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By De Wet Boshoff, executive director of AFMA

What will 2015 hold in store?

The new year is certainly a period to reflect on what the future holds in store for our industry.

Starting off on a positive note, we can look at the movement in the raw material markets, which actually started in the second quarter of 2014 and is believed to continue well into 2015. Commodity markets which are characterised by its volatility over the past two to three years, saw a drop in some of the main commodity prices since March 2014, causing feed prices to decrease in most cases, allowing a bit of a relief in the feed and related livestock industries from the constant cost pressure. These price drops come as world commodity markets are stocking up on the back of good crops experienced globally.

Local poultry processors have also seen price increases in the retail, although with very small increments and not always in line with food inflation and the average food basket. Poultry price increases are mainly due to a combination of variables such as anti-dumping duties against certain European Union (EU) member states (Germany, the United Kingdom and the Netherlands), as well as avian influenza outbreaks in these exporting countries, causing a ban on imports from these countries.

The question is how long the South African feed industry will continue to enjoy the benefits of the global raw material stock situation, and whether the South African poultry industry will effectively benefit from the trade remedies that currently apply?

In this regard AFMA recognises the fact that the single largest influence in the equation of an improved South African business environment, is the government. Therefore the government will receive the majority of AFMA's focussed attention. But a few highlights and critical focus areas worth mentioning are:

Legislation and regulations

With regard to feed legislation and regulations, AFMA wants to make a direct impact by assisting the government to finalise the consultation process with related industry stakeholders in a bid to complete the drafting of the *Feeds Bill*. This will commence early in 2015 with a joint stakeholders workshop that will deliberate the principles and intended approach to be taken to finalise the Bill.

Besides the larger legislative framework, AFMA has taken the bold step to create the necessary capacity in the AFMA office to assist and facilitate the administrative processes involved in feeds registrations (feed registration facilitation desk), in cooperation with the office of the registrar of *Act 36 of 1947* after an agreement was reached between the registrar and the AFMA board of directors.

Government cooperation structures

Under the leadership of AFMA, in cooperation with other livestock and related industry role-players, the restructured Livestock and Animal Feed Industry Forum (LAFIF) is about to start functioning in its new format in early 2015.

The new structure agreed upon and finalised in late November 2014 will provide the necessary technical working group structures to facilitate cooperation between the government and industry at all levels (Animal Health Forum, Animal Feeds Forum, Feed Safety Forum as well as the Animal Production and Meat Safety Forum). It is foreseen that the newly restructured LAFIF will not only cover more aspects of the livestock and feeds sector, but that it will also have a wider field of interaction with the government at a more senior level.

The Agricultural CEO Forum is also enjoying a much awaited revival under the leadership of the new director-general of the Department of Agriculture, Forestry and Fisheries, Prof Edith Vries. This revival will gain even more momentum due to the fact that the CEO Forum has been earmarked as the official structure of engagement between the government and industry in specifically driving the Agricultural Policy Action Plan (APAP) under the National Development Plan (NDP).

Food and feed value chain

Within the food and feed value chains (maize, wheat and oilseeds) AFMA will build on the positive breakthrough made during 2014 in terms of the private sector and the government on GMO product approvals. During 2014 AFMA and Sacota, in cooperation with Sansor, managed to convince seed companies to submit their GMO product applications timeously, allowing for synchronised GMO product approval to facilitate free trade.

This type of cooperation should not only continue, but must be intensified and expanded to address the current South African GMO approval policy to bring about a better dispensation for value chain partners from producers and traders to processors.

One of the most positive developments in the value chain structures since deregulation in 1997 is that the government was requested to join these structures with the aim of working towards a better understanding between the industry and the government.

AFMA optimistically awaits 2015 to maintain the momentum gained and to intensify the focus where needed.

Editor's Note

Apart from meeting the animal's basic requirements, the primary objective when formulating diets is to either maximise production performance or maximise profit margins according to the individual animal's needs. Even then this objective has to fall within the basic safety margins for animal health and liveability.

To attempt to increase profit margins or production performance of poultry, for instance, seems to be easier than with ruminants, considering poultry's more "fixed" and "easy-to-manipulate" environment, whereas the ruminant has variable and sometimes challenging conditions to contend with.

A lot of research has been focused on the physical form in which feed is presented to animals. For example, while there may still be a debate as to whether mash or pelleted feed should be fed to layers, mash seems to be the feed of choice in South Africa – be it for financial reasons or the possible benefits of pelleted feed.

Another example could be the optimum nutrient density of broiler pellets and how it is correlated to animal performance. On the ruminant side a lack of physical feed properties, such as short particles or low fibrousness, could result in rumen acidosis and the inhibition of milk fat synthesis.

The same purpose

In the case of ruminant feeds the application seems to be different, but the purpose remains the same. Yes, there may be more environmental variables affecting ruminant performance, but dietary characteristics, nutrient availability and feed density are just as important as with other species. Whatever the rationale behind the decisions producers and formulators use to decrease cost and increase profitability, the effort with which animals consume their diets also affects basal metabolism, hence energy expenditure.

The energy cost of feed consumption related to ruminants, is affected by not only the physical properties of a feed (physically effective neutral-detergent fibre – peNDF), but also by the chemical composition of its fibre component. This includes its acid-detergent fibre (ADF) or acid-detergent lignin (ADL) content, as well as the species of roughage (Suzuki *et al.*, 2014). Thus, the energy cost of mastication could also be available as an index of the physical properties of feed.

Changing characteristics

A lesser known fact is that the ratio of energy cost of chewing to metabolisable energy intake can be in the range of 6 to 9 MJ/100 MJ MEI, and is estimated at 2 to 5 MJ/100 MJ MEI for rumination (Susenbeth *et al.*, 2004). Therefore, ME loss caused by chewing could have some effect on animal productivity.

While the physical or chemical form of feeds are accounted for when measuring the production efficiency of ruminants, one has to wonder to what extent the changing characteristics of plant species and their products affect energy expenditure?

Before making any recommendations regarding optimum or maximum production parameters, we have to adhere to the basics of animal husbandry. Available nutrients per se are not the only driver of efficiency. Quantifying the cost of energy by the way in which the animal obtains its energy, must be accounted for.

Ockert Einkamerer

Published by: Plaas Publishing (Pty) Ltd
217 Clifton Ave, Lyttelton, Centurion, RSA
Private Bag X2010, Lyttelton, 0140, RSA
+27 12 664 4793 • www.veeplaas.co.za

Chief editor: Lynette Louw
+27 84 580 5120 • lynette@veeplaas.co.za

Sub-editor: Chris Jooste
+27 12 664 4793 • chris@veeplaas.co.za

Design & layout: Karien van Wyk
+27 12 664 4793 • karien@veeplaas.co.za

Advertising: Karin Changuion-Duffy
+27 82 376 6396 • karin@veeplaas.co.za

Advertising: Susan Steyn
+27 82 657 1262 • susan@veeplaas.co.za

Accounts: Marné Anderson
+27 72 639 1805 • marne@veeplaas.co.za

Subscriptions: Rochelle Mabebe
+27 74 153 8380 • rochelle@veeplaas.co.za

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PO Box 8144, Centurion, 0046, RSA
Embankment Road, 194 Kwikkie Crescent, Centurion 0157
Tel: +27 12 663 9097 · admin@afma.co.za
www.afma.co.za

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On the cover:
Zheng Chang Feed Machinery & Engineering
Tel: +86 21 6418 8282
Fax: +86 21 6416 3299
Email: info@zcme.com
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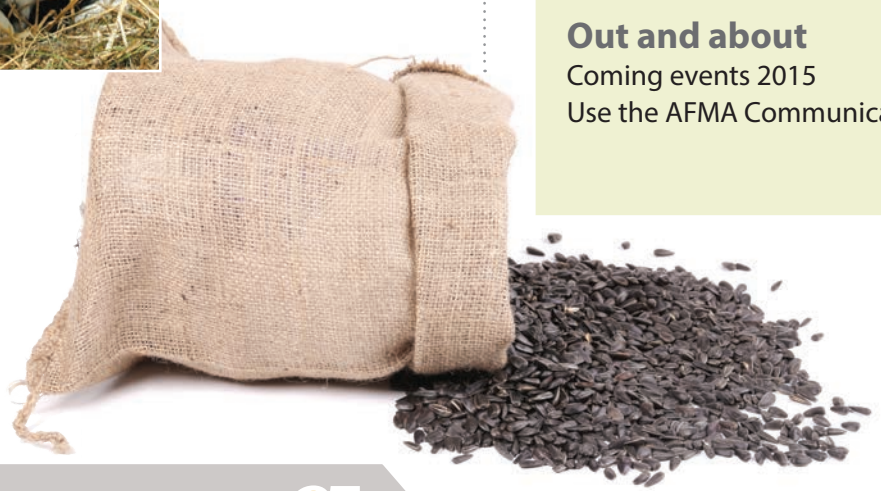

NEWS & views

Addcon moves to new headquarters

Addcon Germany, a major manufacturer and supplier of animal feed additives and silage inoculants, has moved its German headquarters to a newly-established multi-million Euro office complex in Bonn to provide farmers with more advanced technical services, says Klaus Oster, managing director of Addcon Africa Feed and Grain Additives, South Africa.

The new complex will accommodate, among others, the management, finance, sales and marketing departments. Space is also available to accommodate international events such as the International Silage Summit. R&D will remain at the two production sites in Bitterfeld, Germany, and Porsgrun, Norway.

Specialised technicians from the company's headquarters will visit South Africa from time to time to address technical issues concerning ruminant nutrition, including silage inoculants.

A recent visitor from the German headquarters was Dr Horst Auerbach, technical director, who warned pig farmers to take urgent and timely steps to break the salmonella cycle.

"Producers should take precautionary measures. These include pest control, heat treatment of feed, a coarse feed structure and the use of proven organic acids. Addcon has developed a worldwide highly successful and proven product range to combat salmonella," he said. – *Press release*

InVivo invests in Brazil

InVivo NSA, a subsidiary of the InVivo Group and a major French player in animal nutrition and health, has reached an agreement to acquire Total Alimentos, third player on the Brazilian pet food market. This operation confirms the InVivo NSA development strategy on this industry and allows it to get a key position on the Brazilian market, the second market in pet food after the United States at world level.

Total Alimentos generates revenues of €170 million and employs 1 400 people. The company also has key positions in dairy cattle, horse and aquaculture feed. The acquisition of Total Alimentos confirms the pet food global strategy of InVivo Animal Nutrition and Health, and allows it to get a key position on the Brazilian market. – *Press release*

AB Vista appoints Avipharm as SA distributor

AB Vista has announced a new distribution partnership with Avipharm, a leading poultry and pig specialist company based in South Africa, with offices in KwaZulu-Natal, Gauteng and the Eastern Cape.

Michael Noonan, AB Vista's business manager for the EMEA region, says: "Avipharm is a well-established distribution company and we are proud to be working with a partner that shares our commitment to excellent customer service and reliable supply.

"Thanks to this partnership, AB Vista customers will benefit from Avipharm's excellent distribution network across South Africa, and have ease of access to our range of feed ingredients.

"AB Vista's approach – including Quantum Blue super-dosing – fits in well with the generally high level of technical knowledge, understanding and acceptance of new concepts within the South African industry."

For more information, contact Dean Royden Turner at Avipharm on +27 33 342 7041 or email dean@avipharm.co.za. – *Press release*

Bupo Animal Health – the way forward

Bupo Animal Health is a South African company well entrenched in animal health since 1988. According to the founder and chief executive officer, Oscar H Bupo, Argentine born and South African at heart, the company is growing at a steady pace in the whole of the African continent with a business model fully adaptable to African conditions and needs. They aim at growing organically above South Africa's economic growth rates.

The company managed to ameliorate the recent South Africa poultry crisis. Their next strategic branch on the continent is Nigeria, where they are very close to opening in early 2015, with Ghana to follow in 2016.

Their main investments at the moment are a new manufacturing plant in Pretoria and the financing of their own operations. They have also decided to invest in a feed mill operation in Argentina, which produces 10 000 tons per month with two production lines in one shift. The mill caters for dairy and feedlots destined for exports (dairy and meat products to the European Union). – *Bupo Animal Health*

Revitalising the poultry industry

The Ghana Broiler Revitalisation Project (GHABROP) aimed at boosting capacity in production, processing and marketing of broiler chickens was launched in Accra recently. The project also seeks to develop the poultry industry along its value chain and ensure that production farms, input suppliers, feed mills, veterinary service producers, processors, marketers/cold stores and consumers all play their roles to ensure self-sufficiency.

The project, which is an initiative of the Ghana Ministry of Food and Agriculture in collaboration with the Ghana National Association of Poultry Farmers, will run for ten years. It was launched by Dr Hanna Louisa Bissiw, deputy minister of food and agriculture in charge of livestock, who describes it as necessary and crucial to the survival of the local broiler industry.

"As you may be aware, Ghana is deficient in its meat and milk requirements. Unfortunately the present levels of livestock and poultry production are woefully inadequate to meet the animal protein needs of the 24 million human population. This has resulted in Ghana becoming a net importer of frozen meat, of which poultry meat constitutes the highest proportion," she says.

Between 2010 and 2012, Ghana imported approximately 200 000 metric tons of chicken, which is equivalent to 2,6 million chickens per week. The target of GHABROP is to produce 30 000 metric tons of broiler meat with an expected increase to 60 000 metric tons by the year 2016.

To date eight hubs and 58 satellite farms have been selected to start the project in the Ashanti and Brong-Ahafo regions. The hub farms will subsequently work with satellite farms to grow more broilers for them under production contracts. – *Ghana News*

Chemunique invests in future talent

Chemuniqué is pleased to announce that Zeno Bester, Chemuniqué's ruminant technical manager for feedlots, has been accepted into the prestigious feedlot nutrition PhD programme offered by New Mexico State University in the USA in 2015. Zeno will be obtaining her doctorate in feedlot nutrition under the supervision of Drs Michael Hubbert and Clint Loest. Dr Hubbert is one of the most reputable and experienced feedlot consultants in the USA and is the superintendent of the Clayton Research Facility, where he mentors students in the finer nuances of feedlot nutrition and management.

This is a unique opportunity for someone as talented and passionate about feedlot nutrition as Zeno to obtain international experience from one of the foremost graduate programmes in the world in beef nutrition and management.

Currently the South African feedlot industry relies on nutritional expertise and advice from abroad, which comes at a significant cost from consultants who do not necessarily understand South Africa's unique production, management and economic constraints. Having Zeno applying her over ten years of local feed industry experience to her research and interactions at New Mexico State University, will no doubt add incredible value to the industry in the future. – *Chemunique*

Astral performs commendably

Astral Foods Limited released a set of robust final results for the year ending 30 September 2014. Chris Schutte, CEO of Astral, stated that the results reflect an improved performance by the group despite the local poultry industry continuing to face tough market conditions.

The group reported various increases including:

- Revenue increased by 13% to R9,6 billion.
- Operating profit up by 88% to R493 million.
- Headline earnings per share increased by 99% to 864c per share.
- Headline earnings increased by 100% to R330 million.
- Total dividend to shareholders for the year up by 98% to 440c per share.

Get the full report on the AFMA Communicator under Resources/ information.

Danisco scientist lectures on probiotics

The role of probiotics in animal production profitability and sustainability was the subject of a presentation by Dr Ajay Awati, senior scientist at Danisco Animal Nutrition, a subsidiary of DuPont Industrial Biosciences, at Animal Nutrition 2014 in October last year.

His talk covered aspects ranging from sustainability and profitability challenges to the symbiotic relationship between nutrition, the gut microbiota and immunity, and how probiotics can help address physiological challenges and improve healthy bird performance.

He said profitability and sustainability challenges can mainly be met by supporting the development of healthy gastrointestinal micro-biota. He revealed newly published research pointing to the vital role that probiotics played in resolving poultry production challenges such as foot pad dermatitis and necrotic enteritis (NE).

Dr Awati commented: "Numerous scientists have made the connection between healthy nutrition, a balanced gut micro-flora and animal immunity and performance. In my talk, I looked at how probiotics can help to solve sustainability and profitability challenges posed by animal physiology and 'gut reactions', and how this can be of broader benefit in terms of reducing pollution, increasing liveability and improving food safety and quality."

Dr Awati's presentation is available for download on the website animalnutrition.dupont.com. Alternatively send an email to info.animalnutrition@dupont.com for a copy. – *Press release*

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By Loutjie Dunn

Africa's animal feed awakening

While Africa's "awakening" has been much heralded as the continent continues to experience unprecedented growth in gross domestic product (GDP) and interest from investors in agriculture, the production of animal proteins has lagged behind. The consumption of animal protein is at an all time high, but livestock are resource-intensive, requiring more land, labour and water when compared with traditional plant-based production systems.

If animal protein consumption reaches similar levels to the United States, Europe, Brazil or China, and if these needs are met by local products, the animal feed industry in Africa could increase tenfold compared to today.

More efficient farmers

While the demand for meat is higher than ever before, we have fewer animals, fewer farmers and limited arable land. For example, in the 1970s there were approximately 45 million head of beef cattle in the United States. Today there are less than 30 million. Fewer animals in the United States are producing more meat and this is due to modern farmers becoming remarkably efficient producers of protein. Animals are bigger and healthier now, compared to 30 years ago (USDA, National Agricultural Statistics Service).

Can Africa model itself on the American market and become a consistent, reliable supplier of meat for itself and indeed, people beyond its borders in the future? To determine Africa's potential for animal protein, and consequently animal feed production, there are three main factors to consider: Population and demand for protein, available resources and the marketplace environment, both now and in the future.

Population and demand for protein

Africa is the world's second-largest and second-most-populous continent. It is comprised of more than 30 million square kilometres and covers 20% of the earth's total land area. *Figure 1* shows Africa's size in relation to several other countries.

Figure 1: Africa's size in relation to several other countries.

Although Africa houses over a billion people, it consumes significantly less animal feed if considered on a per capita basis compared to other regions of the world:

Table 1: Feed consumption per capita.

Region	Human population	Feed production (mil tons)	Tons of feed manufactured per inhabitant
United States	316 million	165	0,53
European Union	507 million	155	0,30
Brazil	220 Million	67	0,30
Africa	1,1 billion	29	0,03

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While Africans are increasingly consuming more meat on a per capita basis, it still lags behind other continents. Slowly but surely meat is becoming more available and affordable in Africa and people now have more disposable income to use towards the purchase of meat, but much of this is being imported from places such as Brazil. In particular, chicken is more accessible in Africa. Chickens are cheaper to raise and slaughter and have a better feed conversion rate than other livestock species.

The consumption of meat is growing at 2,7% per annum, while the consumption of milk and dairy is growing at 3,5 to 4% per annum. Meat production in Africa takes place mainly in Algeria, Egypt, Ethiopia, Kenya, Morocco, Nigeria, South Africa, Sudan, Tanzania and Uganda. Each of these countries produced in excess of 350 000 tons of meat in 2010 (FAO, 2010).

Africa's resources

In a paper published earlier this year, Van Rooyen stated: "Global food production may need to increase by 70% above 2005 to 2007 levels by 2050, in order to feed the world's growing population. While Africa and South America have an abundance of untapped agricultural resources to deal with this challenge, other continents will find it increasingly complicated to expand their use of agricultural production resources." (IFAMA 2014)

Table 2: Utilisation of arable land resources (Source: FAO and Standard Bank).

Region	1980-2004 (percentage)	To 2050 (percentage)
World	21	15
South America	16	40
Asia	46	12
Central & North America	-2	2
Europe	114	-2
Africa	18	60

Over the past decade, an unparalleled transfer of land ownership has occurred in Africa. Estimates that range from approximately 60 million hectares to more than 230 million hectares have changed hands (Connolly, *et Al*, 2012). This change has a number of implications for future food production on the African continent.

Investors have arrived in Africa and negotiated long-term leases of large tracts of land. African governments such as Ethiopia have deployed massive irrigation and infrastructure projects. Chinese, Korean, South African, Saudi and Indian investors see the potential of Africa to rival Brazil and Argentina as an important contributor to world food production.

African entrepreneurship itself is also rising, buoyed by improved incomes and more readily accessible microcredit. Interestingly, it is not just Ethiopia that has changed. Land ownership and leasing is changing the shape of Africa. For example Kenya, Tanzania, Nigeria and Sudan may seem unlikely candidates, but all are seeing dramatic changes in their agricultural landscape.

This isn't the first time outside investors have been drawn to Africa's natural resources, but this time they are interested not just in its minerals, but also the agricultural capabilities of the continent, and the investors are predominantly Asian. The World Bank said agribusiness will be a $1 trillion USD industry in sub-Saharan Africa by 2030 (2013).

Unfortunately, this outside interest could have negative consequences for Africa, mainly because of the prevalence of antiquated land administration systems. Very little land is legally registered to official owners, which means the remainder could be acquired and used without fair compensation.

Africa's abundance of land and water, combined with the fact that local African governments are eager to do business deals, has resulted in skyrocketing numbers of land deals and transfers of land ownership in this region. Nearly 1 000 different development projects encompassing over 160 million hectares in Africa were completed between 2006 and 2011 (Anseeuw and Ducastell, 2011).

"While some sceptics have viewed this as a form of land grab or new colonialism, others emphasise that this has potential to increase food security, employment and income generation," Van Rooyen points out (IFAMA, 2014).

Africa's food production?

Africa produces the lowest amount of milk of all global regions, at less than 50kg per person. The African countries producing the most milk are Algeria, Egypt, Ethiopia, Kenya, Mali, Morocco, Niger, Somalia, South Africa, Tanzania, Tunisia and Uganda, at one million tons each in 2010.

According to a report from the United Nations, there has been a decrease in the amount of starving people around the world over the last 30 years. Statistics reflect that there are now fewer mouths left unfed in the world, but the number of starving people is still staggering – more than 800 million – 214 million of those in sub-Saharan Africa and another 276 million in Southern Asia. Perhaps it is more accurate to reframe the discussion in terms of undernourishment, rather than starvation *per se*.

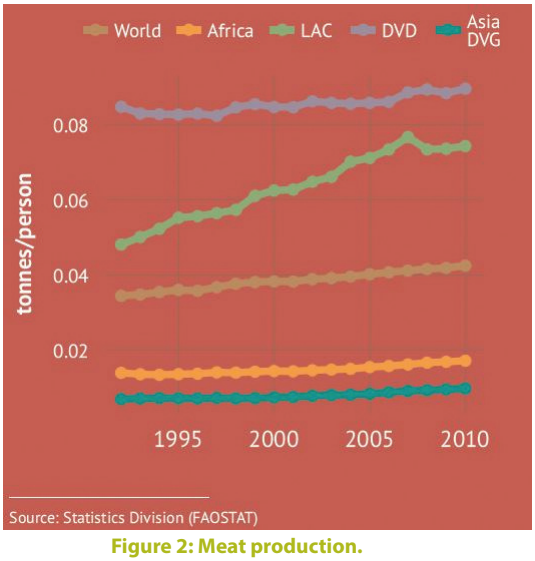

Figure 2: Meat production.

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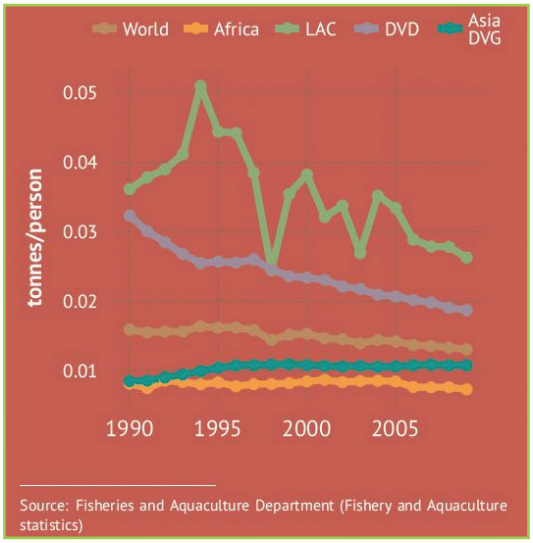

Figure 3: Fish production.

More than 60 countries have reached, or are expected to reach, their Millennium Development hunger targets, and the Global Hunger Index shows that overall, sub-Saharan Africa has a better score than South Asia (UN Millennium Development Goals Report, 2014). This is a twist on the thinking that Africa has the worst levels of hunger and it is a show of progress for the continent.

The world's population is expected to reach more than nine billion by 2050 and much of the planet's arable land is already in use. Inventors and innovators are now thinking of new ways to meet food shortage needs, such as artificial farms, vertical farms and growing produce on rooftops.

In order to identify the factors which are limiting Africa's ability to reach its animal protein production and consequently feed production capacity, the GLIMPSE framework (IFAMA, 2012) can be useful to develop the discussion (*Tables 2, 3 and 4*).

Table 2: Livestock production: Milk eggs and poultry.

	Milk			Eggs			Poultry		
			p.a. growth			p.a. growth			p.a. growth
	Thousand tons	Thousand tons	%	Thousand tons	Thousand tons	%	Thousand tons	Thousand tons	%
	2009	2010	2000-2010	2009	2010	2000-2010	2009	2010	2000-2010
Zimbabwe	389	396	-1.9	30	30	3.0	62	62	9.3
Africa	39 132	4 1081	4.0	2 611	2 758	3.7	4 428	4 672	4.6
ECOWAS	3 577	3 724	6.2	844	861	4.2	533	563	5.2
SADC	6 432	6 657	2.9	654	683	3.2	1 754	1 846	5.3
COMESA	211 709	22 446	4.0	739	806	4.4	1 324	1 356	3.1
UMA	5 837	6 047	3.7	541	578	1.8	1 088	1 181	4.7
ECCAS	787	828	1.6	41	42	1.4	111	116	6.0
IGAD	16 826	17 983	4.1	202	199	2.3	156	162	2.5
CEMAC	578	592	2.2	24	25	1.4	85	89	8.7
UEMDA	2 887	3 004	7.1	154	160	2.6	197	210	4.4
CEN-SAD	27 096	28 582	4.1	1 677	1 794	3.7	2 203	2 337	4.6
Asia developing	250 239	259 234	4.9	39 477	39 987	2.8	31 461	33 077	4.3
LAC	77 564	80 170	3.1	7065	7 109	3.4	20 205	21 242	5.4
Developed regions	341 289	342 589	0.3	18 896	19 229	0.9	38 133	39 499	2.4
World	708 292	723 143	2.2	68 067	69 103	2.3	94 251	98 517	3.7

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Table 3: Livestock production: Pig meat, beef and buffalo meat, and sheep and goat meat.

	Milk			Eggs			Poultry		
			p.a. growth			p.a. growth			p.a. growth
	Thousand tons	Thousand tons	%	Thousand tons	Thousand tons	%	Thousand tons	Thousand tons	%
	2009	2010	2000-2010	2009	2010	2000-2010	2009	2010	2000-2010
Zimbabwe	31	31	3.6	104	100	-0.2	13	13	-0.4
Africa	1 198	1 214	4.7	6 523	6 619	4.3	2 823	2 841	2.9
ECOWAS	343	351	3.7	935	1 001	3.5	813	838	3.7
SADC	629	640	5.4	1 641	1 723	2.0	372	371	1.5
COMESA	322	326	4.8	3 577	3 429	6.3	1 101	1 073	4.1
UMA	1	1	1.2	403	416	1.4	486	503	1.1
ECCAS	115	130	3.5	422	445	2.4	131	141	2.3
IGAD	131	130	3.7	2 341	2 307	8.4	900	889	3.7
CEMAC	51	60	6.0	290	311	2.8	91	101	2.9
UEMDA	79	78	2.7	544	604	5.1	327	342	4.7
CEN-SAD	370	376	3.6	4 066	4 074	6.1	2 018	2 024	3.0
Asia developing	58 711	60 639	2.6	15 538	16 017	2.5	7 903	8 005	2.7
LAC	6 482	6 445	2.3	18 220	17 334	2.3	435	436	0.4
Developed regions	40 089	40 778	0.9	27 323	27 613	-0.3	2 576	2 432	-1.7
World	106 565	109 167	2.0	67 626	67 603	1.4	13 738	13 714	1.7

Table 4: Fish production.

	Capture					Agriculture			
	Total	Inland	Marine	Total	p.a. growth	Inland	Marine	Total	p.a. growth
	Thousand tons	Thousand tons	Thousand tons	Thousand tons	%	Thousand tons	Thousand tons	%	Thousand tons
	2008	2009	2009	2009	2000-2009	2009	2009	2009	2000-2009
South Africa	645	1	510	511	-2.5	3	1	3	2.3
Swaziland	0	0		0	0.0	0		0	0.6
Zambia	79	85		85	2.7	9		9	8.0
Zimbabwe	10	10		10	-2.4	3		3	2.4
Africa	7 337	2 424	4 774	7 197	0.7	984	6	990	10.6
ECOWAS	2 041	637	1 362	1 998	1.0	163	0	163	19.8
SADC	2 385	716	1 466	2 182	-1.0	25	2	28	3.7
COMESA	1 744	1 308	418	1 726	1.4	812	1	813	9.5
UMA	1 473	22	1 596	1 618	2.7	5	4	8	8.5
ECCAS	846	421	401	822	0.1	4		4	3.2
IGAD	704	617	46	662	2.3	84		84	48.8
CEMAC	283	168	124	292	-0.6	1		1	-3.3
UEMDA	716	239	482	722	0.2	3	0	3	9.4
CEN-SAD	4 052	1 151	3 020	4 171	1.1	878	4	882	9.9
Asia developing	42 109	6 922	35 738	42 660	1.2	35 480	13 224	48 704	6.5
LAC	15 994	486	14 784	15 270	-2.9	763	1 125	1 887	9.4
Developed regions	23 480	477	22 647	23 124	-2.1	839	3 258	4 097	1.7
World	89 579	10 324	78 586	88 910	-0.6	38 065	17 611	55 676	6.2

In Africa the degree to which a particular country is primed for investment potential is influenced by government bureaucracy, policies and regulations. Investors can use indication transparency indexes or those measuring the degree of corruption to identify which are the most business-friendly. Alternatively one can follow the money and review the map generated by STRATFOR, listing countries which have collectively received over $100 billion in investment offers from China.

> Africa's natural environment, with abundant water, land and sunshine is a huge opportunity and will certainly be part of the solution of feeding a world with more than nine billion people.

Losses and infrastructure

A full third of food produced in Africa is lost or wasted, due to some of the inherent inefficiencies in processing, distribution and use. These issues are exacerbated by the poor distribution infrastructure, which prevents maximum return from the food supply. In the case of Africa, this is mainly roads and railways, but also the lack of refrigeration or a cold chain of distribution.

Markets

Nigeria may be set to become the world's third largest market, but the challenge for farmers is the lack of open and transparent markets. This is evident throughout Africa. African markets are often fragmented and depend heavily on middlemen, which makes it difficult for food producers to develop efficient operations, achieve full value from their produce or invest successfully in the future.

Policies

Government policies can present both opportunities and threats. For instance, both Ghana and Malawi have made substantial progress in halving the degree of poverty and reducing child mortality through subsidising fertilisers and seeds, which supports progressive markets for both large and small operations. On the other hand, policies can do harm by supporting bureaucracy and the wasteful use of resources.

Science

The unwillingness of consumers in markets such as the European Union to accept technologies such as genetically modified organisms due to consumer concerns is well documented. Interestingly, many African countries have followed this practice as well, even though these types of technologies could be very helpful in areas with a high risk of famine. Slowly, from Burkina Faso to Sudan, countries are gradually loosening the rules. The lesson here for investors is clear: Don't assume that because a country is poorer or underdeveloped, they will not embrace new technologies.

Environment

Africa's natural environment, with abundant water, land and sunshine is a huge opportunity and will certainly be part of the solution of feeding a world with more than nine billion people. Africa will need to sidestep the seemingly constant conflict to ensure the consistent and sensible use of irrigation and protection of its tropical soils in order to achieve long-term productivity. The Democratic Republic of the Congo, for example, not only has the highest rainfall in the world that supports dense grasslands in the north and savannahs in the south, but also a turbulent political history.

Marketplace outlook

What do economists say about the outlook for Africa? In 2014, some African countries, such as Kenya, started looking at their GDP figures differently. The newer figures are based on data from 2009 onward, giving a more positive picture of true growth in different areas such as communications, banking and manufacturing. Visit *www.economist.com/blogs/baobab/2014/04/kenya-recalculates-its-gdp-figures?zid=295&ah=0bca374e65f2354d553956ea65f756e0* for more information.

Conclusion

The consumption of animal proteins in Africa will rise naturally in tandem with its economic development. Initially these needs are met through imports, but logically its agricultural development shows great promise. With abundant resources of rainfall, land and sunshine, Africa is afforded advantages that the rest of the world is envious of in the quest to produce enough food to feed nine billion people.

Limitations may be described by the GLIMPSE framework, but these can be overcome by opening the potential for Africa to feed itself and export to the rest of the world. In such a scenario feed production would rise tenfold from its current level to nearly 300 million tons, making it the second most important continent in animal feed production. The question is whether it is a dream or a reality. The next ten years will tell. ❖

Cal Labs receives
ISO 17025 international accreditation

Central Analytical Laboratories, better known as CAL Labs, received ISO 17025 accreditation in October 2014. This is the highest technical accreditation available to laboratories worldwide.

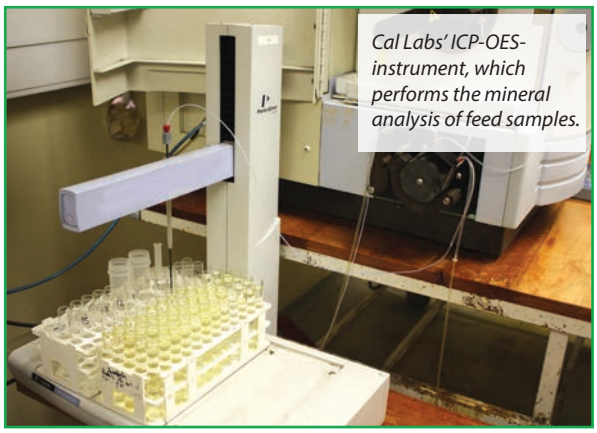
Awarded by the International Organisation of Standardisation (ISO), ISO 17025 accreditation is the standard by which a laboratory is deemed technically proficient. The criteria for this accreditation are concentrated on the general requirements for the capability of testing and calibration laboratories. There are two main areas of focus, namely the management requirements, which assess the operation and effectiveness of the quality management system, and the technical requirements, which include factors that determine the correctness and reliability of the tests performed by the laboratory.

CAL Labs received accreditation for nine mineral tests across a matrix, including monogastric and ruminant finished feed, pet food, oilcakes, forages and animal by-products.

Accepted internationally

Elaborating on the significance of this accreditation, Dr Neil Dominy, general manager of CAL Labs, said that the ISO 17025 stamp of approval is yet another means of assurance for those customers with international technical partners or owners. "We now have the international accreditation, which means our test results will be accepted internationally.

"This accreditation also means that our processes and capabilities are vouched for by a highly respected international external organisation. Animal feed manufacturers and other agricultural organisations have more trust in the results received from an accredited laboratory, and rightly so," he said.



Cal Labs' ICP-OES-instrument, which performs the mineral analysis of feed samples.

The accreditation process was by no means simple, as it meant that all of CAL Labs' policies and test procedures had to be scrutinised and verified in the finest detail. The management system requirements are similar to those of ISO 9000, which are about processes, paperwork and traceability. The technical system requirements are however more complicated.

"The use of a validated or accredited method is a requirement, technicians' competency must be proven and one has to demonstrate participation in a proficiency scheme that meets international guidelines. Tests are also run to prove accuracy and repeatability. In addition, one has to identify areas of variability and ways in which these can be controlled and the impact of this variability on the outcome of the tests can be correctly quantified," Neil explained.

Wide range of sample types

Nine of CAL Labs' mineral tests have been accredited across a matrix that includes monogastric diets, ruminant diets, pet food, cereals and cereal by-products, oilseeds and oilcakes, forages and animal by-products. The extensive accreditation allows CAL Labs to use a proven test method that accommodates a wider range of potential sample types than most accredited laboratories in the region.

This LC ms/ms instrument in Cal Labs laboratory is used for the detection and quantification of mycotoxins and infeed medications.

This accreditation is not only a feather in the cap of CAL Labs, but also of great benefit to the South African feed and pet food industry. Neil used feed exports to demonstrate this point: "Feed destined for Botswana has to be tested by an approved laboratory that is audited by the Botswana Bureau of Standards. ISO 17025 forms the basis of this audit, and they are very meticulous."

A track record of quality CAL Labs, a wholly owned subsidiary of Astral, was established in 1997 as a one-stop analytical


Cal Labs' fat analysis instruments.


Charlene van Staden in the receiving room, where all the feed samples they receive are registered for analysis.

service to the agricultural industry. Today, it is the leading commercial laboratory servicing the animal feed industry, its suppliers and customers.

Restructuring process

Originally, the lab's testing concentrated on proximate and mineral analysis. However, CAL Labs went through a restructuring process and opened a custom-built chromatography laboratory in Roodepoort, which made it the largest mycotoxin testing laboratory in the Southern Africa Development Community (SADC) region.

CAL Labs has a large customer base across the SADC region and currently employs 23 staff members.

Commenting on the award of the ISO 17025 accreditation, Astral CEO Chris Schutte said that it is a "commendable achievement". "CAL Labs was subjected to stringent tests and compared to an international peer group of laboratories over a period of five years leading up to the final accreditation.

Neil said that Chris, who was the managing director of Astral's feeds division at the time, was instrumental in the restructuring. "Our mandate was to decrease our turnaround time, because customers wanted the results as soon as possible – and we had to adhere to international quality standards.

Preferred laboratory

"We achieved a doubling of volumes and reduction of turnaround time by two thirds by adopting methodology from the Association of Analytical Communities (AOAC), the American Oil Chemists' Society (AOCS) and ISO, as well as substantial investments in the latest instruments as advised by international contacts. This investment in laboratory equipment has also allowed us to become the preferred reference laboratory for the soybean industry."

Andy Crocker, the current managing director of Astral's feeds division, Meadow Feeds, commented that the proficiency of CAL Labs will continue to be tested on a monthly basis on a wide range of analytics (proximate, minerals, infeed medications and mycotoxins) using a range of international accredited proficiency schemes from the Association of American Feed Control Officials (AAFCO), AOCS, BiPea and Neogen Africa.

Text and images courtesy of Poultry Focus Africa magazine.

By Rob Gous and Colin Fisher, EFG Software

Should we formulate diets for maximum or optimum growth response?

Animal nutritionists continually have to deal with changes – in ingredient prices, availability and quality and, in an integrated organisation, in demand for the product and hence the price being realised for these products. The extent to which these changes will affect the profitability of an enterprise, depends on how the changes are managed. The technical challenges raised by these changes need an immediate response if the enterprise is to weather these storms.

The nutritionist, mill manager, farm manager and marketing department all need to work together to maximise profitability in the entire enterprise rather than regarding each department as an independent profit centre. Feeding the broiler is only a small part of the total process but, whereas in the past it was not possible to take account of all aspects of production when formulating feeds, advances in simulation modelling now improve the prospects for achieving this goal.

Nutritional strategies

Poultry nutritionists base their nutritional strategies on the concept of a "nutrient requirement". This is seen as a characteristic of the bird and is the nutrient content required to support "maximum" production. Such requirements are published as tables by learned committees (e.g. NRC, 1994), by national extension services in many European countries, by breeding companies and by some universities and research institutes. Within a company the nutritionist will attempt to adapt these requirements to local circumstances taking some account of the business's objectives and also of economic circumstances.

The application of systems thinking and modelling to the problem of feed formulation leads to a new approach in which nutritional decisions are made entirely in terms of the objectives of the business. Nutrient specifications are chosen that will maximise profitability, not performance, subject to the constraints which act on the business and subject of course to avoiding any abuse of the animals. This is not the same as feeding to meet a "requirement".

Economic circumstances will change from time to time, and different nutritional strategies will be needed to maximise margins. Also, nutritional decisions will depend on the stage in the production process at which margin is to be assessed. For example if nutrition is optimised for margin at the farmgate, with live bird weight (and perhaps downgrading) affecting revenue then nutritional responses in growth, feed conversion ratio and mortality will need to be considered.

> "The important point is that opportunities arising from changes in input costs or product value need to be grasped immediately if maximum benefit is to be gained, and this is only possible if performance can be predicted rather than measured in the field."

If, however, margin is based on the production of processed portions or meat then nutritional responses in these characteristics, as well as those operating at the farmgate, will affect the outcome. These are real differences, each requiring specific nutritional decisions. Modelling enables these differences to be accommodated.

The process followed is not dissimilar from that proposed by Deming (1986) to improve product quality, except that in this discussion it is profitability and not quality that is being targeted, which is not to say that quality should not also be considered. The nutritionist's typical role at present is to complete the Plan/Do/Study/Act (PDSA) cycle by changing the formulation specifications and measuring the resultant response that is obtained in the field over a number of cycles.

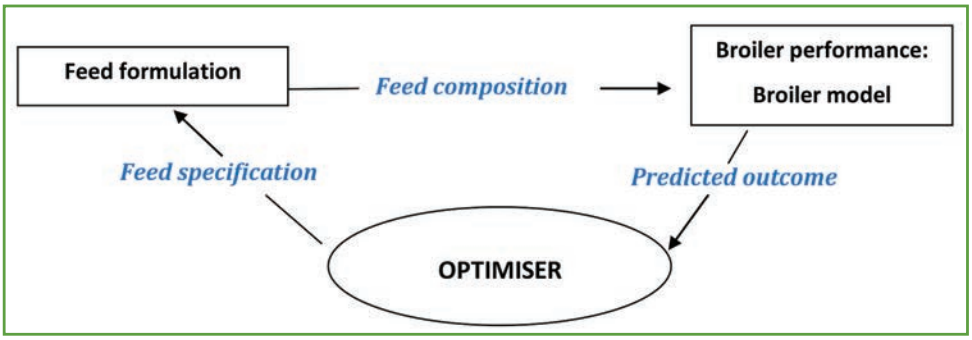
Benefit in good and bad times

Decisions about which nutrients to manipulate, and by how much, are generally made with reference to the shadow price of each limiting nutrient and without regard to the value of the end-product. Progress, if at all, is at best slow, but may be negligible. The important point is that opportunities arising from changes in input costs or product value need to be grasped immediately if maximum benefit is to be gained, and this is only possible if performance can be predicted rather than measured in the field.

The PDSA cycle could then be completed in seconds rather than months and the company would benefit in

good and in bad times. The role of nutritional modelling in this process is thus to predict nutritional responses so that the PDSA cycle can be automated through the process of optimisation. The process is illustrated in *Figure 1*.

Figure 1: Flow of information in optimising the feeding programme of a broiler chicken.



Bird populations cannot have "requirements" for nutrients: What nutritionists seek, are the optimum economic dietary contents of each nutrient, and for this they need to know how populations respond to increasing dietary contents of the essential nutrients.

Poultry nutritionists are interested in responses to nutrients in economically important outputs such as body weight (or protein) gain, breast meat yield, egg output, food intake and conversion efficiency, numbers of chicks produced per hen, etc.

Because such responses are usually measured using groups of birds, they are invariably curvilinear, being the result of integrating the responses of individuals making up that population. Populations of birds therefore cannot have "requirements" for nutrients: What nutritionists seek, are the optimum economic dietary contents of each nutrient, and for this they need to know how populations respond to increasing dietary contents of the essential nutrients.

Optimal approach

Descriptions of such responses, whilst taking account of marginal costs and revenues, are therefore invaluable in determining how to maximise or minimise the profitability of any given commercial operation. It should be made clear that the "optimum" feeding strategy referred to throughout this discussion is that which will maximise or minimise the objective function defined by management, and is very different from formulating to meet some fixed requirements at "least cost" that may or may not be designed to achieve maximum, as opposed to optimum, growth.

In the two sets of graphs, after Lemme *et al.* (2008), the consequences of following an "optimal" approach are compared with the approach taken by most conservative nutritionists, namely

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to follow the guidelines set by breeding companies.

In this case, the Aviagen recommendations for Ross 308 and 708 males and females are compared with balanced protein levels above and below the recommended under various economic circumstances: Different markets (farmgate versus further processed) and different relative ingredient prices. In 2006 the cost of dietary protein was lower than in 2008, and the range in costs from low protein to high protein feeds was considerably greater in 2006.

It was clear that there is a considerable advantage in moving away from the recommended dietary protein level under many circumstances. Although these recommended levels were optimal for male broilers in 2006 when selling birds at the farmgate, this was the only situation where profitability was highest when making use of the recommendations.

In virtually all other situations more money could be made by moving away from (either below in some cases or above) the recommended levels. The opportunity cost would not be realised if the breeder's recommendations were used.

The difficulty is being able to predict what the optimum balanced protein level should be under the prevailing economic circumstances. To do this effectively, it is necessary to predict the voluntary food intake of broilers given feeds varying in dietary protein content, and to do this it is essential to know the potential performance of the strain and sex.

Predicting responses of poultry to nutrients has been a goal of nutritionists and modellers for a long time. The controlled feeding model of a growing pig (Colin Whittemore's Edinburgh Model Pig) was the first serious and successful attempt to integrate information about an animal, its feed and the environment in which it was kept, with a view to simulating its performance.

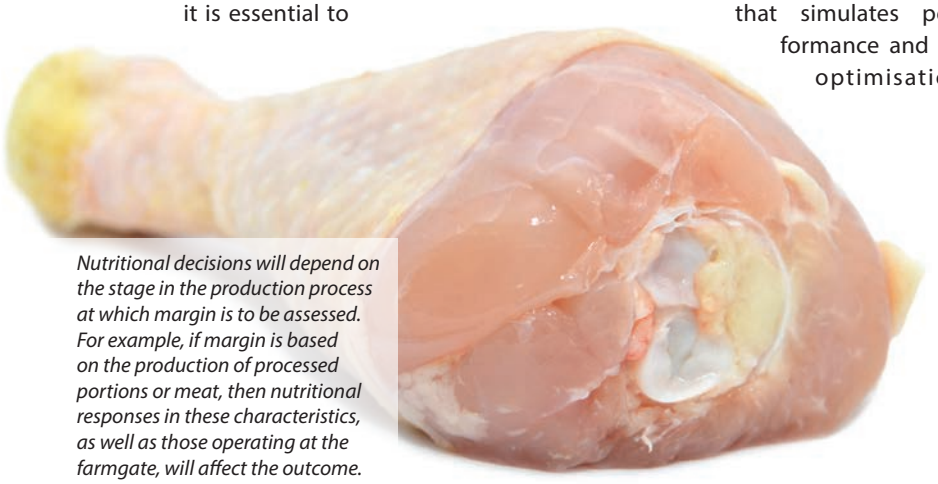
This provided the impetus for the development of further models, for modifications to existing models and for research targeted at filling the gaps in our knowledge of critical aspects of the theory incorporated into these models.

Predicted performance

The most important subsequent contribution to response modelling was the theory proposed by Gerry Emmans to predict voluntary food intake in poultry and pigs. Use of this theory in models made food intake an output from the model, as opposed to an input, thus greatly enhancing model value, especially for growing poultry.

Once food intake has been predicted, the performance of the broiler can also be predicted, leading to the possibility of determining the feeds and feeding programme that will maximise or minimise the objective function defined by management.

The process involves a feed formulation programme, a model that simulates performance and an optimisation algorithm (equivalent to the key elements in Deming's PDSA cycle). Models incorporating this theory are more realistic and useful, providing the nutritionist with a tool for making decisions about the most appropriate course of action to take under different circumstances.



Nutritional decisions will depend on the stage in the production process at which margin is to be assessed. For example, if margin is based on the production of processed portions or meat, then nutritional responses in these characteristics, as well as those operating at the farmgate, will affect the outcome.

> "The difficulty is being able to predict what the optimum balanced protein level should be under the prevailing economic circumstances."

The optimiser manages in a few minutes what a nutritionist would take months to achieve, if at all. It works from a given starting point and then varies the diet composition or feeding programme until the combination of circumstances which maximises (or minimises) the objective function is reached. The feeds being formulated, invariably at least cost, at this stage are optimised for the conditions used.

What is this objective function? Normally the objective function will be some measure of profitability, but any output parameter from the growth model may be used for this purpose. Because the optimum feeding programme for broilers is that which results in the highest profit for the enterprise, to be of economic relevance objective functions should include revenue, space and time, the most obvious example being margin/m^2 per annum.

Considerable savings

This takes account of both the fixed and variable costs of production and the income derived from the sale of the product. In broiler production, fixed costs are invariably high, so throughput is particularly important. Reducing the

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The controlled feeding model of a growing pig (Colin Whittemore's Edinburgh Model Pig) was the first serious and successful attempt to integrate information about an animal, its feed and the environment in which it was kept, with a view to simulating its performance.

age at slaughter by one or two days results in considerable savings in fixed costs. Such objective functions are more sensible than attempting to minimise feed conversion ratio, for example.

Determining the optimum concentrations of amino acids relative to energy in each feed, the optimum nutrient density and the optimum length of time (or amount) that each feed should be fed, are therefore both a nutritional and an economic decision. The information required for optimisation consists of feed costs at different levels of amino acid provision, a description of all the relevant animal responses, both fixed and variable costs affecting the production system, and details of revenue.

The complexity of the information required would depend on the level of organisation at which the optimisation is to be made. If profit of the broiler grower is to be maximised at the farm gate, then responses in liveability, growth and feed conversion ratio will probably suffice. However, and more realistically, a wider view will be required, and the effect of broiler nutrition on slaughterhouse variables (eviscerated yield, rejects etc.) and further processing (carcass composition) will need to be defined.

The approach described above, of defining the composition and amount of each feed to be offered to broilers during their growing period, differs considerably from that of meeting fixed nutrient requirements at least cost, which is the approach most commonly used in the broiler industry at present. It is now possible to change the emphasis when choosing nutrient specifications for formulating feeds from "least cost" to "maximise profitability" subject to the constraints which act on the enterprise.

Because economic circumstances change periodically, different nutritional strategies will be needed to maximise margins. Instead of sticking rigidly to a set of nutrient specifications it is possible, with the use of simulation models, to respond immediately to those changed circumstances, ensuring that the profitability of the enterprise is maximised under all economic circumstances. Such is the way that broilers should be fed in the future.

For more information about the software that can be used to optimise the way in which broilers and pigs should be fed during growth, visit *www.efgsoftware.net.* ❖

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The successful candidate will be a self starter, who enjoys a challenge, while working with people and have the ability to work largely unsupervised. The candidate will be responsible for promoting the sale of our dairy range of feeds and for providing on farm technical and nutritional support to farmers.

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By Ioannis Mavromichalis, PhD

Sunflower ingredients in pig feeds

Sunflower by-products are a viable alternative to soybean meal, especially in countries with a colder climate. Sunflowers (*Helianthus annuus*) are grown mostly in cold climates for their seeds. These are used for oil production or as a confectionary item. There are distinct varieties for each use because confectionary seeds are not rich enough in lipids for efficient oil extraction.

Sunflower meal is the residual matter after oil extraction, usually by the use of solvents (as in the case of soybeans), but also by hydraulic pressure (older but still used method). The latter process produces sunflower meal rich in residual oil, and this should be taken into account during feed formulation.

Sweet taste

Pigs will readily consume diets based on sunflower meal, assuming upper crude fibre limits are not exceeded. The appetising effect of sunflower meal is due to the small concentration of sugars, which gives a slightly sweet taste to feed. This is very important, especially for piglet feeds, where a sweet taste is often simulated by the use of artificial sweeteners.

No anti-nutritional factors

Sunflowers contain no known anti-nutritional factors, in contrast to other protein sources such as soybean meal that contains a plethora of such compounds. Nevertheless, the use of sunflower meal in poultry and pig diets is restricted by its concentration in crude fibre, something that is considered undesirable, with a few notable exceptions (as in diets for gestating sows). In any case, sunflower meal can be included freely in diets as long as dietary crude fibre concentration does not exceed 3 to 5%.

Commercial products

Sunflower meal is available commercially in three forms, depending on the level of hulls in the final product, which determines the final crude fibre level.

> "The appetising effect of sunflower meal is due to the small concentration of sugars, which gives a slightly sweet taste to feed."

Dehulled sunflower meal contains no hulls and is the most desirable, albeit the most expensive, product. It has about 38% crude protein and 14% crude fibre. This is the preferred type of sunflower meal for piglet and sow lactation diets.

Partially dehulled sunflower meal contains a (variable) part of the hulls. Usually, it has approximately 32 to 35% crude protein, and 20 to 25% crude fibre, with exact levels depending on the concentration of hulls. This product is suitable for growing pigs and sow gestating diets.

Standard sunflower meal contains all the seed hulls. Here the crude protein concentration is usually less than 30%, with approximately 25 to 30% fibre. This product should be avoided in low-fibre diets, but it can be used in maintenance diets (boars, gestating sows), or when growth rate must be reduced (as in late finishing pigs).

Sunflower seeds (full fat) are often available after being discarded by the oil or confectionary industry for a number of reasons pertaining to their quality. Whole seeds contain about 16% crude protein, 45% oil and 16% crude fibre. Research has demonstrated that the high fibre content in whole seeds places them in the same level with sunflower meal in terms of usage limits.

But, in addition, it appears the high oil content in full-fat seeds creates further feed intake problems, related to palatability, even in cases where a high-fibre concentration is not a major concern, such as in gestating sows. ❖

Article courtesy of *Pig International*.

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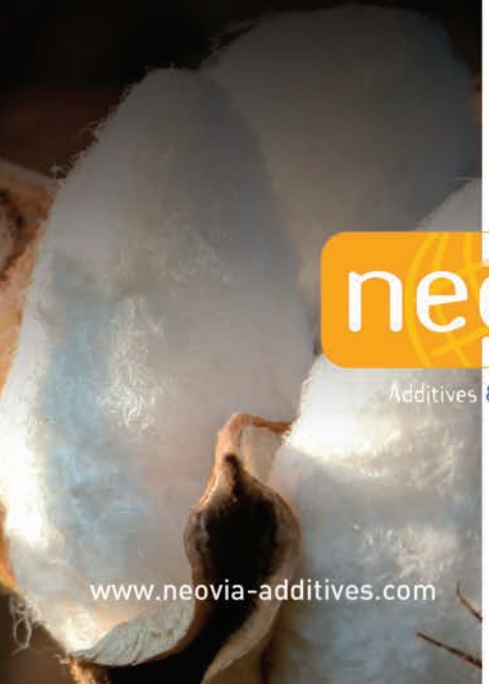

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By Zoe Kay, Feed International

Additive technology improves alternative feed ingredient performance

The use of alternative raw materials to reduce reliance on imported materials and improve sustainability has been much discussed. Food security is high on the agenda for government and retailers, so research into home-grown crops and co-products is important.

There are economic, logistical and agronomic reasons why these resources are not used to their full potential. However, this article will look at performance limitations and how various technologies can improve them.

Challenging materials

There are several challenges to formulating with alternative raw materials. They may be higher in fibre or include anti-nutritional factors (ANF). In particular, there are higher levels of insoluble fibre in crops like sunflower and oilseed rape (canola). Arabinoxylans form complexes with protein, reducing nutrient availability. Digestibility is therefore lower and it results in more undigested material in the digestive tract. This in turn can encourage the proliferation of pathogens, which has a negative effect on poultry health and performance.

Consistency can be a particular issue when using co-products. Nutrient profile and digestibility may vary between sources and even batches. In a recent experiment, four batches of dried distillers grains with solubles (DDGS) were each fed at two different levels to laying hens. There were significant differences in digestible energy and protein digestibility between the batches that were not correlated to differences in proximate nutrient composition. This unpredictability will have a corresponding effect on the productivity of the birds.

Processing for improvements

There are various options to process or treat raw materials prior to feeding in order to improve their nutritional value. Pulses may benefit from de-hulling to reduce both the fibre and ANF levels. Heat treatment has been used to improve digestibility of a variety of cereals and pulses. Micronisation, in particular, has a positive effect on insoluble fibre, meaning that nutrients have a longer time to be digested and absorbed.

The use of enzyme pre-treatment for co-products like DDGS and rapeseed meal has been investigated. The use of proteases is particularly interesting to make protein more digestible before it is fed. Phytases are already used in ethanol plants, resulting in lower levels of phytate in DDGS. However, cost and logistics currently preclude these kinds of processing despite the significant opportunities.

Enzyme technology

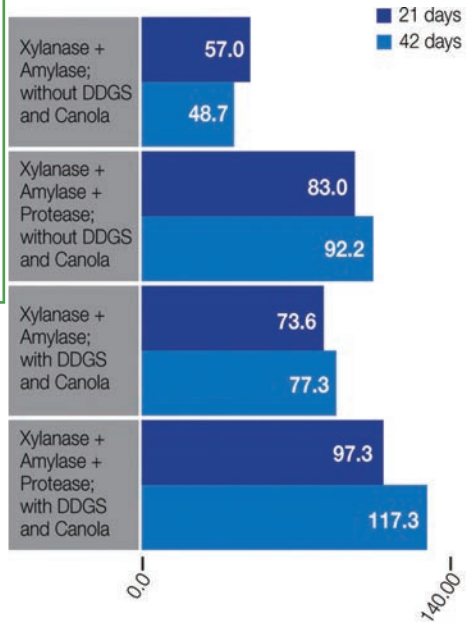
Enzyme technologies can help to improve feed formulation precision, diet efficiency and ultimately performance by reducing raw material variability. They also have the potential to complement endogenous enzyme production, sparing energy. When formulating with alternative raw materials, there is more potential for enzymes to have a positive effect than with standard diets.

Luis Romero from Danisco Animal Nutrition stated: "In general, you see bigger energy and protein digestibility improvements with alternatives."

This is particularly true for the disruption of protein-fibre interactions, which are important in DDGS, rapeseed and sunflower.

A recent broiler digestibility study looked at the effects of adding high-fibre ingredients to both corn- and wheat-based diets. Corn DDGS and rapeseed meal had the effect of reducing the availability of protein in particular. Greater effects of enzymes were found in the higher fibre diets, increasing the combined energy contribution of protein, starch and fat (*Figure 1*).

Figure 1: Improvement of ileal digestible energy from starch, fat and protein (kcal/kg dm).



Contribution of protein, starch and fat to the apparent ileal digestible energy of corn and wheat-based broiler diets in response to exogenous xylanase and amylase without or with protease.

"The additive protein digestibility effect of protease on top of xylanase and amylase was also demonstrated," Luis reiterated.

The lower digestibility of alternatives means there is the potential for more undigested material in the poultry digestive tract. This creates an environment that is favourable for pathogen growth, making birds more susceptible to enteric disease. Xylanase is able to create the prebiotic compounds arabino-xylo-oligosaccharides from cereals. They encourage the growth of beneficial bacteria and the production of short-chain fatty acids.

Performance benefits

A number of investigations have been carried out to demonstrate the efficacy of enzymes in diets containing alternative raw materials. These recent examples were presented at the 14th European Poultry Conference 2014 and are summarised below.

In two trials, broilers were fed diets made up of corn, corn DDGS, soybean and rapeseed meal – supplemented with either xylanase or xylanse and beta-gluconase. The enzyme combination significantly improved FCR and ileal digestibility energy, compared to the control. Both treatments significantly improved starch digestibility and tended to improve ileal fat digestibility (*Figure 2*).

Another study fed broilers diets containing three different levels of rapeseed and sunflower meal, with or without an enzyme combination, i.e. xylanse and beta-gluconase. Birds fed diets with high (H) levels had lower weight gain and poorer FCR, compared to those fed the medium (M) or low (L) treatments. Enzyme supplementation was shown to significantly improve FCR for the three diet types, with the highest response being seen in the H treatment.

Novel strategies

The combination of different groups of feed additives with potentially complementary modes of action, e.g. probiotics and enzymes, has also been investigated. These can help to improve digestibility, support a healthy gut microbiota and improve bird liveability. In trials with non-challenged broilers fed a corn-soy diet containing some fibrous cereal by-products, significant incremental increases in nitrogen corrected apparent metabolisable energy (AMEn) with additions of a three-strain Bacillus probiotic and xylanase, amylase and protease enzymes. Luis commented: "This combined mode of action further improves the digestibility of alternative raw materials."

Older birds deal better with solubilised fibre due to gut maturity. This is why the use of some alternatives is limited or precluded in younger poultry. By having a maturation effect on the intestine, the combination of enzymes and DFMs could allow some increase in levels. Laying hens, breeders and turkeys have longer lifecycles, and so have a larger fermentative capacity and are able to better digest fibre. Therefore there is even greater potential for enzymes to improve performance in diets containing alternative raw materials.

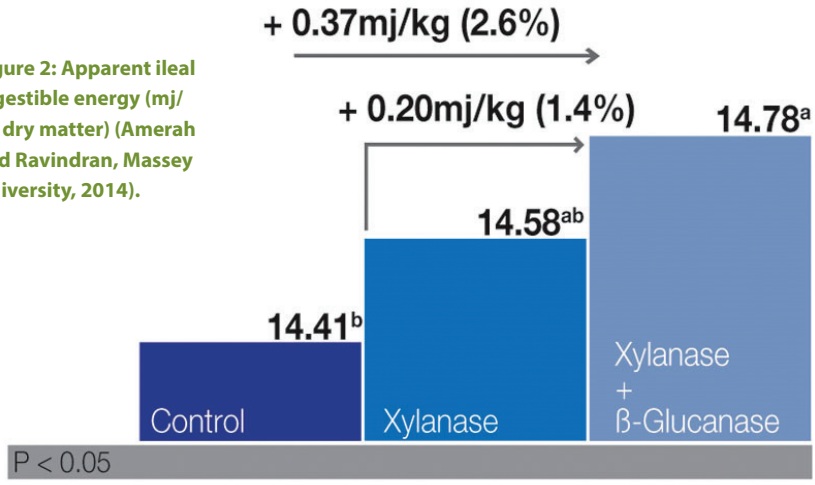


Figure 2: Apparent ileal digestible energy (mj/kg dry matter) (Amerah and Ravindran, Massey University, 2014).

abvalues without a common superscript are significantly different (P<0.05)

Enzyme combinations significantly improved FCR and ileal digestibility energy in two 21-day trials, where broilers were fed diets made up of corn, corn DDGS, soybeans and rapeseed meal supplemented with either xylanase or xylanese and beta-glucanase against control.

> Older birds deal better with solubilised fibre due to gut maturity. This is why the use of some alternatives is limited or precluded in younger poultry.

Future possibilities

With advancements in enzyme technology it is possible to significantly improve poultry performance when fed rations containing alternatives. By improving the digestion and absorption of nutrients, nutritionists are able to make greater use of ingredients like DDGS, rapeseed and sunflower. This offers flexibility when formulating different types of diet, dependent on both the cost and sustainability of the raw materials.

Research has shown that enzyme combinations are particularly effective when feeding alternatives. Whilst carbohydrates help to improve fibre digestion, proteases are interesting to get more value from lower quality protein sources. Enzyme producers are looking at the possibility of creating raw material specific matrixes for their products.

This would enable formulators to better predict the nutrient value of alternative raw materials, particularly when there is variability, creating confidence in consistent poultry performance when fed rations containing these products. Then potentially alternative feed ingredients can be included at higher levels, benefiting both efficiency and environmental impact.

Article courtesy of *Feed International*.

Small-scale fish feed production now available

It is well-known that the aquaculture industry is expanding fast worldwide. Today, over half of all fish consumed comes from farming operations. This young, dynamic and profitable industry nonetheless faces many challenges, including environmental protection and disease control.

In Africa, there are added hurdles such as a lack of regulatory frameworks for water rights, a lack of quality feed at a price which allows the fish farmer to make a profit and a lack of fingerlings. One tilapia farmer in Ghana sums it up as needing "feed and seed".

While there are plenty of equipment suppliers offering extrusion equipment for larger-scale fish feed production in the 5 to 10mt/hour range, many feed companies in Africa cannot afford a multi-million dollar investment for a market that is still discrete.

New 1mt/hour extruder

Insta-Pro aims to change the game by offering the MS 3000, a 1mt/hour 125hp medium-shear extruder with the same high-quality output as large volume extruders. The MS 3000 is designed specifically for floating fish feed pellets and other shaped feeds such as pet food and horse treats (*Table 1 and 2*).

The MS 3000 comes with a steam pre-conditioner and cutter head for pellet shaping. Pellet sizes range from 2 to 8mm and larger. Of course fish feed production requires ancillary equipment too, such as a fine-grind hammer mill or pulveriser, a mixer for blending raw ingredients and premix, and a dryer-cooler to dry pellets down to 10% before storage or bagging.

Table 1: Insta-Pro MS 3000 Extruder – specifications.

Model	Power main motor	Drive	Weight	Dimensions
MS 3000	125hp, 94kW	Single-ribbed, non-slip belt	2 640kg	L x W x H 343x203x267cm

Table 2: Insta-Pro MS 3000 Extruder – capacity.

Fish and aquatic feeds	Pet food
850 to 1 000kg/hr	1 000 to 1 500

Insta-Pro also offers a medium-shear conversion kit, which enables customers who already own an Insta-Pro high-shear extruder for processing soy or cereals to convert their high-shear to a medium-shear extruder at a minimal cost. An Insta-Pro service technician – there are already three resident in Africa – can make the conversion on-site or the customer can convert himself with the help of an easy-to-follow instruction video.

Less drying needed

When it comes to drying moist fish pellets, Insta-Pro offers an unseen advantage. The industry norm for standard wet extrusion systems for fish feed is 24% RMC (remaining moisture content), which means pellets must lose 14% moisture in the dryer. The MS 3000 produces high-quality pellets with only 18% RMC, needing only 8% moisture removal – this offers a 43% advantage in drying costs.

The MS 3000 remains a "dry" extruder in the Insta-Pro tradition. No steam is added in the barrel.

The extruder is ergonomically designed, with the barrel positioned for easy maintenance and the cutter head on a swing arm that can be moved by a single operator. A rounded platform minimises material build-up and an open base facilitates wash-down. The steel frame is designed to increase rigidity and reduce vibration to a minimum.

Medium-shear versus high-shear

Whereas high-shear extrusion is required for oilseeds and cereals, which are cooked at high temperatures under high pressure over a short period, medium-shear is a gentler process. When making shaped products, less heat and more moisture are required. This enables a gentler extrusion process and greater capacity during the 20 seconds that the ingredients spend in the extruder.

As a result, less mechanical energy is needed, which can result in lower production costs. The MS 3000 has been designed with proprietary component geometry to cook and handle material less aggressively than high-shear extruders.

Sinking or floating fish feeds

While each ingredient affects the final product, starch and fat levels are especially important. In general, starch expands during extrusion and lowers pellet density, which promotes floating. Sinking feed typically

contains 10 to 15% starch while floating has 20 to 25%.

Fat has the opposite effect – it prevents expansion during extrusion. Higher fat contents inhibit expansion and increase pellet density, which promotes sinking. Similarly, heated animal proteins do not expand well.

Higher temperatures and more moisture promote starch expansion and encourage floating. In most cases, the extruder will be operated within a temperature range that varies about 20°C to make both sinking and floating feeds.

Diet formulation is important. Insta-Pro offers a formulation advisory service for all animal feeds, including fish feed and pet food. Typical formulas for specific species of fish can be prepared with locally-available ingredients and local prices.

Food for dogs and cats

When it comes to feeding dogs and cats, sinking and floating is no longer relevant, but making a wide variety of shapes and sizes is important. Insta-Pro offers customised die inserts which allow for a wide range of sizes and shapes suitable for dry pet foods and treats.

Modular system

Modular systems are a hallmark of Insta-Pro extrusion processing. Several MS 3000 extruders can be installed side by side, permitting a high level of production flexibility. This facilitates capacity expansion – just add another extruder – and enables the processor to adapt day-to-day production to market conditions by switching extruders on and off.

The MS 3000 offers African feed millers and larger fish farming operations the means to produce their own fish feeds to the same high standards as larger extruder models, but without the high level of investment and risk that large volume production demands. As such it is an ideal market entry model, supplied with the same high standard of technical assistance and friendly professional support that Insta-Pro customers have learnt to expect.

For more information, visit *www.insta-pro.com.*

Insta-Pro has parts distribution centres in Cairo, Lagos, Limbe and Nairobi, as well as a rapid parts delivery service from its head office in Des Moines, USA.

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By Norman Downey, ruminant species technology manager, Cargill Animal Nutrition, EMEA region

Calf and heifer performance affects longevity

In an average European dairy herd about 25 to 35% is replaced annually with replacement heifers of which the rearing represents one of the largest costs within dairy farming. The average age of first calving (AFC) and the onset of the first lactation range from 26 to 30 months in most European countries.

A reduction in the non-productive rearing period provides an opportunity to reduce rearing costs. Besides the reduction of rearing costs per heifer, the reduction in the number of young stock required impacts profitability when AFC is reduced (Mourits, 2013). The impact of AFC on longevity and lifetime production was examined in a Belgian database, where animals that first calved at 24,6 months had more lactations and productive days during their life (Froidmont, 2012).

In a meta-analysis performed by Heinrichs (2006) the optimum growth required during the entire heifer rearing period until calving was established to be 800 grams per day for Holsteins. Excessively high average pre-pubertal growth rates can affect the development of the mammary gland negatively due to an increased gain of adipose tissue in the mammary gland (Sejrsen, 1996).

However, increased average gain during the pre-weaning period established through pre-weaning nutrient intake can have positive effects on development of the calf, first lactation and lifetime productivity as implied by a meta-analysis performed by Soberon (2013).

As the majority of the studies in this meta-analysis correlate a poor growth in the control group to lower first lactation milk yield as compared to the treatment group, the conclusion should be drawn that poorly formulated milk replacers fed at low rates might be detrimental to the productivity of the animal compared to adequate to high levels of whole milk or milk replacer (Heinrichs, 2013). The magnitude of this effect when comparing a moderate growth to an exceptional growth under European conditions remains to be observed.

> In a liquid feeding programme cow's milk is often seen as the most natural and convenient way of rearing calves as it is always there and often in excess.

Colostrum intake and health

Acquisition of passive immunity has long been recognised as essential to calf survival and health. Current recommendations are for calves to consume 150 to 200 grams of IgG with the first meal occurring within two hours of birth. Colostrum hygiene must be managed to minimise bacterial contamination – samples of colostrum should routinely be evaluated for total bacterial counts to ensure sanitary handling. Colostrum should contain <100 000 cfu total bacteria/ml to be considered good quality.

Variation in apparent efficiency of IgG absorption (AEA) indicates that many factors influence a calf's ability to absorb and retain antibodies. Some factors affecting AEA include age at feeding, prepartum diets, pasteurisation of colostrum, breed and sex of calf, method of feeding colostrum and others. Management to maximise AEA and minimise rates of failure of passive transfer (FPT) are essential in immunising the risk of disease and death loss. Unfortunately, rates of FPT and neonatal morbidity and mortality remain unacceptably high in dairies in many parts of the world.

Feeding calf milk replacer

To achieve these standards in pre-weaning weight gain, several management factors need to be aligned of which colostrum management is a key determinant, next to hygiene, housing and feeding management. In a liquid feeding programme cow's milk is often seen as the most natural and convenient way of rearing calves as it is always there and often in excess (e.g. milk above quota,

antibiotic milk and milk with a high cell count).

Nevertheless, feeding calf milk replacer has many advantages compared to cow's milk. Besides hygiene and price, the composition of calf milk replacer is considered to be more optimal to match the protein and energy requirements of today's calf.

The composition of cow's milk has changed over decades of genetic selection for yield, fat and protein, leaving a sub-optimal composition coupled to modified calf requirements in modern-day rearing systems. Cow's milk has a higher fat content compared to calf milk replacer and coupled to the digestive physiology of casein, the most predominant protein type in cow's milk, leaves calves feeling more satiated.

When targeting a pre-weaning growth rate of at least 750g/day, a high quality and sufficient quantity of calf milk replacer should be fed. Liquid feed should contain a sufficient level of protein, and protein to energy ratio (51g CP/Mcal ME; Hill, 2009) to optimise muscle development and limit fat deposition. Opposite to common practice in monogastrics and lactating dairy cow rations where diets are balanced for amino acids, it has only been recently that this has gained attention in the liquid feeding phase of young rearing calves.

Moreover, as predicting amino acid requirements are complicated in a calf milk replacer and calf starter system in a rumen under development. Hill (2009) fed calves diets formulated for amino acid requirements (Lys: CP ratio of 0,09 and Met: Lys ratio of 0,31) which gained approximately 15% more weight than calves without amino acid consideration.

As the fat in dairy products remains with the cheese and butter during processing, dairy ingredients available for calf milk replacers are in their first instance free of fat. Throughout the drying process vegetable fat sources can be added and co-spray-dried with dairy protein, leaving a small fat droplet encapsulated with soluble dairy protein.

As a good compromise between digestibility, metabolic utilisation and physical properties, a mixture of coconut oil and palm oil is widely used in spray-dried, fat-filled whey products used for calf milk replacer production. As a further optimisation, specific functional fatty acids like short-chained fatty acids (butyric), medium-chained fatty acids (lauric) and essential fatty acids (linolenic) can be added. A commercial additive including these fatty acids (Neotec4) has shown to alter immune and inflammatory responses, reduce scours and improves growth rates and feed efficiency (Hill, 2011).

Feed more during cold periods

During periods of cold or heat stress the maintenance requirement of calves increases (NRC, 2001). Housing situations where the bedding does not insulate the calf (i.e. concrete, metal, wood, rock, sand, shavings or any type of wet bedding) increase the maintenance requirements of the calves in cool and cold weather. Housing and bedding management alleviates cold stress to a significant degree (Hill *et al*, 2007d, 2011a, 2012a).

Bateman *et al* (2011) conducted a meta-analysis of 20 trials across many feeding rates, compositions of MR programmes, and seasons of the year with ambient temperatures in the unheated nursery ranging from near 17,7 to 37,7°C (average trial temperatures ranged from -5,5 to 25,5°C). In this meta-analysis, calf ADG increased as ambient temperature decreased.

Heat stress appears harder to alleviate than cold stress with cooling using fans reported to reduce panting and increase ADG during summer heat stress (Hill *et al*, 2011a, 2012a). Moderate increases of 25 to 50% in the amount of milk or MR fed when using conventional pro-

Housing that allows drafts should be evaluated in cool and cold weather. Housing situations where the bedding does not insulate the calf increase the maintenance requirements of the calves in cool and cold weather.

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Novus South Africa has recently realigned their local team to add more value to our customer base.

Natasha Snyman (Natasha.Snyman@novusint.com)
Technical Manager Africa, Novus Africa
Natasha Snyman completed her Masters degree in Animal Nutrition in 2005. She then joined a large feed company as an Operational Nutritionist. During her time as a feed mill nutritionist she was responsible for multi species feed formulation as well as quality control at the feed mill. She was lastly Technical Executive: Monogastric responsible for all technical aspects of the feed company's monogastric feed, this included product development and on farm problem solving. Natasha is responsible for technical support throughout Africa.

Karen Brandt (Karen.Brandt@novusint.com)
Sales Manager, South Africa
Karen Brandt obtained an MSc (Agric) degree in Animal Science from the University of Pretoria and a post graduate qualification in Food Science and Nutrition from the University of Ghent, Belgium.
After completing her degree, Karen obtained experience in research at both the Universities of Pretoria and Stellenbosch. In 2002 she joined a large feed company where she was working as nutritionist responsible for analytical services, quality as well as the development, maintenance and management of the (NIR) Near Infrared Reflectance spectroscopy network of the company. She joined Novus in 2010 she recently promoted to lead Novus development in South Africa as Sales manager.

Alex van Heerden (Alexander.VanHeerden@novusint.com)
Sales Manager, Southern Africa
Alex van Heerden completed a BSc. Hons degree in biochemistry in 1998. Alex started working in the pharmaceutical industry for a well German R&D company, focusing on human pharmaceuticals in the sales and marketing department. . He was responsible for establishing a sales and marketing team as well as the registration of new veterinary therapeutics to the market. He started with Novus in March 2013 now with a focus on developing Novus business in Southern Africa countries.

Nicole Christian (Nicole.Christian@novusint.com)
Product & Marketing Specialist Africa
Currently furthering her studies in Marketing & Product management. Nicole started working in the animal health industry about 6 years ago involved with the sales and marketing department. She started with Novus in the beginning of 2011 where she was involved with marketing and communications for Africa. Recently, she was promoted to Marketing and Product Specialist where she will focus on the specialty market in Africa.

Clint Crowie (Clint.Crowie@novusint.com)
Financial Manager Africa
Clint Crowie obtained his B.Comm Accounting degree in 2001 from the University of the Free State. He the then joined the Office Of the Auditor General in Kimberley where he completed his SAICA articles internship. Upon completion he relocated to Johannesburg and worked in various industries. He has 12 years' experience of which 8 years included performing various finance functions across the African continent. He is currently focused on the finance function in Africa as well as providing a support function to the regional sales personnel. Clint is currently furthering his accounting studies.

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grammes feeding 0,454 of DM to 0,570 to 0,68kg of DM are justified in extreme cold or heat stress (Hill *et al*, 2007d, 2011a, 2012a). However, management of the environment with insulating, dry bedding and draft (wind) protection is critical to the calf before more calories are fed (Hill *et al,* 2007d).

Increased average gain during the pre-weaning period established through pre-weaning nutrient intake, can have positive effects on development of the calf, first lactation and lifetime productivity.

Starter feed intake

Equations from the Dairy NRC (2001) suggest that energy limits ADG in typical dry diets fed to weaned calves. As forage is increased in the weaned calf's diet, energy becomes more limiting compared to diets containing no or low forage.

Recent publications from different labs each using over 900 calves report that ADG of the dairy calf between birth and two months of age is positively related to starter intake (Heinrichs and Heinrichs, 2011; Bateman *et al*, 2012). Because so many factors impact starter intake and because starter intake is positively related to growth of dairy calves (Heinrichs and Heinrichs, 2011; Bateman *et al,* 2012), it is important to design feeding programmes and diets to maximise starter intake in the transition calf.

Diet formulation for young calves is usually limited to manufactured calf starters with a fixed number of ingredients formulated to simple nutrient requirements – i.e. fixed levels of crude protein, metabolisable energy plus vitamins and minerals. Rumen development causes dramatic changes in the flow of nutrients, proportion of nutrients degraded in the rumen and production of microbial protein and volatile fatty acids. Fermentation of carbohydrate and subsequent production of VFA, but particularly propionate and butyrate, are stimulatory to development of the ruminal epithelium.

Most research suggests that the rumen is functionally mature two to four weeks after the calf begins consuming measurable amounts of dry feed. Production and absorption of VFA influence digestive and peripheral development, production of enzymes and utilisation of nutrients for maintenance and growth.

> "Housing cannot be overlooked. Housing that allows drafts should be evaluated in the cool and cold weather since maintenance requirements are increased considerably in these situations."

Differences in animal performance among various studies may be related to physical form of the concentration (meal vs. pellets vs. textured feeds), use and type of bedding (calves may eat small amounts of straw bedding), and carbohydrate sources used in concentrates. Forage intake as a percentage of total DM intake may also affect observed responses. Canadian researchers reported that as little as 10g/day of forage may increase ruminal pH and reduce the time at which the rumen pH is below 6,0.

Rumen pH of samples taken from rumens of calves prior to or shortly after weaning are almost always well below 6,0 for a significant portion of the day. Low rumen pH is associated with impaired forage fermentation, loss of protozoa populations, and a shift in site of starch digestion from the rumen to the intestine. In adult ruminants, sub-acute acidosis (SARA) is defined as pH less than 5,8, and is associated with reduced production and an increased risk of disease.

Recent research suggests that increased fermentation with high starch diets produces large amounts of endotoxin in the rumen and blood stream, leading to the production of acute phase proteins by the animal. Acute phase proteins are indicative of increased stress, which may predispose the animal to an increased risk of disease. Clearly, SARA occurs in young calves. However, the full

effects of SARA on growth, health or efficiency are as yet undetermined.

Supplementing the diets

Nutrition and management during the milk feeding period and their effects on immunity prior to and shortly after weaning have been the topic of many recent research trials. Many studies have evaluated different feed additives (e.g. probiotic bacteria, prebiotics or essentials oils, yeasts, antibodies) and their ability to support calf health (primarily intestinal health) prior to weaning. Additives should be judged on their ability to provide a consistent improvement in calf health and performance and provide the producer with a significant ROI.

Summary

Feed costs to raise calves can be substantial. Milk replacer is only a portion of the total costs to rear a dairy calf to a milking cow, but it has a high cost per kilogram. Understanding how to select the right milk replacer nutrient profile and feeding rate is essential for profitable results. Additionally, correcting for underfed nutrients (i.e. protein, amino acids and fatty acids) can substantially reduce feed costs per unit body weight gain.

During cold and heat stress, conventional programmes based on approximately 0,5kg DM milk replacer provide inadequate nutrients in many rearing and management programmes. Moderate and intensive programmes have been controversial, but do increase calf ADG and possibly future milk production. When considered, they need to provide the proper protein (amino acid) to energy ratio to achieve protein tissue and frame growth, and this type of growth is what is possibly linked with future enhancement in milk production.

Housing cannot be overlooked. Housing that allows drafts should be evaluated in the cool and cold weather since maintenance requirements are increased considerably in these situations. Housing situations where the bedding does not insulate the calf (i.e. concrete, metal, wood, rock, sand, shavings or any type of wet bedding) increase the maintenance requirements of the calves in cool and cold weather.

For references, please refer to the AFMA Communicator. ❖

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By Aidan J Connolly and Karl A Dawson

A glimpse into the concept of nutrigenomics

For generations cultures all over the world have understood that the foods animals and humans consume plays an important role in determining their health, wellbeing and, in the case of animals, efficiency of production. Articles prior to 1785 described theories of how food was metabolised, but only with the so-called "chemical revolution" in France at the end of the 18th century, with its identification of the main chemical elements and the development of methods of analysis, old and new ideas began to be tested in a quantitative, scientific way (Carpenter, *A Short History of Nutritional Science*, 2003).

This was in effect the birth of animal science. Since the 18th century much has been learned. In the early 1900s farmers began using synthetic fertilisers, which dramatically increased crop yields. In turn, humans were able to raise more livestock and also consume more nutritious foods. This resulted in healthier humans around the world, and also allowed a doubling of the global population in less than 100 years.

Between 1950 and 2000 the food system has become simpler and more mechanised. This has spurred changes in the demographics of farmers. The number of farms has shrunk, the size of farms grown and the first "mega farms" have emerged.

The use of chemical pesticides, antibiotics and hormones increased, which improved efficiency and production, and yet has had ecological consequences as well as in terms of consumer acceptance of modern agriculture. More recently, scientists and farmers alike have been seeking out technologies and practices that are considered more natural, perhaps in an attempt to avoid some of those negative consequences.

Understanding nutrition

Since 2000 a further leap in the understanding of nutrition has emerged – nutrigenomics, which aims to bridge the gap between genetic potential and actual performance through more precise nutrition. Nutrigenomics is "the study of how foods affect our genes and how individual genetic differences can affect the way we respond to nutrients (and other naturally occurring compounds) in the foods we eat", according the NCMHD Centre of Excellence for Nutritional Genomics.

Why are human nutritionists taking notice of this new science? Because of its enormous potential to prevent, mitigate, and/or treat chronic diseases such as cancer. The NCMHD Centre outlines the five tenets of nutrigenomics:

- Under certain circumstances and in some individuals diet can be a serious risk factor for a number of diseases.
- Common dietary chemicals can act on the human genome, either directly or indirectly, to alter gene expression or structure.
- The degree to which diet influences the balance between healthy and disease states may depend on an individual's genetic make-up.
- Some diet-regulated genes (and their normal, common variants) are likely to play a role in the onset, incidence, progression and/or severity of chronic diseases.
- Dietary intervention based on knowledge of nutritional requirement, nutritional status and genotype (i.e. "personalised nutrition") can be used to prevent, mitigate or cure chronic diseases.

Leading researchers today believe that nutritional genomics holds the key to formulating personalised healthcare and medicine based upon an understanding of nutritional needs, nutritional and health status, and genotype. Further, scientists believe that nutrigenomics will have impacts on society in many ways, ranging from medicine to agriculture to social and public policies, with a long list of envisioned applications. Knowledge gained from comparing diet/gene interactions in different populations may even provide information needed to address the larger problem of global malnutrition and disease.

Molecular tools

A number of molecular tools are used to evaluate the effects of dietary strategies on gene expression and the flow of information from the genetic code (DNA) to biolo-gical functions and structure. These include transcriptomic tools that quantitatively evaluate the formation of m-RNA (gene expression), proteomic tools that measure the formation of specific proteins (protein expression) and metabolomic tools that measure the products from the resulting metabolic activities (metabolic profiling).

Perhaps the most powerful molecular tools for examining nutrient effects at the most basic level come from high-throughput micro-arrays (gene chips), which allow for the examination of the expression of thousand genes at a time. These arrays have allowed investigators to directly examine the effects of nutrient supplies in great detail and at the most rudimentary level of gene transcription (gene expression).

These techniques not only allow for an understanding of the effects of nutrition on individual genes, but also for the examination and comparison of gene expression profiles (gene interactions). As

a result, it has now become possible to fingerprint the control mechanisms for all metabolic activities.

Diet effects on specific genes

In the last ten years, gene expression studies have become increasingly valuable as tools for examining specific effects of nutrients and diseases on gene expression. For example, some expression studies have allowed for a better understanding of the physiological effects of caloric restriction on ageing (Lee *et al,* 2002) and the effects of minerals such as selenium on intestinal function (Rao *et al*, 2001).

> "Under certain circumstances and in some individuals, diet can be a serious risk factor for a number of diseases."

In poultry, gene expression studies have lead to a better understanding of disease resistance (Liu *et al*, 2003; Karaca *et al*, 2004; Van Hemert *et al*, 2004) and of growth and tissue differentiation (Afrakhte and Schultheiss, 2004; Cogburn *et al*, 2003).

These tools have also been used to determine the effects of specific nutrient forms. In studies with chickens in Alltech laboratories, comparisons of dietary selenium in its inorganic and organic forms have suggested both functional differences and similarities. These were easily seen in the expression of some key genes associated with antioxidant systems (*Table 1*).

Gene expression profiling

Gene expression profiling using microarray technology is rapidly becoming an important tool for nutritional studies and for evaluating nutritional strategies. These profiling procedures allow for examination of nutrient effects in ways that have never been possible in the past. While individual gene markers may have variable response in individual animals receiving similar diets, hierarchical cluster analysis and pattern recognition methods are becoming tools for comparing nutritional responses with different diets (*Figure 1*).

Table 1: Similarities and differences in some key genes from chicken ovarian tissue as influenced by the form of supplemental selenium in the diets.

		Fold change (FC) in gene expressionrelative to low selenium control with:	
Gene symbol	Gene title	Sodium selenite	Selenium yeast (Sel-Plex)
GPX4	Glutathione peroxidase 4	1,79*	2,12**
GPX7	Glutathione peroxidase 7	4,51**	3,36**
TXNRD2	Thioredoxin reductase 2	4,59**	1,94
RCJMB04_23a5	Thioredoxin reductase 1	3,58**	3,21**
TXNRD3	Thioredoxin reductase 3	4,57**	1,64
RCJMB04_2n3	15 kDa Selenoprotein	3,36	2,23**
RCJMB04_2f9	Selenoprotein P, plasma, 1	2,02	2,04**
SELK	Selenoprotein K	1,6	2,14*
SEPX1	Selenoprotein X, 1	2,64	1,41
SELT	Selenoprotein T	1,19	1,78*
IYD	Iodotyrosine deiodinase	4,18*	2,13
DIO1	Deiodinase,iodothyronine, type I	2,23**	2,31*
DIO3	Deiodinase, iodothyronine, type III	2,05**	1,49
TXN	Thioredoxin	2,74**	2,02**
RCJMB04_14g3	Thioredoxin 2	4,29**	2,92*
SOD2	Superoxide dismutase 2	1,30	1,58**
SOD1	Superoxide dismutase 1	6,16*	2,7*

*$p<0,05$ **$p<0,01$

In addition, it has been possible to show tissue-specific effects of different forms of selenium, with selenium yeast inducing greater changes in gene expression in the intestinal tract (991 of 14 000 transcripts examined) and sodium selenite inducing greater changes in ovarian tissue (4 135 of 14 000 transcripts examined).

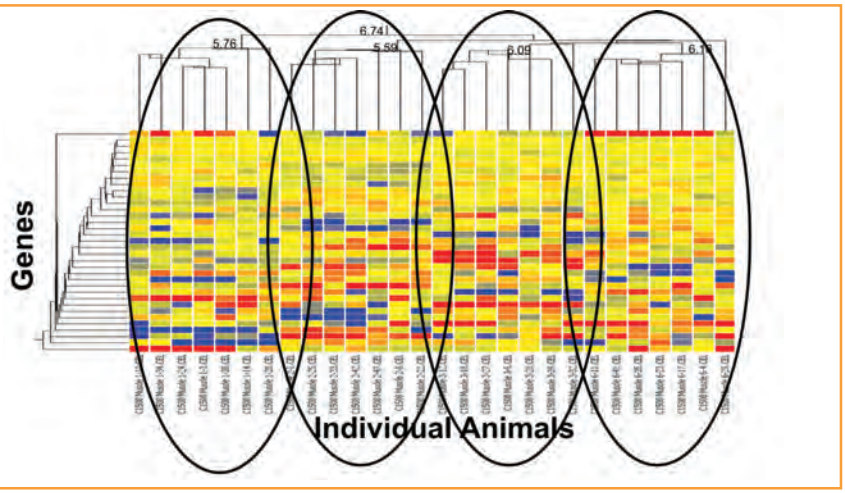
However, more importantly, gene arrays have been useful in defining some hidden effects of selenium supplementation strategies on the basic transcription. These changes in gene expression suggest both physiological and functional effects that have never been associated with selenium supplementation in the past (*Table 2*).

Table 2: Hidden genes in chicken ovarian tissue influenced by dietary selenium supplementation.

		Fold change (FC) in gene expression relative to low selenium control with:	
Gene symbol	Gene title	Sodium selenite	Selenium yeast (Sel-Plex)
GADD45G	Growth arrest and DNA damage	-3,35**	-1,82**
LOC396058	Ovalbumin	2,55*	4,14**
RLN3	Relaxin 3	1,20	2,52**
ACVR1	Activin A receptor type 1	1,19	1,60*
CCND1	Cyclin D1	1,51*	2,01*
PDGFA	Platelet-derived growth factor alpha	1,54	1,94*
FGF2	Fibroblast growth factor 2	1,75	2,50*
FGF1	Fibroblast growth factor 1	1,02	6,87*

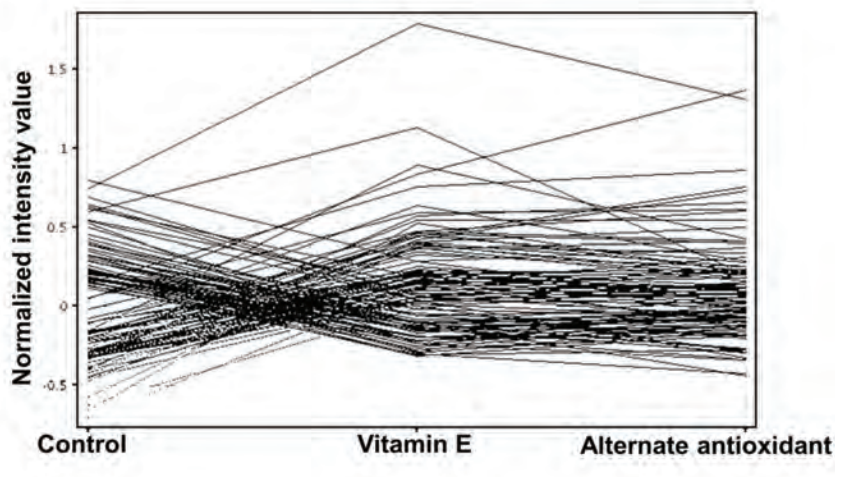
*$p<0,05$ **$p<0,01$

Figure 1: Hierarchical clustering of gene expression patterns from chickens on four different dietary antioxidant treatments. Expression level represented as higher (red) or lower (blue) than normal median value of the corresponding genes. Even though no two animals have the same expression pattern, animals in dietary groups cluster together. Distance measures serve as a measure of the relative similarity between groups.



Using such techniques, it is clearly possible to compare or fingerprint gene expression patterns in groups of animals, as well as identify specific similarities and differences in nutrient effects across a number of genes. For example, a recent study compared the gene expression profiles associated with dietary vitamin E and an alternative antioxidant mixture (e.g. EconomasE™). In this case, the two antioxidants influenced the gene expression of influenced genes in the same way (*Figure 2*), suggesting that both nutritional approaches have similar physiological actions and nutritional roles.

Figure 2: Changes in the individual gene expression patterns in intestinal tissue from chickens fed diets with vitamin E or an alternative antioxidant mixture. Genes shown are those that were significantly changed by both antioxidant treatments. With few exceptions, the direction of genes expression changes (up or down regulated) were similar with both antioxidant supplementation strategies.



From gene expression studies, it is clear that it is possible to use alternative ingredients to meet the specific requirements and select biologic functions that were once only associated with vitamin E. Freed from the models of the past, in the next decade, scientists will be able to redefine the criteria for evaluating "nutrient" requirements and focus instead on the ability of dietary components to meet physiological needs.

Beyond performance trials, nutritional efficiency can be measured at the cellular and biochemical levels. Nutrigenomics supplies the potential to rapidly learn about the hidden effects of nutrition and feeding strategies on digestive processes, immunity and reproduction. We are able to evaluate nutrient forms, define the nutritional needs of specific tissues or metabolic processes, and begin to tailor tissue-specific or process-specific nutritional applications.

New feeding strategies

Using nutrigenomics as a tool in animal nutrition will allow us to develop new feeding strategies, thereby creating an opportunity to lower the cost of materials, improve supplementation and rapidly adapt formulations in response to changes in feed supplies. It also allows us to identify and address nutritional bottlenecks that prevent us from taking advantage of the advanced genetics that are so key to livestock and poultry industries today.

Gene expression profiling techniques are now being evaluated as a way to define quantitative relationships between dietary ingredients and supplementation strategies. By defining common changes in gene expression patterns and understanding the basic role of specific genes through pathway analysis, it is now possible to gain a greater understanding of common modes of activity for supplementation strategies. For example, recent expression studies with two functional carbohydrates used as feed supplements have recently identified their roles in stimulating digestive enzyme synthesis in the small intestine (*Table 3*).

Table 3: Effects of two yeast-derived functional carbohydrates on the expression of genes encoding for digestive enzymes in the small intestines of broiler chickens.

Gene	Protein	Signal intensity (SI) for gene expression in intestinal tissue in: Unsupplemented	Bio-Mos supplemented	Actigen supplemented
SI	Sucrase-isomaltase	33,27 + 1,90	41,99 + 2,26*	40,93 + 1,12*
LIP1	Lipase, member 1	3,98 + 0,28	5,88 + 0,56	6,84 + 0,77*
SCPEP1	Serine carboxypeptidase 1	2,57 ± 0,23	3,27 + 0,21*	3,66 + 0,25*
GGH	Omega peptidase	1,78 + 0,07	2,26 + 0,12*	2,39 + 0,18*

**Differ from the unsupplemented diet (p<0,05).*

These observations suggest a totally new role for such nutritional supplements and implicate them as regulators of overall digestive processes at the level of gene expression. Such roles for functional carbohydrates have not been suspected before the applications of nutrigenomic approaches. The information coming from such studies suggests a new line of approaches for increasing the values of specific nutrients in animal diets and provides some new approaches for enhancing production.

Applications of nutrigenomics

From the previous research three main areas of developments in the field of nutrition have occurred based on nutrigenomic insights. These include the development of new generations of feed supplements, optimising nutrition and improving meat quality.

- **New product development:** Understanding the role of mannan oligosaccharides has been informed by observations made in almost 900 publications. Researchers have noted improvements in performance, livability, immune function, food safety and intestinal health. Nutrigenomics information has made it possible to evaluate different fractions of yeast, including a mannose-rich fraction (MRF) called Actigen, which is detectable in feed and premix using an ELISA test. Gene changes relating to intestinal health (*Table 3)*, and immune parameters have served as a way to screen candidate fractions for desirable biological activities and to choose candidates with the potential to supersede the previous generation of mannose-based technologies.
- **Optimising nutrition:** The inclusion of ingredients such as vitamin E in animal diets has become an expensive but necessary addition. Genetic selection pressures have the purpose of achieving higher productivity, but as a consequence also resulted in animals with a higher requirement for antioxidants to alleviate the deleterious effects of higher metabolic levels. Vitamin E supplementation has benefited productivity, immunity, fertility and meat quality in animals. The example of reducing vitamin E levels in the presence of other antioxidants such as economase has been discussed in this paper earlier. Gene expression changes can be used as a powerful tool to demonstrate the synergy between antioxidants and to precisely identify optimal levels in zootechnical changes.
- **Meat quality improvements:** Feeding ever improving genetics, with an extraordinary ability to deposit protein at ever faster rates, is a constant challenge for nutritionists. New problems are constantly emerging, metabolic diseases, susceptibility to environmental challenges and, more recently, meat myopathies. In poultry, for example, "woody" or "leather" breast, white striping, fatty depositions, dorsal myopathy and hemorrhages are becoming more commonly reported and integrated operations are searching for nutritional responses. Nutritional strategies which "programme" gene expression responses to specific nutrients have the ability to improve antioxidant content of the meat, improve tenderness and moisture retention and have demonstrated the ability to affect meat composition. Nutrigenomics has allowed the development of these approaches at a speed which would not have been possible using traditional techniques.

Future implications

From a basic nutrition point of view, nutrigenomics approaches promise to set new standards for nutritional research and will revolutionise our views of nutrient requirements and interactions. It will provide methods and specific markers for rapidly evaluating the nutritional status of individual and groups of animals. Such markers will open new avenues for nutritional research and truly change the way we think about nutrition as a science.

In addition, we can expect detailed gene expression studies to help us define the hidden effects of specific nutrients and nutrient interactions. We are just now beginning to see how little we really understand about nutritional control of metabolism. By understanding some of these new nutrient effects, we will be able to define and test new nutritional concepts that have never been considered in the past.

From a more practical point of view, we can expect nutrigenomics to change the way we feed and manage livestock and poultry. Advances in nutrigenomics promise to provide the tools needed for a more programmed approach to nutrition in both animals and humans. As we begin to understand the role of nutrition in gene expression, we will begin to appreciate the long-term effects of nutrition on animal product quality, reproductive performance, the ageing process and the long-term health and disease resistance.

It will also be possible to examine the tissue programming that is triggered by nutrition in young animals and the effects of maternal nutrition on offspring. More importantly, the more precise measures of nutrient effects afforded by more reliable genomic markers and molecular profiling techniques will provide new tools for evaluating practical nutrient requirements and diet formulation strategies in a relatively short time. This will lead to improved livestock productivity, improved sustainability and the production of more wholesome animal products.

Aidan J Connolly is the chief innovation officer and vice-president of corporate accounts at Alltech, Lexington, KY, and Karl A Dawson is the vice-president and chief scientific officer at Alltech, Lexington, Kentucky.

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By Dr PW Plumstead and Dr LF Romero

Advances in nutrition to optimise gut heath, nutrient digestibility and broiler performance

Ongoing research to better understand the dynamic interactions between the gut microbiota, digestive function and performance efficiency of poultry has recently resulted in a shift in traditional nutritional thinking.

Previously, digestible nutrient levels of feed raw materials used in least-cost feed formulation were considered to be fairly static and predominantly a function of the raw material itself. Consequently, one of the main strategies to improve the inherently variable nutrient digestibility of raw materials was to add exogenous enzymes, with the understanding that broiler performance was mediated directly by the increment in digested nutrients from the enzyme.

However, rapid advances in molecular analytical techniques have advanced our understanding of dynamic diet-microbial-host interactions on digestive function. This has slowly elicited a shift in traditional nutritional thinking that, in addition to feed ingredient quality, the digestibility and absorption of nutrients to which diets are formulated is heavily dependent on the microbial composition and diversity in the intestine.

The intestinal ecology of broilers is again in turn shaped by shifts in the supply of nutrients and substrate provided by the diet to microbes in the small intestine and ceca, and is altered by enzyme addition to feed.

Stated another way, the microbial composition in the gut plays a fundamental role in determining intestinal morphology, function and the amount of nutrients available to the host, with part of the performance improvements achieved by enzymes being mediated by their effects on modulating substrate supply and subsequent microbial ecology in the small intestine and ceca (Bedford and Cowieson, 2011).

With high feed costs and the low-margin, high-volume nature of commercial broiler operations, the role of nutrition in supporting a balanced microbial ecology using strategies that reduce variation in nutrient supply and mitigate negative interactions between the gut microbiota, host nutrient utilisation and performance, is fast becoming the next frontier in poultry nutrition research.

In-feed antibiotics and gut microbes

A broad negative association of the microbes in the gut with variable animal performance was recognised almost a century ago. This early work largely followed Koch's postulates that specific micro-organisms were responsible for disease and poor performance, and could be treated by removal of the specific disease-causing organism (Collett, 2007).

The general negative association of the gut microbiota on broiler performance was further supported when chicks reared in a bacterial-free environment grew 15% faster than those grown under conventional conditions in the presence of pathogens and viruses (Klasing, 1987).

Other research supporting detrimental interactions of gut microbiota and the dietary nutrient utilisation showed that negative effects of viscous rye-based diets on broiler performance were substantially reduced in germ-free broilers vs. conventional broilers, while the addition of antibiotics to the viscous diets was also able to partly restore performance.

This and other research has resulted in general agreement that the gut microflora exert a variable nutritional "burden", reducing performance of fast-growing broiler chickens (Dibner and Richards, 2005; Lan *et al*, 2000).

To date, these adverse effects of microbes on broiler performance have primarily been managed by standard inclusion of in-feed antibiotic "growth promoters" (AGPs), as well as prolific use of therapeutic antibiotics to reduce dysbacteriosis and bacterial transfer across the mucosal lining and improve broiler performance. The mechanism whereby AGPs exert "growth promoting" effects is clearly related to the gut microflora because no performance benefits of AGPs are observed when fed to germ-free animals (Bedford, 2000).

Neonatal immune system

However, the prolific use of antibiotics as a single strategy to modulate microbial populations in the intestine frequently results in the development of resistance by specific pathogenic bacteria, making continued positive growth performance effect of antibiotics unpredictable, and the long-term use of single or compound antibiotics unsustainable.

Furthermore, the approach of using antibiotics as the sole strategy to mitigate

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microbial effects on broiler performance frequently masks underlying nutritional shortcomings and also fails to leverage important beneficial synergies that exist between other micro-organisms and the host. For example, early development of a healthy, balanced commensal microbial flora has been shown to be essential to normal gut development and function later in life.

There is also growing evidence that the development of commensal enteric flora stimulates the maturation of the neonatal immune system. This is supported further by germ-free animals having a large number of immune deficiencies and higher susceptibility to infections compared to conventional animals (Umesaki and Setoyama, 2000).

High antibiotic usage early in life that suppresses the development and maturation of a mature microflora, characterised by an increasing proportion of lactobacillus spp., has the potential to impair the functional development of digestive capacity, the mucosal immune system, and have long-lasting impacts on health status and performance (Collett, 2007).

Routine antibiotic intervention

Routine antibiotic intervention and the associated reduction in performance consequences of poorly digested diets has also distracted from the fundamental role that nutrition has in establishing and shaping the gut microbiome and a functional, healthy gastro-intestinal tract (GIT). Increasingly, research suggests that feed, substrates within feed and the associated micro-environment in the intestinal lumen are one of the single biggest factors determining the composition and stability of the microbial community in the GIT.

Stress, combined with high levels or sudden changes in undigested nutrient fractions provided by the diet, frequently contributes to undesirable shifts in the gut microbiota with direct consequences for digestive capacity, feed conversion and also pathogenicity of a variety of disorders associated with poor enteric health. While this can be treated using antibiotic intervention, solely using this approach will not correct fundamental diet-related factors that may have supported an unfavourable microbial ecology.

The interactions between nutrition and the microbial load and balance in the GIT are complex and not fully understood, but ultimately dictate the development, morphology and functionality of the GIT, host nutrient utilisation, health and performance.

Nutrition and the gut barrier

Therefore the role of nutrition, including feed additives such as enzymes and direct fed microbials that maintain a diverse and stable balance of microbes in the intestine, is now no longer seen as desirable, but rather as being critical for optimum nutrient utilisation and performance of poultry.

Although the intestinal epithelium is only one cell layer thick, it has the capacity to adapt morphologically and functionally to the type of diet provided and the intestinal microflora by feedback mechanisms that regulate the type of cells it consists of, tight junctions between cells, production of mucin and secretion of antimicrobial compounds.

Principally the gut barrier has two fundamental roles, namely to act as a conduit to digest and absorb nutrients from the digesta and secondly, to protect the bird from the challenge posed by close contact to large numbers of microbiota.

Unfortunately, these two functions oppose each other and the balance between the digestive capacity and maintenance of the gut barrier to prevent pathogenic microbial invasion is constantly in flux. Depending on the level of challenge and conditions in the intestinal lumen at the time, gut maintenance comes at a considerable cost to the bird. For example, even in a "healthy state" the GIT is estimated to have a protein turnover rate of 50 to 75% per day, using up 20% of dietary energy and almost 25% of dietary protein consumed by the bird (Applegate, 2011).

Higher microbial load

Stated another way, the dietary energy consumed by the gut represents up to 600kcal ME/kg feed consumed, and the equivalent of 5% dietary protein of a 3 000kcal/kg, 20% CP diet. In states of higher microbial load, or subclinical challenges, the cost of maintaining the gut increases even more and is associated with concomitant reductions in nutrients digested.

The latter effect of microbial composition on nutrient digestibility is a result of structural changes to the digestive capacity of the gut lining, tight junction architecture and mucus secretions. Cells comprising the epithelium of villi start differentiating in the crypts with their ultimate function along the villus being dependent on the microbiota in the lumen and brush border of the intestinal lining.

Under conditions of high microbial load or adverse balance of pathogens vs. commensal bacteria, there is an increased migration rate of cells up the villus, with increased differentiation into goblet cells and paneth cells at the expense of enterocytes that function as the absorptive cells for nutrient uptake.

Faster turnover of enterocytes

There is also evidence that a high microbial load with increased numbers of pathogenic bacteria contributes to shorter villi and an increased rate of aptosis, or cell death causing faster turnover of enterocytes, changes in enzymes secreted at the brush border of enterocytes and an overall decrease in digestive capacity. Lastly, effects of the gut microflora on nutrient absorption are also mediated by closure of tight junctions between enterocytes, which combined with increased mucous secretion leads to reduced net nutrient absorption.

In its entirety therefore microbial challenges to the gut barrier lead to a reduction in nutrient digestion, increased maintenance costs of the intestine well above the 20% of dietary ME shown by Applegate (2011) and loss of performance. With this understanding, it becomes clear that both nutrient utilisation of the diet, as well as nutrient requirements of the bird, cannot be fixed, but will be dependent on the interaction between the microbiome and its influence on structure and functionality of the GIT and the proportion of dietary nutrients required to maintain it.

This is an interesting divergence from traditional nutritional thinking in which

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feed ingredients are formulated into diets assuming a fixed level of nutrient digestibility, determined in individual trials with no prior knowledge of the gut microbiota of birds in the trial. Similarly, diets are formulated to meet fixed average nutrient requirements that do not always consider variations in the demand for nutrients required to maintain the gut barrier, depending on the degree of challenge being experienced.

Failure to support a balanced microbial ecology will result in reduced performance and in extreme cases subclinical or even clinical microbially-mediated disease. Lastly, although the inflammatory response in the gut is designed at combating microbial challenges at the gut interface, this comes at a high cost of reduced feed efficiency and is potentially damaging to the cells lining the intestinal tract (Collet, 2007).

Undigested nutrients and enzymes

Although many factors cumulatively affect the load and composition of the microflora in the intestine, following environmental stressors, one of the single biggest contributors is the type, amount and variation of nutrient substrates present in various segments in the GIT (Snel *et al*, 2002). At small intestinal level, microbes compete with the host for nutrients and there is an inverse correlation between the microbial load in the small intestine, rate of nutrient absorption and broiler performance.

A rapid rate of nutrient removal by means of a high absorptive surface area and prolific enzyme secretions in the proximal small intestine is one of the strategies used by the host to reduce microbial proliferation in this part of the digestive tract (Bedford and Cowieson, 2011). The extent of starch and protein digestion achieved in the small intestine is further influential on the downstream microbial ecology.

Undigested nutrients of dietary and endogenous origin contribute to a pool of substrates available to bacteria in the ceca and colon, the composition of which is determined by the supply fermentable substrates provided. Sudden changes in dietary ingredients or substrates have been shown to result in shifts in microbial diversity and if unfavourable, can be associated with disease and poor performance.

Many publications have demonstrated enhanced ileal digestibility of nutrients such as protein, starch, fat, and NSP fractions with the use of exogenous xylanase, amylase, glucanase or protease enzymes and their combinations, in both viscous grain diets (rye, wheat and barley) and non-viscous corn or sorghum-based diets.

A consequence of this research has been the almost ubiquitous use of exogenous enzymes to improve nutrient digestibility, broiler performance and reduce broiler production costs through improved efficiency of feed nutrient utilisation.

Reducing specific nutrients

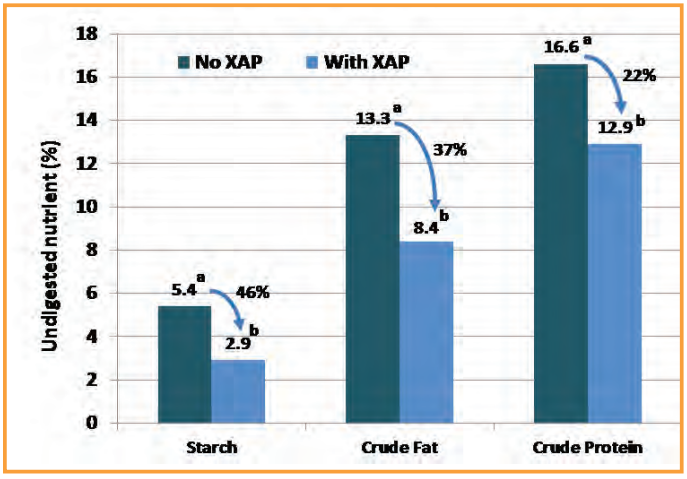
However, by facilitating increased and less variable nutrient digestion, enzymes will also shape the underlying microbial ecology of the host by reducing the supply of specific nutrients such as starch, fat and protein, and altering fermentable substrates that support commensal microbes both in the small intestine as well as in the ceca and colon.

For example, Romero *et al* (2011) showed ileal starch digestibility of broilers fed corn/soy-based diets following supplementation of a combination of xylanase, amylase and protease (XAP) to increase from 94,6% to 97,1%. Concomitant responses in fat digestibility from XAP were 86,7% to 91,6%, while ileal protein digestibility increased from 83,4% to 87,1%.

The increment in the digestibility of these nutrients also corresponded to 106kcal/kg higher ileal digestible energy in diets containing XAP enzymes. The economic value of these responses in digestible nutrients and energy in feed formulation has been the primary driver of enzyme use to date.

However, while the XAP enzymes improved starch, fat and protein digestibility of 2,9%, 8,4% and 12,9% respectively, the corresponding reduction in residual undigested nutrients available to gut microbes was much larger and amounted to 46%, 37% and 22% decreased starch, fat and protein substrate entering the hind-gut (*Figure 1*).

Figure 1: Undigested starch, fat and protein remaining at the terminal ileum of broilers fed diets with/without a xylanase, amylase and protease (XAP) enzyme added to corn/soy-based diets (Adapted from Romero et al., 2011).



The substantial effects of enzymes in enhancing the rapid removal of nutrients in the small intestine, as well as modifying levels of starch, protein, fat and fermentable NSP-oligosachharides entering the ceca, must clearly limit nutrients available for the microbes, reducing not only population size but also diversity (Bedford and Cowieson, 2011).

While the effects of reduced undigested nutrients as a consequence of enzyme addition may be small in healthy broilers fed highly digestible corn/soy-based diets, negative effects of undigested nutrients appear to be magnified substantially when broilers are subjected to environmental or disease challenges.

A good example of the beneficial effects of enzymes reducing negative effects of a disease challenge is shown in *Figure 2*. In this study by Romero *et al* (2012), broilers fed corn/soy-based diets were challenged with *C. perfringens* from 17 to 19 days of age and effects of amylase, protease, or and XAP enzyme evaluated either alone, or in combination with a three-strain bacillus DFM.

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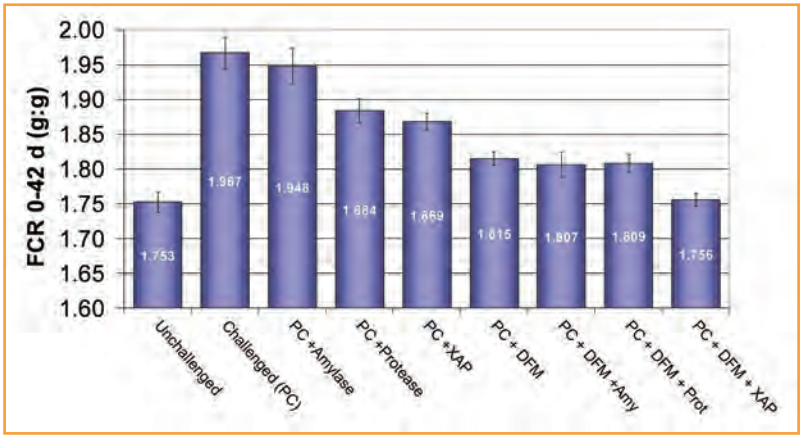
Figure 2: Enzyme addition (amylase, protease, or XAP) alone or in combination with a 3-strain bacillus DFM reduced effects of C. perfringens challenge on 42-d FCR of broilers fed corn/soy-based diets (Romero et al, 2012).



The positive effects of single amylase, protease or the XAP enzyme on reducing the negative effects of a NE challenge on FCR in the study by Romero *et al* (2012) are clear and support other research that has undigested nutrients to be a predisposing factor for dysbacteriosis related to necrotic enteritis (Dahiya *et al*, 2006).

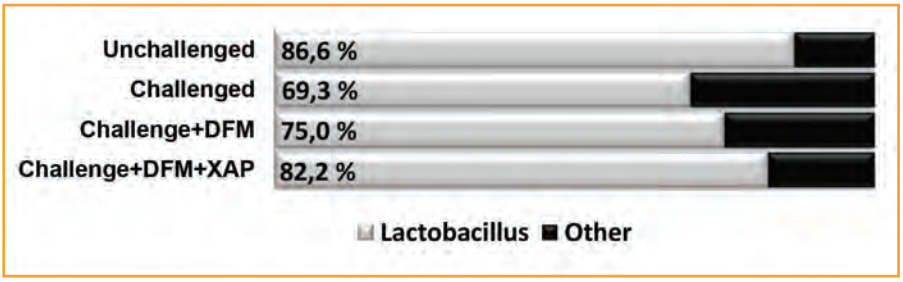
Effects on live performance

Therefore the mechanism whereby enzymes are able to mitigate performance reductions in disease challenge situations appears to be mediated by enzymatic reduction in undigested starch, fat and protein, possibly combined with the provision of prebiotic fermentable oligosaccharides. This altered substrate flow would support concomitant shifts in the microbial ecology and reduce the ability of pathogens like *C. perfringens* to colonise the gut, thereby reducing adverse effects on live performance.

What is furthermore shown in this study was that while the effects of enzymes alone were significant, further improvements could be obtained with the addition of a direct fed microbial (DFM) containing three different strains of bacillus.

While treatment effects on microbial composition were not determined in the study by Romero *et al,* other trials with XAP+DFM enzyme supplementation to corn-based broiler diets have shown these treatments to restore reductions in lactobacillus populations in the jejunum of broilers challenged with *C. perfringens* (*Figure 3*).

Figure 3: Effects of a direct fed microbial (DFM) without/ with a xylanase, amylase and protease (XAP enzyme on the relative proportion of Lactobacillus spp. at 21d in the jejunum in broiler chickens challenged with C. perfringens.



While not the subject of this paper, multiple studies in broilers and layers have demonstrated synergistic effects of exogenous XAP enzymes when combined with DFMs on altering nutrient digestibility, gut morphology, tight junctions and pathogen shedding, culminating in improved broiler performance under both challenge and non-challenge conditions that was greater than that from either additive alone.

In summary

Research advances in understanding the dynamic interactions of nutrition, the gut microbiota and the functionality of digestive and immune systems of the host, suggest that the resilience of broilers to disease challenges and the magnitude of associated performance losses are dependent on the stability and diversity of the microbial ecology in the gut.

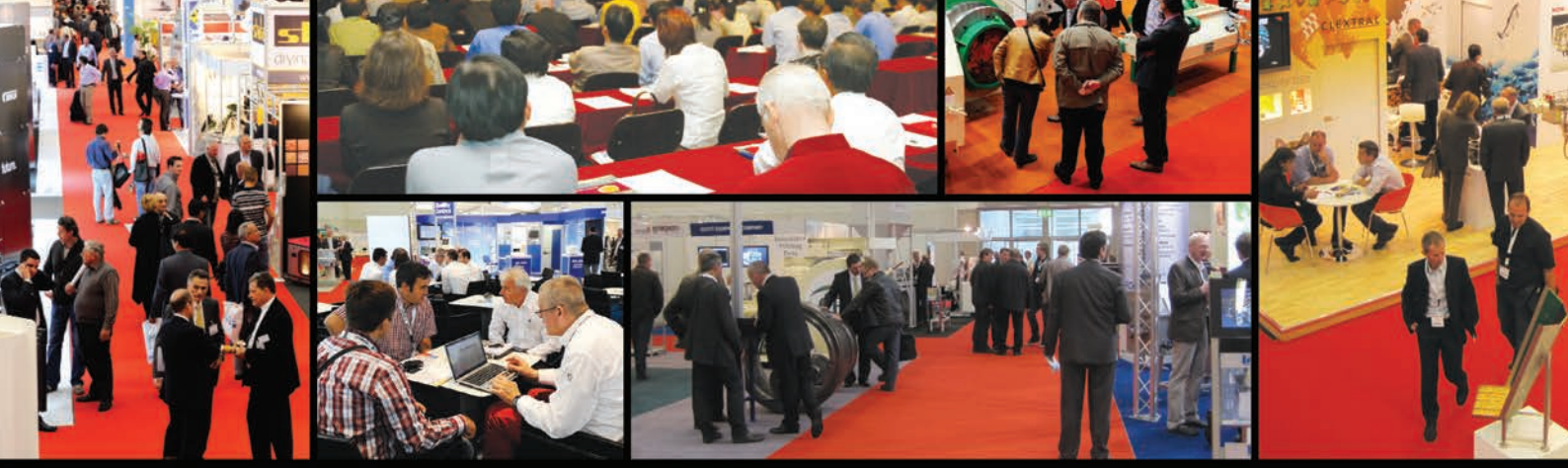
The prolific use of antibiotics as a primary strategy to "treat" enteric diseases without considering the fundamental role of nutrition in supporting the establishment and maintenance of a commensal climax flora is costly, and will also not support maximal nutrient digestibility and broiler performance. At times when feed ingredient prices are at an all-time high, the importance of maximising the digestive capacity of the gut and subsequent conversion of feed nutrients to performance becomes even more paramount.

The intestinal microbial diversity and load is to a large part shaped by the diet and supply of nutrient substrates to microbes in the small intestine and ceca. Exogenous enzymes have traditionally been supplemented to feed to improve energy and amino acid digestibility and reduce feed cost. However, a second benefit shown in research with XAP enzymes is substantial reductions of 46%, 37% and 22% decreased starch, fat and protein substrate that can be utilised as substrates for pathogenic bacteria.

The use of enzymes, either alone or in combination with DFM's to reduce variation in undigested nutrients of dietary and endogenous origin and support the establishment of a balanced microbiome in the intestine, is a critical component of nutritional tools that modulate gut health and immune development, and can in combination substantially reduce performance losses in broilers under conditions of disease challenges.

Dr PW Plumstead is from the Department of Animal and Wildlife Sciences at the University of Pretoria and Danisco Animal Nutrition, DuPont Industrial Biosciences, Marlborough, UK. Dr LF Romero is from Danisco Animal Nutrition. For more information, send an email to peter.plumstead@up.ac.za. ❖

Full references are available on request.



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21-23 September 2015	48th SASAS Conference	Umfolozi Hotel Casino Convention Resort Empangeni KwaZulu-Natal South Africa	Trevor Dugmore Tel: +27 (0)33 355 9262 Email: Trevor.Dugmore@kzndard.gov.za Website: *www.sasas.co.za*
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14 October 2015	AFMA Symposium	CSIR International Convention Centre Diamond Auditorium Pretoria/Tshwane South Africa	Teresa Struwig Tel: +27 (0)12 663 9097 Fax: +27 (0)12 663 9612 Email: admin@afma.co.za Website: *www.afmasymposium.co.za*
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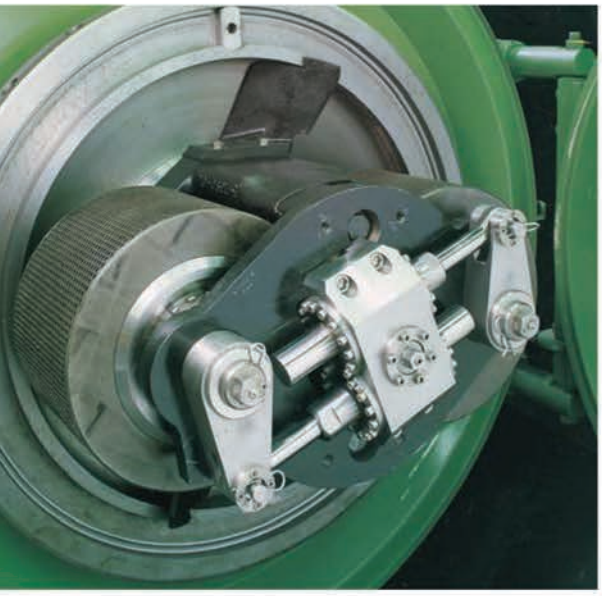

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