we use? What about cellulose?

Current and future raw materials

The current global grain and protein supply stands between 2,000 and 2,200 million tonnes, including 120 million tonnes of soy, the predominant protein for animals. The main cereals are maize (corn) at 700 million tonnes, wheat at 620 million tonnes, rice at 400 million tonnes, barley at 137 million tonnes, sorghum at 60 million tonnes, oats at

Figure 3 – Grain consumption vs. production

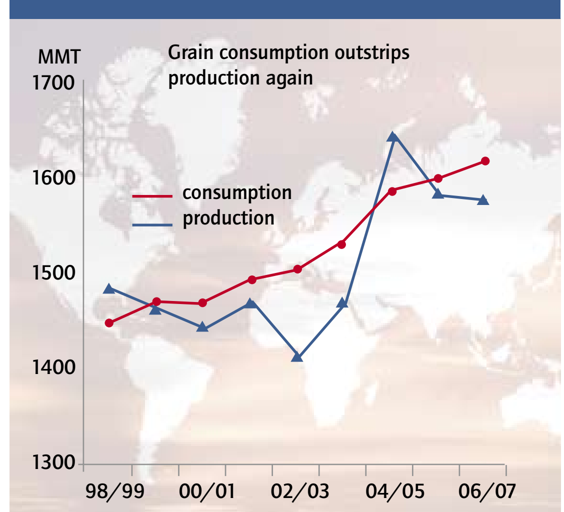

Table – World supply of cereal and starch (million tonnes)

Corn (Maize)	700	Wheat	620	Barley	137	Rice	400
USA	300	EU	122	EU	53	China	127
China	140	China	197	Russia	16	India	87
EU	131	India	72	Canada	13	Indonesia	36
Brazil	43	USA	57	Australia	10	Vietnam	22
India	33	Russia	47	Ukraine	9	Bangladesh	28
Mexico	26	Canada	17	Turkey	8	Thailand	18
Canada	26	Australia	24				
Ukraine	18	Ukraine	1				
Argentina	18	Turkey	18				

24 million tonnes and rye at 15 million tonnes (*see Table*)

Fuel alcohol programmes currently focus on these raw materials, and as they do, the consequences for feed supplies become significant. If the Kyoto Protocol and the Clean Air Act are enacted, these figures will change dramatically with 52% of the US grain crop removed from feed use and producing 47 million tonnes of fibre and protein source DDGS.

The balance of raw material/population/feed production by 2010 could look completely different than today. At the very least, the industry must find a way to use 47 million tonnes of DDGS as a protein source and energy source. However, the fact that government policies are mandating fuel independence will ensure tough competition for raw materials.

The protein side

As energy is becoming limited so, too, is protein. The predominant protein for animals is soy, with the US and Brazil being the largest producers. This protein is often supplemented with about 6.3 million tonnes of fishmeal, however, but both quantity and quality of fishmeal are decreasing. Price, on the other hand, continues to escalate with fishmeal now as high as US$1,500 per tonne. An alternative protein is required or at the very least a way to maximise the use of existing protein such as distiller's grains.

As previously noted, the current world protein and grain supply stands at 2,200 million tonnes, of which 120 million tonnes is soy. In certain parts of the world, starch can also be supplied from cassava (60 million tonnes) or rice (410 million tonnes). While the fish industry catches about 130 million tonnes, only 30 million tonnes goes to fishmeal. But, stocks are declining.

While maize, wheat and barley production can and will increase in countries such as the Ukraine, Brazil and Argentina, those nations also have ethanol programmes that will consume grain. The prediction is for grain prices to rise. In the US, the supply of corn is limited, causing land to be diverted into corn production for ethanol and away from other crops such as soy.

Focus on cellulose

In the presence of such multiple demands for land, the feed industry must have a flexible approach from raw materials to feed formulation. Utilisation of DDGS - an excellent protein source if it can be utilised - will increase, but so, too, must the use of cellulolytic materials. Cellulose, the ultimate renewable raw material, will have to be used for both feed and fuel.

It is estimated that 1.4 billion tonnes of fibre (cellulose) are produced annually in the US alone (including switch grass, wood shavings, etc.), which can also be converted into ethanol. In fact, the yield of ethanol (at 70 gallons per tonne of cellulose) is not too different from corn (100 gallons), but the technology has to be developed. The US Department of Energy's thrust for the next 20 years is in this area and it can also indirectly help the feed industry. If we can learn how to deconstruct cellulose into energy (glucose and xylose to ethanol) we can also learn how to use cellulose for feed. It is going to take a cross-cutting or a cross-fertilisation of technologies. The goal, however, is enormous. It is no less than a world of no oil imports, a world of no feed shortage, a world in which the non-ruminant may be fed like a ruminant.

How far off are we? Possibly 20-30 years. In the meantime we have technologies that we can certainly use when it comes to alternative raw materials for feed: Solid state fermentation and biorefineries.

Solid state fermentation

Some 4,000 years ago, the Chinese faced similar problems to those of today: limited protein and poor digestibility of raw materials. They developed what is called the koji process - or solid state fermentation (SSF) - where the microorganism does the "digesting" for us. SSF also includes a number of well-known microbial processes, such as soil growth, composting, silage production, wood rotting and mushroom cultivation. In addition, many familiar Western foods, such as mould-ripened cheese, bread, and many Asian foods including miso, tempeh and soy sauce, are produced using SSF. By combining the latest advances in microbiology and engineering, a revitalised SSF technology is applicable to today's feed industry. The fungi aspergillus and rhizopus feature strongly.

This is how it works: The selected fungus is first propagated in liquid media to produce a large volume of inoculum. This is mixed with pre-sterilised selected solid substrate (fibre) media to produce a mixture known as koji. Under strict aseptic conditions the koji is evenly distributed onto trays and introduced into environmentally controlled fermentation culture chambers. During this time, the fungus grows rapidly and secretes enzymes to break down the fibre to release nutrients it requires for continued growth.

This release of nutrients and the conversion of cellulose to glucose provide the opportunity. The fungus is doing the digestion for us and by harvesting the koji - the enzyme complex - we can then transport that ability to the animal. By varying the raw materials, the fungus varies its response. In the case of wheat bran, some seven different enzymes are expressed – more than 15 for distiller's grains. This, in effect, overcomes the inconsistencies of distiller's grains as a feed ingredient.

DDGS diets

Recent results from the Alltech University of Kentucky Nutrition Research Alliance have shown the potential to release as much as an extra 200 kcal/kg of apparent metabolisable energy (AME) in broiler chicken diets containing 25% DDGS. While preliminary, results such as these are extremely encouraging for the potential to allow nutritionists to consider adding DDGS to diets at levels previously unheard of. Consider that saving 200 kcal/kg is equivalent to 200,000 kcal/tonne of feed. Assuming an average fat has a value of 8,500 kcal/kg, one could theoretically save up to 24 kg of fat per tonne of feed.

Conclusion

The world is facing a food/feed-fuel dilemma. On the one hand, fuel consumption increases oil shortages and the agreement to limit greenhouse gases is encouraging the ethanol industry. The logical raw materials for ethanol are maize, wheat, barley and sugar cane. On the other hand, world population increases and prosperity advances an ever-growing appetite for meat and hence, feed. The world can simply not supply grains for both feed and fuel. While in such a competition, food (feed) will win.

Nonetheless, feed raw material supplies will become tight. Fibre utilisation from by-products or from cellulose will be the key for both food (feed) and fuel. Technologies that allow such utilisation, such as solid state fermentation (SSF), will play a major role. ■