Jan-Mar 2024
Vol 33 No 1
ISSN 2308-0647

Matrix

AFMA
SAFE FEED FOR SAFE FOOD
Animal Feed Manufacturers Association

Quarterly magazine of the Animal Feed Manufacturers Association

Defatted soya bean flour • Fibre analysis • Feed trends • Edible insects
Underutilised feed sources • Circular food production • Protein nutrition for broilers
Dietary chitinase

On the cover:
FAMSUN Co Ltd
Contact person: Andy Wang
Contact numbers: +27 71 131 3643
or +86 18 8527 11153 (WhatsApp)
Email: wangqi@famsungroup.com
www.en.famsungroup.com

CONTENTS

Editorial Committee

Published by: Plaas Media (Pty) Ltd
217 Clifton Ave, Lyttelton, Centurion, RSA
Private Bag X2010, Lyttelton, 0140, RSA
Tel: +27 12 664 4793 • *www.agriorbit.com*

Associate editor: Liesl Breytenbach
+27 12 663 9097 • liesl@afma.co.za

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

Deputy editor: Jayne du Plooy
+27 82 414 0151 • jayne@plaasmedia.co.za

News editor: Elmarie Helberg
+27 73 339 2920 • elmarie@plaasmedia.co.za

Design & layout: Inge Gieros
+27 82 959 9607 • inge@plaasmedia.co.za

Advertising:
Karin Changuion-Duffy
+27 82 376 6396 • karin@plaasmedia.co.za
Susan Steyn
+27 82 657 1262 • susan@plaasmedia.co.za
Zona Haasbroek
+27 82 960 7988 • zona@plaasmedia.co.za

Sales manager: Marné Anderson
+27 72 639 1805 • marne@plaasmedia.co.za

Subscriptions: Beauty Mthombeni
+27 64 890 6941 • beauty@plaasmedia.co.za

Printed and bound by: Typo • 011 402 0571

Published on behalf of AFMA
Agri-Hub Office Park, Block B, 477 Witherite Str,
The Willows, Pretoria
+27 12 663 9097
www.afma.co.za

‘COST *EFFECTIVE* PRODUCTION OPTIMIZATION’

- ***New generation growth promotion***
- ***Gut health enhancement***
- ***Metabolic and skeletal support***
- ***Correcting nutritional deficiencies***
- ***House and site sanitation***
- ***Air quality improvement***

IN FEED PRODUCTS

CARDIO OS®
ACT 36 OF 1947; REG NO V34299
Promotes optimal metabolic function

BAMBERMYCIN 4%
ACT 36 OF 1947; G2473
Growth promotor

TAUROS®
ACT 36 OF 1947; REG NO V32601
Taurine supplement
Improved energy production

SUPER OS®
ACT 36 OF 1947; REG NO V32383
Betaine supplement
Heat stress prevention

KITASAMYCIN 10%
ACT 36 OF 1947; G1905
Mycoplasma and Pneumonia control

TYLOSIN 10%
ACT 36 OF 1947; G278
Mycoplasma control

SUPER NOURISH®
ACT 36 OF 1947; REG NO V31997
Pellet binder and nutrient protector

OXYTETRACYCLINE 20%
ACT 36 OF 1947; G2499
Broad spectrum antibiotic

ON FARM PRODUCTS

ULTIGRO®
ACT 36 OF 1947; REG NO V31443
Buffered organic acids

SUPER SAL STOP®
ACT 36 OF 1947; REG NO V31443
Prevention of pathogenic enterobacteriaceae

GUTPRO®
ACT 36 OF 1947; REG NO V26234
Organic acid solution

SUPER TONIC®
ACT 36 OF 1947; REG NO V28454
Water soluble nutritional supplement

SUPER BONE®
ACT 36 OF 1947; REG NO V33906
High phosphorous mineral emulsion

SUPER AIR®
ACT 36 OF 1947; REG NO V29002
Aromatic oils

SUPERZYME™
ACT 36 OF 1947; REG NO V34678
Water soluble enzymes

HEAT STRESS HYDRATION
ACT 36 OF 1947; REG NO V29003
Prevents dehydration

ELIMINATOR®
ACT 36 OF 1947; REG NO V29002
Site powder disinfectant

SUPER AGRI SCIENCE®

Corné Prinsloo	@	(+27) 81 552 8491	corne@sasorp.co.za
George Miller	@	(+27) 61 475 4373	george@sasorp.co.za
Elsje Le Roux	@	(+27) 68 470 0457	elsje@sasorp.co.za

www.superagriscience.co.za

Back to basics

By Liesl Breytenbach, executive director, AFMA

Each new year goes hand in hand with the traditional set of resolutions, designed to guide our lives and work in the 12 months to come. Often, we deviate from these resolutions quicker than we formulated them. It is human to do this because life happens, things get busy, and priorities change. At times, these resolutions are also based on negative experiences and events of the recent past – things that we want to change and put a positive spin on.

This year, I decided to change my approach by going back to basics and instead of basing my resolutions on the past year, tailoring them to timeless principles taught by wise humans over hundreds of years. After all, it doesn't matter how experienced or well educated or well positioned we are – the grey beards are always there to remind us what life and work is really about. And besides, 2023 was a difficult year in so many aspects, that I don't want to focus on exports and load shedding and politics. Those are the things we manage and deal with every day – so let's leave it at that for now.

Here are a few resolutions/principles that I want to share with all AFMA members. Even if only one resonates with you, my work is done!

Keep it simple, but not simplistic

The English philosopher and Franciscan friar, William of Ockham, once said: "It is futile to do with more things that which can be done with fewer." This phrase is referred to as the principle of Occam's razor or the parsimony principle. It refers to the principle that one should not multiply entities beyond necessity. Simply stated: A simpler explanation is preferable to a more complicated one, but it should not be simplistic. Keep it simple, but don't dumb it down.

In addition, the preference for simplicity is a virtue but realism is always necessary. Do not use grand words to hide intent or look clever, and never underestimate your audience. Explain things as they are and when you are searching for truth, answers and explanations, look to those explanations that use fewer words and more honesty.

Acknowledge your limitations

Knowledge of your ignorance is key to wisdom. The great philosopher, Socrates, said: "The only true wisdom is in knowing you know nothing." Knowing more relies on a few skills: the willingness to listen to others with intent; reading body language and thereby understanding intentions; reading books for the wealth of opinions and knowledge contained in them; reading between the lines so that you may form a second opinion.

The one thing I am going to practice is to stop saying "I know" when someone wants to discuss something with me. Yes, I might know what the drift of the conversation is going to be, but do I really know what bit of new information I might be getting by listening and not halting the conversation with "I know"? I am going to listen and learn.

Embrace the Socratic method

Socrates believed that our ability to think critically and reason logically is key to living a happy and fulfilling life. He believed the path to developing reasoning abilities involves asking questions, seeking out knowledge, and challenging our assumptions. An open mind and a desire to learn more will expand our understanding of the world and allow us to make more informed choices.

We live in a world in which false information and information overload both have a huge impact on our ability to reason and not simply assume before we decide. We have become accustomed to being told and not thinking and finding out for ourselves. It is time to go back to basics: Think through a problem to reach a logical conclusion.

All problems, questions and issues can be broken down into smaller parts and examined from different angles to gain a deeper understanding. Give yourself space and time to do this, and you will be very surprised at the outcome. Become your own philosopher. We need more of that these days.

Live and let live

This proverb of Dutch origin was first recorded in *The Ancient Law Merchant* published in 1622. "Live and let live" is actually a law and not really a proverb. Much of today's commercial law is still based on the basic premises laid down by the Law Merchants. These laws had their roots in the days before nation states existed. The premise of this law was simple: Run your own life the way you want to, and let others do the same; be tolerant of differences.

How often do we discuss and fret over others' lives and doings while we really cannot change what they do and how they live? In fact, ask yourself whether your concern or interest or fretting over someone else's life is not perhaps a form of projection. Take a step back, look inward, and focus on what you can change and improve closer to home.

May 2024 be a year of great personal growth in which we all come to realise that politics, the economy and (fake) news are not what define us. Be your own person.

NEWS & views

Animal diet still paramount, says survey

As consumers continue to be conscientious about their food choices, a new survey from the United Soybean Board reveals valuable insights into consumer preferences and purchasing attitudes for animal protein, particularly pork products. According to the survey, 70% of respondents say an animal diet is extremely or very important to them when purchasing meat, up from 51% in 2019.

Meat consumers who prefer soya-fed meat say it offers better health, higher quality, greater nutrition and better taste. This research confirms that consumers desire to know more about their meat choices, such as what poultry and livestock consume. When it comes to soya bean meal, this nutritional package of protein, the amino acids that make it up, and energy concentration continues to be the standard for all other plant protein feedstuffs.

One of the key take aways from this survey was that 65% of consumers are more likely to purchase meat if it's not fed synthetic ingredients, which bodes well for United States soya bean meal as a natural ingredient. – *Feed Strategy*

New insights into fatty acids

New findings in the science of fatty acids have led to the development of a technology designed to meet calves' nutritional requirements while nurturing ruminant health.

The results of that research were disclosed at the third LifeStart Symposium recently co-hosted by Trouw Nutrition, the livestock feed business of Nutreco, and the University of Nottingham School of Veterinary Medicine and Science, in Nottingham in England.

Dr Michael Steele, professor at the University of Guelph, and Juliette Wilms, PhD candidate, Trouw Nutrition, presented findings from research that compared the health and development of calves fed whole bovine milk powder along with three milk replacers based on high-fat, high-lactose, or high-protein formulations.

They saw that differences in the macronutrient profile and composition of high-protein and high-lactose milk replacers resulted in distinct profiles relevant to metabolism and endocrinal functions compared to calves receiving milk. In contrast, they observed a lack of difference between calves receiving whole milk or the high-fat milk replacer. Additionally, calves fed the high-fat diet in the first week had higher liver weights suggesting the role milkfat plays in organ development, they noted. – *Feed Navigator*

Flies fattened up to feed livestock

Raised on vertical farms and stuffed with fruit waste, fly larvae have become animal feed and the pillar of a circular economy venture in Costa Rica. In the agricultural town of Guápiles, 60km north of the capital San José, an innovative company put the flies that swarmed crops to work in 2018.

The black soldier fly (*Hermetia illucens*) is native to tropical climates like the Costa Rican one and its larvae ceaselessly swallow organic waste. "It is a high-quality protein," Miguel Carmona, president of the company ProNuvo, said. Thus, fly larvae become 'healthier' proteins for animals and with less environmental impact than animal feed based on animal protein (beef or fish) or vegetable (soya).

The end products are exported as dried larvae, powdered protein and insect oil, for now only to the United States, although a fish farming company in Costa Rica already uses it in its tilapia hatchery in the north of the country. Fly larvae are turned into proteins and oils and fats that are a rich source for animal feed. – *The Tico Times*

Population growth drives protein demand

The livestock sector must "transform" along with other elements of global agri-food systems to be more efficient, the Food and Agriculture Organization of the United Nations (FAO) has warned recently. The demand for animal protein, particularly poultry and pork, is increasing primarily due to "population growth, urbanisation and improved purchasing power".

However, the FAO cautioned that this demand needs to be balanced with environmental concerns, socio-economic considerations and "an array of safety issues affecting both animals and humans". It believes in order to achieve this, that there needs to be "management and restoration of grasslands and pastures to the production of fodder and feed ingredients, and the processing and use of compound feed".

The FAO has estimated that 40% of global arable land is currently used to feed livestock and there is a major opportunity to improve the sustainability of agri-food systems by optimising land use. Feed typically constitutes between 60 and 80% of livestock production costs.

Globally, commercial production or sale of feed takes place in more than 130 countries and some 8 000 plants produce more than 600 million tonnes of feed annually. Another 300 million comes from on-farm production. – *Agriland*

Explosion at Mowi facility in Norway reported

Salmon producer Mowi reported an explosion in one of its silos at its facility in Valsneset, Norway, in the beginning of November.

Production was back at full capacity the day after the explosion, a spokesperson said, and investigators are looking into the cause of the explosion. According to media reports, a local fire service spokesperson said the explosion was due to dust gas in a silo where flour is stored and that a conveyor belt may have overheated.

Headquartered in Bergen, Norway, Mowi operates salmon farms in Norway, Scotland, Canada, the Faroe Islands and Ireland. The company has 11 500 employees and in 2022 reported revenue of €4,9 billion (around US$5,2 billion) and a harvest volume of 464 000 tons.

Founded in 1964, Mowi first stocked salmon smolt in seawater five years later. In 2006, Marine Harvest Group was formed from the merger of three companies, but in 2018, it returned to its earlier name. – *Feed Strategy*

Egypt releases feed supplies

Elsayed Elkosayer, the minister of agriculture and land reclamation in Egypt, recently announced that the release of animal feed supplies, such as maize and soya beans, will continue in co-ordination with the Central Bank of Egypt (CBE). He said that from 20 to 26 October 2023, 121 000 tonnes of these supplies, worth $60 million, were released from ports.

He added that the release consisted of 88 000 tonnes of maize for $31,6 million and 33 000 tonnes of soya beans for $24,5 million, as well as feed additives for $3,6 million. The total amount released from 16 October 2022 to 26 October 2023 reached 8,4 million tonnes, valued at $4,1 billion.

Elkosayer explained that the release aims to ensure the availability of maize and soya beans in the markets, which are essential for poultry and livestock feed production. He urged poultry project owners to lower their prices and join the government's initiative in this regard. – *Daily News Egypt*

Orffa seminar back in full swing

After a few years of absence due to Covid restrictions, Orffa Belgium NV was able to organise its seminar again for Flemish customers, a well anticipated event.

Since the values of Orffa coincide very well with current challenges in the animal feed industry, such as methane reduction, feed cost reduction, alternatives for antibiotics, reduction of ecological footprint and reduce energy costs during production, the theme of this year's seminar was "One Health".

Several experts in their field were invited to shed some light on different aspects. Dr Ir Alfons Jansman, senior researcher at Wageningen Livestock Research, focussed on how to reduce nitrogen excretion by adjustments to the feed of pigs and poultry. Shannon Groen, researcher at Delft Solids Solutions, discussed the different techniques available to test dustiness of feed additives and feeds. She also highlighted solutions to improve dustiness in order to safeguard worker's health.

Katrien D'hooghe, managing director of the Belgian Feed Association, gave some insight on the vast number of topics they are currently focussing on, to be a bridge between farmers and politics on all levels. Their 12 topics with goals to make the feed producing sector more sustainable by 2023 are very much in line with Orffa's focus points to maintain the Ecovadis Gold recognition in years to come. – *Press release, Orffa*

Evonik's cost savings drive Q3 profit beat

German chemicals group Evonik Industries beat quarterly core profit expectations in 2023, as its cost discipline helped to offset stubbornly low demand.

Evonik reported a 21% drop in adjusted core earnings (EBITDA) to €485 million (around US$519,2 million) in the third quarter (Q3), beating an analysts' forecast of 456 million in a poll provided by the company. The beat was driven by the nutrition and care unit whose adjusted EBITDA fell by 14% to 127 million in the quarter, 22% above estimates, aided by higher demand for its essential amino acids used in animal feeds and initial savings from the restructuring plan launched in April.

The group's free cash flow increased by 63% in Q3, even as its sales fell by 23% to €3,77 billion due to lower volumes and prices, along with a negative effect from converting foreign currencies into euros. – *Reuters*

New head of amino acid business at Evonik

Evonik has appointed Dr Dirk Hoehler as the new head of the essential nutrition product line, under which Evonik is consolidating its amino acids portfolio. Hoehler will take over the role from Dr Jan-Olaf Barth, who has been promoted to become the head of Evonik's high performance polymers business line.

Hoehler will be responsible for overseeing the continued transformation of the amino acids business by focussing on sustainability, efficiency, and cost-leadership. In particular, he will continue to implement the global methionine asset strategy developed under Barth's direction to secure Evonik's leading position in methionine. – *Press release, Evonik*

A competitive analysis of the South African soya bean and crushing industry

By Lucius Phaleng, trade advisor, AFMA

The local soya bean industry is one of South Africa's biggest agricultural and agro-processing success stories. The industry has expanded through the establishment of processing capacity, hectares planted, an improved demand for local products, and more exports.

South African soya bean utilisation is expected to reach 2 773 000 tons by 2023/24, up 3% year-on-year from 2 200 000 tons in 2022/23. Since 2017, the demand for soya beans in the country has increased by around 0,7% annually. Meanwhile, South African soya bean production is projected to reach 1 618 600 tons by 2026, growing at an average of 2,6% year-on-year from 1 387 600 tons in 2021.

The western parts of the country experienced growth in the area planted to soya beans, replacing both white maize and sunflower. Within the norms of crop rotation systems, this area will remain under soya beans – the total area could expand even further in the medium term, following a brief consolidation as prices decline in the short term.

According to the latest Crop Estimates Committee report, South Africa's soya bean production for the 2023 marketing year is projected to remain unchanged at 2,755 million tons and an expected yield of 2,4t/ha. High fertiliser prices during the planting period motivated farmers to plant record soya bean areas, and the total soya bean area for the 2022/23 marketing year was greater than the yellow maize area for the first time.

Soya bean processing

Soya beans are processed in different ways, depending on the product required by the end user (oil and cake, full-fat cake, extracted for human consumption) and the capacity of the facility. Soya beans in the local market, as in global markets, are utilised to satisfy the requirements of processing markets (animal feed, meal and oil, human consumption). The first two (animal feed, meal and oil) are by far the most dominant, with human consumption being significantly smaller.

In terms of animal feed, locally grown soya beans are utilised by the livestock industry as full-fat soya beans, which is an excellent source of good quality protein.

Nutrient yield and quality

Historically, the local soya bean oilcake industry had a negative trade balance, which implies that the country imported soya bean oilcake to supplement domestic production. However, over the past few years, the local feed industry has slowly but steadily moved away from imported to domestically produced soya bean meal. The industry, however, requires a reliable, consistent supply of soya bean meal from crushers that meet stringent quality standards relating to oil and protein content, as well as the digestibility of proteins and amino acids (quality of soya bean meal).

For feed formulations to be optimal and for feed ingredients to conform to the *Fertilizers, Farm Feeds, Agricultural Remedies, and Stock Remedies Act, 1947 (Act 36 of 1947)*, soya bean meal must contain a minimum of 46% protein (with a 12% moisture content). Therefore, shifting the focus from increasing yield per hectare to improving nutrient yield and preserving quality during processing, could benefit everyone in the soya bean supply chain – from the poultry, pig or cattle producer to the silo owner and crusher.

The processing/crushing sector

The oilseed crushing industry is considered extremely capital intensive, as it goes hand in hand with transport economics, commodity trading, hedging, technical excellence, and large economies of scale.

Soya bean meal is the most important source of protein used by feed manufacturers in South Africa, representing more than 75% of the protein meal used in animal feed. According to industry statistics by the Animal Feed Manufacturers' Association (AFMA), soya bean meal plays a pivotal role in feed formulation as it constitutes 14,71% of the total raw materials used in compound animal feed (10,24% sourced locally and 4,48% imported). The utilisation of protein meals such as soya bean and sunflower cake averaged around 18,32% across all species' feed the past decade – in line with global commercial feed rations for dairy (10%), layers (16%), broilers (21%), and cattle (5%).

Given that soya bean is trading at export parity levels, crushing facilities are processing high volumes, despite load shedding, and are offering considerable discounts on soya bean meal, which is providing some relief to the intensive livestock industries.

South Africa crushed a record of 2,5 million tons of oilseeds in the 2021/22 marketing year. Demand and supply estimates indicated that the country would continue to crush around 2,5 million tons of oilseeds in the 2022/23 and 2023/24 marketing years, fully utilising crushing capacity.

The increase in local crushing capacity is attributable primarily to increased investment in local crushing facilities, led by the government through the Industrial Policy Action Plan (IPAP). The outcome of this favourable agricultural policy environment has enabled soya bean farmers to produce high-yielding soya beans. The increased crushing capacity in the local soya bean industry means that more local soya beans will be channelled to crushing for animal feed, thus replacing the historically high volumes of soya bean oilcake imports.

However, unfavourable economic conditions such as rising interest rates and additional operational costs imposed by load shedding, will likely prevent or delay significant investment in increased capacity going forward.❖

For enquiries, email Lucius Phaleng at trade@afma.co.za.

Production of defatted soya bean flour for animal feed

By Prof LJ Grobler, director of CFAM Technologies and professor in mechanical engineering, North-West University, Potchefstroom

Defatted soya bean flour, derived from soya beans after the extraction of oil, is widely recognised as a valuable ingredient in animal feed. This versatile and nutrient-rich product offers numerous benefits for animal nutrition. It serves as an excellent source of high-quality protein, providing essential amino acids crucial for growth, reproduction, and overall health. In addition, defatted soya bean flour contains carbohydrates, fibre, vitamins, and minerals, enhancing the nutritional profile of the feed.

Its inclusion in animal diets promotes optimal feed utilisation, improves weight gain, and enhances feed efficiency. Moreover, it offers versatility and contributes to the development of nutritious and sustainable food and feed formulations.

Uses and reasons for utilisation

Defatted soya bean flour is used in a wide range of applications due to its versatile nutritional profile and functional properties. The following are some common uses and reasons for utilising it:

- **Animal feed:** Defatted soya bean flour is a valuable source of protein for livestock, poultry, and aquaculture feed. It provides essential amino acids for growth, development, and overall animal health.
- **Food products:** It serves as an ingredient in various food products. It is used in baking, extruded snacks, meat analogues, dairy alternatives, protein bars, and vegetarian/vegan products to enhance protein content, improve texture, and add nutritional value.
- **Food fortification:** It is added to fortified food products to increase protein content and enrich the nutritional profile, particularly in areas where protein deficiencies are prevalent.
- **Food extenders:** Due to its protein content and functional properties, defatted soya bean flour can extend and enhance the texture of meat products, such as burgers, sausages, and meatballs. It acts as a binder, improving moisture retention and reducing cooking loss.
- **Gluten-free products:** It is often used in gluten-free baking as a substitute for wheat flour. It contributes to structure, texture, and moisture retention in gluten-free products.
- **Industrial applications:** It finds application in non-food industries, such as adhesives, coatings, and paper manufacturing, due to its binding properties and film-forming abilities.

Methods of production

Defatted soya bean flour can be produced using solvent extraction or mechanical pressing to remove the oil from the soya beans. The flour is produced using a combination of extrusion and mechanical pressing. The process consists of the following:

- **Cleaning:** The soya beans are thoroughly cleaned to remove impurities such as stones, dirt, and foreign materials.
- **Dehulling:** The outer hull of the soya beans is removed through a dehulling machine, which applies mechanical force to crack and separate the hulls from the cotyledons (inner part of the seed). The cracked soya beans, consisting of hulls and cotyledons, are then subjected to air separation. Air blowing is used to remove the lighter hull fragments, while the denser cotyledons are collected.
- **Steam pre-conditioning:** Steam is injected into the preconditioner. This process increases the temperature and moisture content of the soya beans, making them softer and more pliable for subsequent extrusion. Steam preconditioning helps to gelatinise starches, denature proteins, and improve flow properties, leading to enhanced texturisation and overall product quality during the extrusion process.
- **Extrusion:** The pre-conditioned soya beans are passed through an extruder. Inside the extruder, rotating screws convey and compress the soya beans, generating heat and pressure. Extrusion is used to rupture the oil cells and lipid bodies in the soya beans to facilitate the extraction of oil and other components.
- **Mechanical pressing:** The extruded soya beans are fed into a mechanical press that generates pressure causing the oil to be squeezed out from the soya bean flour. The extracted oil is then separated from the remaining solid material. Mechanical pressing efficiently extracts oil from the extruded soya beans while maintaining the nutritional quality of the resulting oil and solid residue.
- **Cooling and drying:** The pressed soya beans are then cooled and dried to remove excess moisture and stabilise the product.
- **Milling:** The defatted soya bean flour obtained from the mechanical pressing process is then milled into a fine powder using a mill. This results in the production of defatted soya bean flour.
- **Packaging:** The defatted soya bean flour is packaged in appropriate bags to ensure its quality and freshness during storage and transportation.

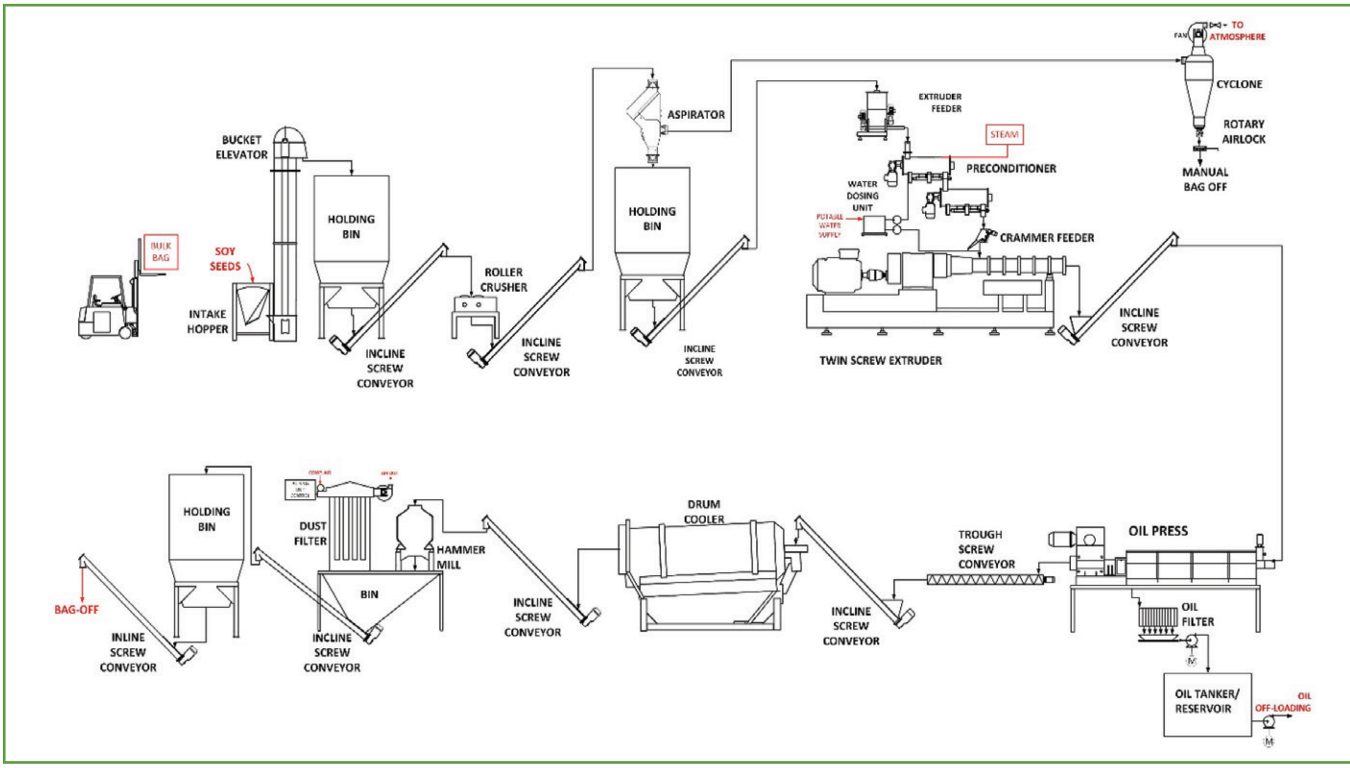
The process flow diagram of such a plant is illustrated in *Figure 1*.

Extrude before you press

Mechanical pressing offers several advantages over solvent extraction for producing defatted soya bean flour:

- **Preservation of natural properties:** Mechanical pressing does not involve

Figure 1: Process flow diagram for mechanical pressing of defatted soya bean flour.



the use of solvents, ensuring that the resulting defatted soya bean flour retains its natural properties, flavours, and aromas.

- **Health and safety:** Mechanical pressing eliminates the potential risks associated with residual solvents, making it a safer option for both producers and consumers.
- **Environmental friendliness:** Mechanical pressing is a more environmentally friendly method as it does not require the use of chemical solvents, reducing the impact on the environment.
- **Cost-effectiveness:** Mechanical pressing typically has lower capital and operating costs compared to solvent extraction, making it a more cost-effective choice for small to medium-scale production.
- **Simplicity and ease of operation:** Mechanical pressing is a straightforward process that requires less specialised equipment and expertise, making it easier to implement and manage.

By extruding soya beans before mechanical pressing, the overall efficiency of the oil extraction process is increased, while also improving the nutritional and functional qualities of the resulting defatted soya bean flour. The benefits of extruding soya beans before mechanical pressing are the following:

- **Improved oil extraction:** Extrusion breaks down the cell structure of soya beans, making the oil more accessible and facilitating its extraction during the subsequent mechanical pressing process. This leads to higher oil yields compared to pressing non-extruded soya beans.
- **Increased protein digestibility:** Extrusion helps to denature proteins in soya beans, improving their digestibility for animals or humans consuming the defatted soya bean flour.
- **Reduced antinutritional factors:** Extrusion can help inactivating or reducing antinutritional factors present in soya beans, such as trypsin inhibitors, lectins, and phytic acid. These factors can hinder nutrient absorption and digestion, and extrusion can minimise their negative effects.
- **Enhanced product quality:** Extrusion can improve the texturisation and functional properties of the soya bean material, resulting in a higher-quality defatted soya bean flour with improved solubility, dispersibility, and emulsification properties.

Benefits of twin-screw extrusion

Single-screw extrusion has traditionally been used to extrude the soya beans before mechanical pressing. New performance data on twin-screw extrusion shows that it produces higher quality products in relation to product digestibility, palatability and the breakdown of anti-nutritional factors and enzymes like urease. Twin-screw extrusion surpasses single-screw extrusion in several aspects, making it highly advantageous and widely preferred in various industries because of the following factors:

Superior mixing: Twin-screw extruders feature intermeshing screws that create intense and efficient mixing. The multiple screw elements, such as kneading blocks, distributive mixing elements, and forward and reverse conveying elements, promote thorough dispersion and distribution of ingredients. This results in homogenous blends, improved ingredient incorporation, and better control over product quality.

Enhanced versatility: Twin-screw extruders offer versatility in processing different types of materials. They can handle a wide range of viscosities, moisture levels, and particle sizes, allowing for the extrusion of various formulations. Whether it is low or high moisture content, powder or liquid ingredients, or challenging ingredients such as fibres or fats, twin-screw extruders accommodate diverse requirements.

Precise control: Twin-screw extruders provide excellent control over process parameters. Operators can adjust temperature profiles, screw speeds, residence times, and other variables with precision. This control allows for tailored processing conditions, ensuring desired product characteristics, such as texture, colour, and nutritional attributes. The ability to fine-tune the process parameters enhances repeatability and consistency in production.

Higher throughput: Twin-screw extruders generally have higher throughput rates compared to single-screw extruders. The intermeshing screws create a larger surface area for material transport and compounding, resulting in increased production capacity. Higher throughput leads to improved efficiency and cost-effectiveness, as more products can be extruded within the same timeframe.

Enhanced product functionality: Twin-screw extrusion enables unique product functionalities. The combination of shear and thermal energy inputs during extrusion allows for texturisation, expansion, modification, and transformation of ingredients. This leads to improved product properties, such as increased shelf life, improved solubility, enhanced digestibility, and enhanced sensory attributes. The versatility of twin-screw extrusion enables the development of innovative and value-added products across industries.

In conclusion

Twin-screw extruders are gaining popularity as a preferred option for extrusion before mechanical pressing due to their numerous advantages. Their superior mixing capabilities result in uniform product quality, while their versatility allows for processing a wide range of materials with varying properties. The precise control over process parameters ensures consistent and tailored product characteristics.

With higher throughput rates, twin-screw extruders improve production efficiency and cost-effectiveness. In addition, their ability to enhance product functionality through shear and thermal energy inputs expands the possibilities for innovative and value-added products.

Overall, the combination of superior mixing, versatility, control, throughput, and product functionality makes twin-screw extruders a compelling choice in the industry. ❖

ExtruAfrica is a non-profit training initiative of CFAM to bring stakeholders together and inform them on topical issues related to extrusion and the industry. Visit *www.ExtruAfrica.org.za* for more information on these events.

Insight into the world of fibre

By Drs Adeoluwa Adetunji and Elrisa Taljaard

Fibre analysis innovations have significantly aided in the utilisation of fibre-rich raw materials in the formulation of products with improved functionality in both animal and human diets. But what is fibre and what is its function?

Dietary fibre is the edible parts of plants that are resistant to digestion and absorption in the small intestine, but completely or partially fermented in the large intestine. Plant fibres include polysaccharides, oligosaccharides, lignin, and other plant substances that are not hydrolysed by digestive enzymes.

Chemical/nutrition definition

There are several definitions for dietary fibre, with the two most common approaches based on chemical composition and nutritional functions. From the nutritional point of view, fibre is a carbohydrate the body cannot digest. While most carbohydrates are broken down into sugar molecules called glucose, fibre cannot be broken down and thus passes through the body undigested.

Because of its indigestibility, it is regarded as a negative diet component, particularly in young animals and humans. This negative perception of fibre stems from a lack of understanding of fibre's critical role in nutrition and health. This is also related to a lack of knowledge about how to determine fibre composition in food and feed raw materials and finished products, as well as a clear understanding of what happens to it when consumed.

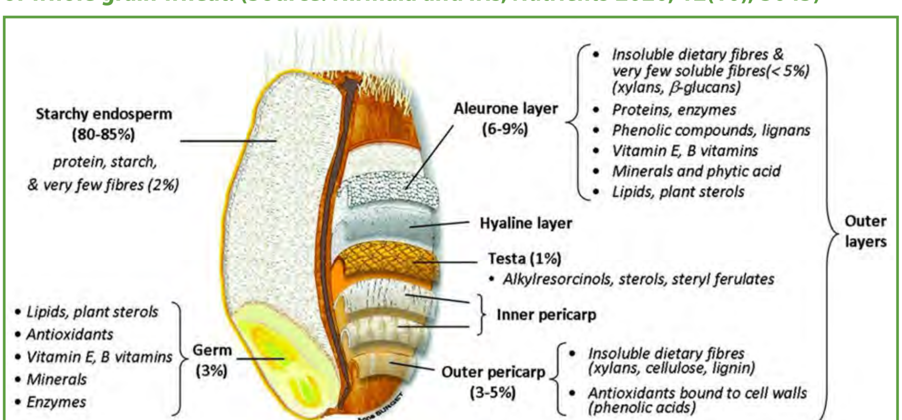
Based on the chemical composition, dietary fibre can be defined as the sum of soluble and insoluble non-amylaceous polysaccharides and lignin. Both soluble and insoluble fibres have significant implications in the animal feed industry. This is especially true given the current increase in the use of fibre-rich alternative feedstocks. Understanding the functional role of various types of fibre in animal nutrition is critical toward increasing production efficiency.

Fermentation of fibre

In ruminants, fibre digestion is mainly achieved through microbial fermentation in the rumen to obtain useful energy for a variety of biological functions. These microbes have the ability to effectively utilise both soluble and insoluble fibre.

For example, fibre utilisation in cows varies depending on the category; dietary fibre improves milk fat in dairy cows by increasing the amount of rumen acetate, which acts as a precursor of milk fat synthesis. In fattening animals, dietary fibre helps control fat deposition in carcasses and improves the marbling score desired by the consumer.

Figure 1: Dietary fibre components in the outer pericarp and aleurone layer fraction of whole grain wheat. (Source: Nirmala and Iris, *Nutrients* 2020, 12(10), 3045)



The response of animals to fibre nutrition, on the other hand, can vary depending on several factors.

In monogastric animals, the degree of fibre microbial fermentation in the large intestine, the extent of absorption, and other factors differ. Soluble fibre sources are rapidly fermented by resident microbes in the distal small and large intestines, increasing digesta viscosity, decreasing digesta passage rate through the intestine, and potentially decreasing feed intake due to increased satiety.

Insoluble fibre, on the other hand, passes through the intestine undigested, increasing passage rate and faecal bulking; however, monogastric species have a limited capacity to ferment insoluble fibre because they lack specific microbial species that ruminants have.

Understanding fibre analysis

What is the difference between crude fibre and dietary fibre? Crude fibre is the plant food residue that remains after extraction with dilute acid and dilute alkali. A plant food residue that is resistant to hydrolysis by monogastric digestive enzymes is referred to as dietary fibre.

On a quantitative basis, fibre is generally referred to as crude fibre or other quantitative terms such as neutral detergent fibre (NDF) and acid detergent fibre (ADF), but modern nutritional thinking wants to separate fibre into its functional properties, namely solubility and fermentability. In evaluating forages and rations formulation for example, more useful measures of their feeding value are determined by using NDF and ADF. They are both used as measures of feeds' cell walls, or structural carbohydrate components.

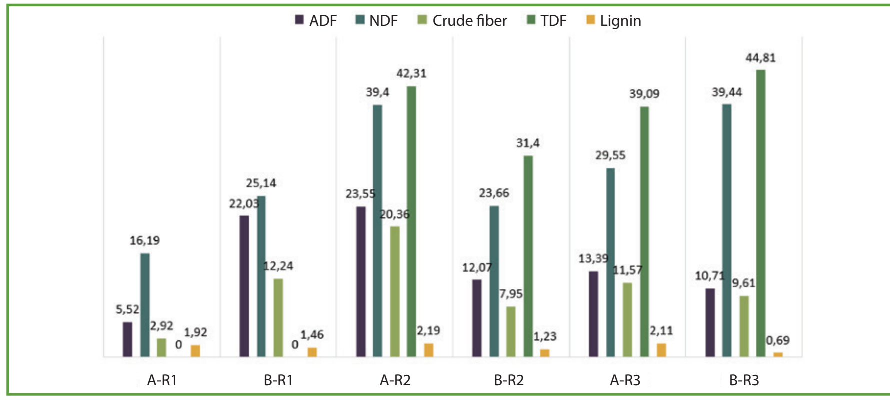
The determination of NDF aids in the quantification of plant structural components, specifically the cell wall. This provides bulk or fill, and the level of NDF predicts voluntary intake. Low NDF values are preferred for inclusion in the diet in general because the level of NDF in forages increases as they mature.

ADF is determined by the plant components that are the least digestible, which include cellulose and lignin. Forages with low ADF concentrations are typically higher in energy because ADF concentrations are inversely related to digestibility.

To further explain these two parameters in fibre quality analysis, the insoluble carbohydrate fraction that remains after a sample of feed has been refluxed in a neutral detergent solution is known as NDF. It is composed of hemicellulose, cellulose, and lignin, all of which contribute to the plant's rigidity. After the NDF procedure is completed, the residue is refluxed in an acid solution; what remains after this process is cellulose and lignin, or ADF.

Note though that these are not completely accurate procedures, and one major reason is based on the possibility of the residues having been contaminated with non-structural carbohydrates such as pectins.

Figure 2: Fibre fractions obtained with different analytical techniques.



**A-R1 and B-R1 were not analysed for TDF, which is why the values are zero.*

Both AOAC International and AACC International have developed analytical methods that are adopted or approved globally following rigorous collaborative studies. Both organisations' methods for dietary fibre analysis are similar and essentially identical.

However, as new sources of dietary fibre, such as inulin, became available as food ingredients, additional specialised methods have been developed and implemented. This is in addition to evolvement in science making available more specialty fibres to be included in food and feed.

Finally, the dietary fibre determination technique, as opposed to the crude fibre method, provides more valuable quality information in order to maximise its benefits in both animal and human diets.

For enquiries, phone Labworld on 011 977 7748 or email labworld@labworldsa.co.za.

FEED TRENDS FOR 2024

By Susan Marais, Plaas Media

When it comes to feed prices in 2024 and beyond, the only guarantee is that there are no guarantees. However, the more informed you are, the better you can be at guessing the future of the feed industry.

When trying to guess what 2024 could have in store for the feed sector, informed sources tell us three things:

- Globally, food prices have come under pressure recently.
- South Africa currently sits with its largest carryover maize crop ever.
- The El Niño weather pattern could place downward pressure on this season's grain and oilseed production.

"During the six-year period between 2016/17 and 2021/22 the contribution of animal products to the total gross value of South Africa's agricultural sector was 46% on average, significantly surpassing the average contribution of field crops (26%) and horticulture (29%) during the same period (*Table 1*)," says Markus Monteiro, a junior lecturer in agricultural economics at the University of the Free State. "This underscores the crucial position of the livestock industry within the greater agricultural sector."

However, the sector is more than the sum of its parts and there are clear links between subdivisions, Monteiro adds. Therefore, given the important role of the South African livestock industry – where feed prices form a significant portion of input costs – one effective strategy for ensuring long-term sustainability and profitability is through the prediction of feed prices.

According to 2022/23 statistics from the Animal Feed Manufacturers' Association (AFMA), animal feed in South Africa is primarily comprised of maize (52,4%) and various oilcakes (21,47%). Soya bean oilcake contributes around 15,21% of the total oilcake percentage (*Table 2*).

Since maize and soya bean are two major ingredients in the production of most South African feed rations, it is worth taking a closer look at what their prices might do in future, Monteiro says.

Global perspective

As South Africa's grain prices are derived from international prices, a global perspective is crucial. According to the latest United Nations' Food and Agricultural Organization's (FAO) food price index at the time of writing the article, global food prices were declining. In fact, it was 10,7% lower than the previous year (September 2022) and 24% lower than the all-time high it reached in March 2022.

International grain prices also decreased by 14,6% between September 2022 and September 2023 according to the FAO cereal price index. That was the seventh month of consecutive decline recorded by the FAO. However, maize prices did increase slightly in September 2022, driven by a confluence of factors, including strong demand for Brazil's supplies, slower farmer selling in Argentina, and increased barge freight rates due to the low water levels of the Mississippi River in the United States (US).

The FAO vegetable oil price index also declined in September 2022. The fall in the index was driven by lower world prices across palm, sunflower, soya bean, and rapeseed oils. The FAO reported that soya bean oil's price was being pulled down by declining rapeseed oil prices. According to the organisation, international rapeseed oil prices declined due to lingering abundant global export supplies. Therefore, world soya bean oil prices followed suit, despite prospects of a firm demand from the

Table 1: South Africa's agricultural gross value breakdown per sector from 2016/17 to 2021/22. (Source: Department of Agriculture, Land Reform and Rural Development)

	Total field crops	Total horticulture	Total animal products	Total agriculture gross value	Field crops' contribution to agricultural gross value (%)	Horticulture's contribution to agricultural gross value (%)	Animal products' contribution to agricultural gross value (%)
	R1 000						
2016/17	66 539 763	77 939 826	126 286 448	270 766 037	25%	29%	47%
2017/18	60 162 784	84 724 489	142 260 930	287 148 203	21%	30%	50%
2018/19	64 470 127	85 881 501	134 102 930	284 454 558	23%	30%	47%
2019/20	77 923 035	92 286 916	140 151 126	310 361 077	25%	30%	45%
2020/21	100 560 570	105 977 633	151 253 821	357 792 024	28%	30%	42%
2021/22	126 380 176	107 998 680	167 203 437	401 582 293	31%	27%	42%
Average	82 672 743	92 468 174	143 543 115	318 684 032	26%	29%	46%

Table 2: Breakdown of maize and oilcake in South African feed composition. (Source: AFMA)

Maize			Oilcake		
Raw material	**Tons**	**% makeup in feeds**	**Raw material**	**Tons**	**% makeup in feeds**
Defatted maize germ meal	10 946	0,15%	**Canola oilcake**	31 941	0,45%
Hominy chop	111 847	1,58%	**Copra and palm kernel**	3 364	0,05%
Maize	3 463 413	49,01%	**Cotton oilcake**	14 823	0,21%
Maize germ meal	7 194	0,1%	**Full-fat canola**	213	0,00%
Maize germ oilcake	643	0,01%	**Full-fat cotton**	6 542	0,09%
Maize gluten meal (20%)	67 547	0,96%	**Full-fat soya**	133 487	1,89%
Maize gluten meal (60%)	15 336	0,22%	**Groundnut oilcake**	-	0,00%
Maize meal	18 682	0,26%	**Maize germ oilcake**	643	0,01%
Maize screenings	7 300	0,1%	**Soya oilcake**	1 081 645	15,31%
-	-	-	**Sunflower oilcake**	244 385	3,46%
Total maize used (tons)	3 702 908	52,4%	**Total oilcake used (tons)**	1 517 043	21,47%

biodiesel sector. (Soya bean oilcake prices are derived from soya bean oil prices.)

The local feed-grain link

When looking more closely at the local picture, the National Agricultural Marketing Council's supply-demand estimates indicated that the country's total supply of yellow maize stood at around 8 267 257 tons in October (2023/24 marketing season). This included an opening stock (on 1 May 2023) of 871 291 tons and local commercial deliveries of 7 465 260 tons.

Total demand (domestic plus exports) for yellow maize was projected at 6 956 000 tons; total domestic demand was projected at 4 721 000 tons. This included 565 000 tons processed for human consumption, 4 100 000 tons processed for animal and industrial consumption, 6 000 tons for gristing (grits), 15 000 tons withdrawn by producers, 30 000 tons released to end-consumers, and a balance of 5 000 tons (net receipts and net dispatches).

A projected export quantity of 135 000 tons of processed products and 2 100 000 tons of whole yellow maize was estimated for exports for the 2023/24 marketing season.

The projected closing stock level for 30 April 2024 was estimated at 1 311 257 tons. At an average processed quantity of 389 250 tons per month, this represents available stock levels for 3,4 months or 102 days.

When utilising 45 days' stock as a proxy, there is potential for 2 835 000 tons of yellow maize available for exports for the 2023/24 marketing season, provided there is efficient logistical capacity, according to the NAMC's report. However, as of 20 October 2023, 1 684 369 tons have already been exported (weekly Sagis figures).

Technical analysis

Monteiro uses technical analysis to analyse the local picture even further. "Technical analysis involves studying past market data focussing on price trends in particular. The core principle of technical analysis is based on the idea that history tends to repeat itself, because people tend to do the same thing in similar situations."

In terms of agricultural commodities, this means that certain price patterns observed in the past are likely to re-emerge in the future. Various technical tools have been developed over time to assist traders identifying these re-emerging price patterns. These tools include chart patterns, which illustrate price movements over time, trends that reveal the general direction of market movements, and statistical indicators that offer insights into potential market shifts.

Figure 1: Candlestick graph analysis for yellow maize prices with trend lines and support/resistance. (Source: Markus Monteiro, UFS)

Application of technical tools

"Among the numerous technical tools available, two of the simplest and commonly applied ones are trend lines and support and resistance levels," Monteiro says, adding that support and resistance are key price levels in the market that traders often use to make decisions about when to buy or sell. "A support level refers to a price level where there's enough demand to prevent the price from falling further. When the price approaches a support level, traders might see it as an opportunity to buy, anticipating that the price won't drop much further."

A resistance level is a price level where there's enough supply to prevent the price from increasing. When the price approaches a resistance level, traders might consider selling, expecting the price to struggle to increase.

"It is crucial to note that a line can serve as either a support or resistance level, depending on the position of the price relative to the line. For instance, a line that was previously a resistance level could transform into a support level once the price rises above it." Similarly, a line that previously acted as a support level might turn into a resistance level if the price falls below it. This dynamic nature underscores the significance of monitoring the price's interaction with these levels, and the importance of adapting trading strategies accordingly.

"Trend lines, on the other hand, is a straight sloping line that connects two or more price points, highlighting the general direction in which a market's price is moving. It serves as a visual representation of the trend, showing whether the market is experiencing an upward, downward, or sideways movement over a specified period," Monteiro explains.

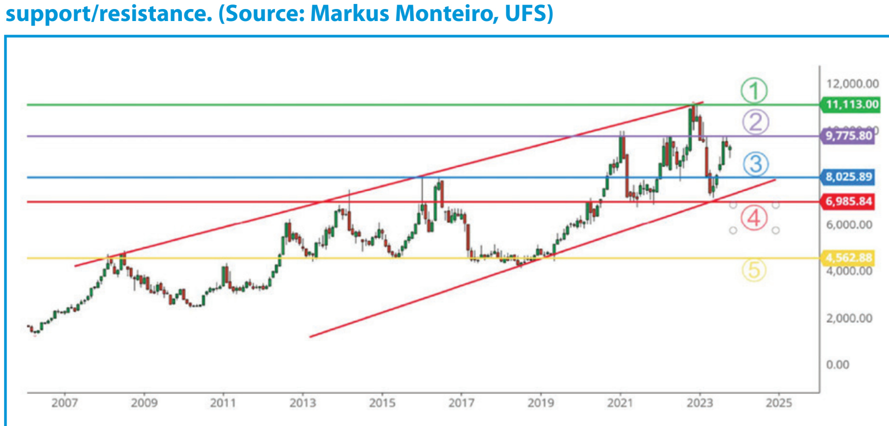
A practical approach to analysis

Figures 1 and *2* demonstrate a practical application of trend lines and support and resistance levels on Safex spot prices for maize and soya bean. These lines have been thoughtfully placed in the graphs, based on historical levels where prices have struggled to break through or have found support. "When examining *Figures 1* and *2*, it becomes evident that these lines have been previously tested, emphasising their significance as critical price levels within the market."

Figure 1 indicates that the yellow maize spot price has trended upward over time. Furthermore, the figure indicates that the yellow maize price is trading between two significant levels. Level 3 at R3 478,88/ton is functioning as a critical support level, whereas level 2 at R4 123,68/ton is proving to be a strong resistance. If the price breaks below level 3, the price could go down and could lead to a potential test of level 4 (R2 878,86/ton). Conversely, a break above level 2 might signal an upward movement where price might test level 1 (R4 929,38/ton). "Keeping a close eye on these levels is crucial for anticipating potential price movements in the upcoming months."

Figure 2 illustrates the technical graph of the Safex soya bean spot price, showing a consistent upward trend over time. At present, soya bean prices are trading below the key resistance level 2 (R9 811,50/ton). If prices do not break above level 2, there is a chance of the price falling and retesting level 3 (R8 025,89/ton). Alternatively, if there is a successful breakthrough above resistance level 2 (R9 811,50/ton), the price might rise and test resistance level 1 (R11 113,00/ton).

Figure 2: Candlestick graph analysis for soya bean prices with trend lines and support/resistance. (Source: Markus Monteiro, UFS)



Monteiro says the analysis of support and resistance levels in the maize and soya bean markets provides valuable guidance for market participants, offering insights into potential price movements as these critical levels are approached.

"Understanding the dynamics of maize and soya bean prices, as highlighted through the analysis of support and resistance levels, is crucial for the livestock industry due to the significant role these commodities play in animal feed production. As such, any fluctuations in the prices of these key agricultural commodities directly impact the overall production costs within the livestock industry."

The close monitoring of trends and critical price levels (as highlighted in *Figures 1* and *2*) will be integral for stakeholders in the South African agricultural sector to make informed decisions and effectively navigate the dynamics of the maize and soya bean markets.

The looming El Niño issue

Like many other local and international institutions, the European Central Bank (ECB) issued a warning that the El Niño weather phenomenon could place global food commodity prices at risk as it could play a major role in feed production and costs in the coming season.

In June 2022, the Unites States National Oceanic and Atmospheric Administration (NOAA) announced that El Niño conditions had arrived, with an El Niño episode likely to develop at the end of 2023. An El Niño event is defined as taking place when the three-month rolling average of the ocean surface temperature in the East-Central tropical Pacific has stayed at least 0,5°C above the 30-year average for five consecutive overlapping three-month periods in a row.

This latest El Niño episode marks a departure from the previous three years, which were dominated by its colder counterpart, La Niña.

ECB warned that El Niño is likely to affect equatorial and global food supplies and prices as it affects weather developments around the globe. Various studies show that the arrival of any El Niño conditions is likely to affect global food commodities, regardless of intensity.

The historical data of the impact of El Niño on crop yields varies from crop to crop and region to region. While an El Niño episode seems to be followed by higher soya bean harvests in the US, it usually has negative effects on US wheat and maize yields. While El Niño has historically had positive effects on soya bean yields in the US and South America, it tends to reduce soya bean yields in Asia. The complex effects make it challenging to predict the implications of El Niño for global food commodity prices.

However, historical analyses do suggest that a normal El Niño has upward effects on global food commodity prices. ECB believes that global food commodity prices could increase by up to 9% if current El Niño conditions develop into a strong El Niño. ❖

For more information, send an email to Markus Monteiro at MonteiroMO@ufs.ac.za.

Edible insects in mixed-sourced protein meals for animal feed and food: An EU focus

By Whitney Vale-Hagan, Somya Singhal, Ilaria Grigoletto, Carlotta Totaro-Fila, Katerina Theodoridou and Anastasios Koidis

Despite insects being nutritious and a sustainable protein source, entomophagy is not widely accepted by Western consumers. After the European Food Safety Authority's (EFSA) positive risk assessment report, few species can be legally farmed and processed in the European Union (EU) under measures set out in Novel Food Regulation 2015/2283. This review summarises scientific progress in the applications of insects as feed and complementary proteins in food during the past five years, including legislative frameworks covering this trajectory.

Despite numerous opportunities presented, insect farming still faces challenges such as gaps in legislative policies, high initial research and development (R&D) costs, and high costs involved in life cycle assessment. As with other novel food, insect production requires new value chains and attention to standardisation, food safety-related issues, certification for mass production, and consumer acceptance. Therefore, the roles of the public sector, scientific community, local authorities, and legislative bodies are extremely important in increasing awareness of sustainability implications and benefits of insects as food and feed.

Insect protein in animal feed

One of the major problems facing the poultry industry is a food supply that will contain all the dietary components needed for rapid growth within a short period of time (Oyegoke *et al*., 2006). Soya bean meal, the major protein source, is supplied together with fish meal, which covers the amino acid (AA) deficiency associated with vegetable proteins. However, these two feed sources have problems, which make insects an increasingly attractive feed option for poultry (Makinde, 2015).

Insect protein includes essential AAs (lysine, methionine, and leucine) which are limited in vegetables. High protein levels (40 to 44%) and AA profiles are better than soya meal and are even similar to fish meal. In general, both free-range poultry and wild birds consume the pupal, larval, and adult developmental stages of insects but in small quantities (2 to 15% range).

The most used insect species in animal feed are the black soldier fly, yellow mealworm and common housefly larvae and the possibilities to feed insect proteins to certain animal species are unlocked, thanks to the lifting of the EU 'feed ban' rules. Insect-derived proteins are now allowed for use in pig or poultry feed; however, insect-derived proteins cannot be included in ruminant diets as per EU regulation (EU Reg 2015/2283).

Wild birds and free-range poultry naturally consume insect species from the order *Orthoptera*. It has been observed that arginine and methionine in *Acheta domesticus* improved the feed conversion ratio in poultry feed. Thus, positive results have been noted when 15% of grasshopper (*Acridia cinerea*) (Wang *et al*., 2007) cricket (*Anabrux simplex*)/*Gryllus testaceus* (Wang *et al*., 2005) meal has been included in the meal fed to broiler chickens.

Most of the experimental diets fed to poultry consisted of black soldier fly of the order *Diptera*. Conventional diets and diets supplemented with black soldier fly meal fed to piglets resulted in a non-significant effect on blood profile as well as gut and histological profile (Biasato *et al*., 2019). Moreover, it has been observed that when pigs consumed 4 to 8% full-fat black soldier fly pre-pupae meal along with their conventional meals, it resulted in increased mucosal immune homeostasis by alternating bacterial count and their metabolites (Yu *et al*., 2019).

Aquafeeds

Considering the scarcity of wild fish and crustaceans, the only way to meet the growing demand for animal protein is aquaculture. Aquaculture depends mostly on the steady supply of fishmeal along with soya bean and meat meal. Fishmeal is the major constituent in commercial fish feeds, contributing 60 to 70% of total aquaculture production cost (Daniel, 2018).

To ensure sustainable and profitable aquaculture production, alternative protein sources such as plant-based components (soya bean, cereal, or oilseeds) and insect proteins are gaining popularity. Due to the presence of anti-nutritional factors and incompatible fatty acid and amino acid profiles, plant-based alternative protein sources are not suitable for aquaculture despite having a similar protein content as fishmeal (Daniel, 2018).

Moreover, plant-based protein sources have higher requirements in terms of land, energy, water, and feed compared to plant-based alternative protein sources. Therefore, insect meals are a more suitable alternative for aquaculture and in some cases have a compatible chemical composition (e.g., *Diptera* protein has a similar amino acid profile than fish meal).

The crude lipid in insects range from 8,5 to 36% while their fatty acid profile depends on their developmental stage and the substrates as a source of nutrients (Barraso *et al*., 2014; Henry *et al*., 2015). Insects have extremely small amounts of docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA), and omega-3 compared to fish meal; however, this can be

Table 1: Inclusion of insect proteins as complementary ingredient in value-added products for human consumption.

Insects (% inclusion)	Supplement	Protein diet content (%)	Sensory analysis
Acheta domesticus, Bombyx mori, Brachytrupes portentosus, Gryllus assimilis, Gryllus bimaculatus, Locusta migratoria	Wheat flour	5 to 50	Not studied
Acheta domesticus (house cricket)	Sourdough fermented with *Lactobacillus plantarum* strain	72,60	Not studied
Tenebrio molitor and crickets *Gryllodes sigillatus* (2 to 10%)	Muffins	11,18 to 14,25	Yes (taste, overall acceptability)
Mealworm *Tenebrio molitor*/buffalo worm *Alphitobius diaperinus*/cricket *Acheta domesticus* (10%)	Wheat bread	16 to 27	Yes (taste, texture, appearance)
Alphitobius diaperinus (7,5%)	Pea (3,7%) and hemp (3,75%) protein for sponge cakes	7 to 10	Yes (characteristic odour, uncharacteristic odour and taste, inner colour, elasticity, crumby, hardness, adhesiveness, chewiness, sweetness)
Alphitobius diaperinus and *Tenebrio molitor* (5 to 10%)	Wheat flour bread	-	Not studied
Tenebrio molitor (10 to 15%)	Maize meal, maize gluten meal, and soya bean meal-based diets	-	Not studied
Cricket (*Gryllusbimaculatus*) (5 to 10%)	Millet flour for pasta	-	Yes (taste, odour, appearance, consistency, and cooking properties)

altered by using substrates, insect breeding or feeding fish offal (Henry *et al.*, 2015).

Although there are less than 20% of carbohydrates in insects in the form of chitin, which is quite indigestible to fish, recent studies showed that chitin acts as an immune-stimulatory. Chitin, a polysaccharide in the exoskeleton of insects, has shown potential as an antimicrobial and for boosting immune system functioning, making it a promising alternative to antibiotics (FAO, 2017).

Human food

As seen in *Table 1*, the most common insect species are silkworm pupae (*Bombyx mori*), crickets (*Acheta domesticus*), mealworm (*Tenebrio molitor*) and locust (*Locusta migratoria*) that has been included as one of the ingredients in producing food such as bread, muffins, pasta and extruded snacks for feeding around two billion people worldwide (González *et al.*, 2019; Zielińska *et al.*, 2021; Ali and Ali, 2022).

Much less exploration has been done regarding the consumption of insects as food for humans as opposed to animals and fish. The major reasons of limited use of insects in human food are less acceptance by the human population, especially in Western cultures, and allergens associated with insects. The primary compounds in insects leading to allergenic reactions in certain human populations are glycoprotein nature of hyaluronidase and phospholipase A. However, the severity of insect-based allergy can be reduced using food processing techniques such as hydrolysis and fermentation, which are yet to be explored (Castro *et al.*, 2018).

Whole insects are dried and grinded and used in food products in the form of insect powders. These dried and powdered insects are texturally similar to plant derived powders such as grain flours (Brogan *et al.*, 2021) resulting in the term insect flour. Spray-drying is another technique to obtain insect powder and, specifically, the one produced from crickets shows both nutritional and antioxidant activities, and no toxic effect on cellular viability and pro-inflammatory activity were detected (Ruggeri *et al.*, 2023).

The effects of insect meal on the quality attributes of protein-rich muffins were measured by replacing wheat flour with 15% of *Locusta migratoria* and *Tenebrio molitor* insect meal to make muffins. Muffins with *L. migratoria* had a 12,91% protein content while those with *T. molitor* had a 36,56% fat content. The study concluded that muffins with mealworm had a higher acceptability score than that with grasshopper. Moreover, muffins fortified with insect meal exhibited less dense structures along with lower specific volume than the standard muffins, making it an effective ingredient in enhancing the nutritional content of bakery products (Çabuk, 2021).

Barriers and opportunities

Contributions to sustainability

Insect farming has been reported as more sustainable compared to conventional meat livestock. The results obtained in a recent study showed that the value chain for producing protein from mealworm is less impactful on the ecosystem – in terms of nitrogen produced, potential for soil acidification, and global warming – than producing an equal amount of protein from pork. In addition, it uses fewer mineral and fossil resources, which makes the insect production system suitable in poor realities where protein demand is growing (Vinci *at al.*, 2022).

Insects are a potential protein source which could contribute to freeing up land to grow crops for direct consumption by the human population and could lead to a concomitant increase in food security. Insect production reduces the land needed

Table 2: General acceptance of feedstocks for insect production and target animal species (adapted from IPIFF, 2022).

Feed stocks		Target species				
✓	Vegetable substrates		Protein	Fat	Live*	Whole insects (dried or frozen, not milled)
✓	Former foodstuffs: vegetal, eggs, and dairy	Companion animals	✓	✓	✓	✓
✗	Former foodstuffs: meat and fish	Fish	✓	✓	✓	✗
✗	Catering waste and slaughterhouse products	Poultry	✓	✓	✓	✗
✗	Animal manure	Pig	✓	✓	✓	✗

**Permitted.*

for protein production compared to the hectares needed for the same quantity of protein from pigs, chickens, and cattle (Raheem *et al*., 2019), contributing, together with vertical farming practices, to fighting biodiversity losses (IPIFF, 2022). In addition, it implements sustainable practices in agriculture, since it does not require pesticides, antibiotics, or growth hormones (IPIFF, 2022), and it contributes to a real circular food system.

Table 2 shows the feed stocks for insect production and target animal species according to IPIFF (2022). The crosses indicate that specific feedstocks are not permitted to be used as a substrate during insect production (i.e., former foodstuffs, catering waste). Moreover, dried or frozen whole insects (not milled) are not allowed to be included in the diet of fish, poultry and pigs. Derler *et al*. (2021) provided an overview on by-products, which have already been fed to *Tenebrio molitor* and which are suitable for its farming, and Kuan *et al*. (2022) discussed the applicability of *Hermetia illucens* and *Zophobas morio* in food and plastics.

Local insect farming can reduce the dependence on expensive and imported feed, particularly important for small-scale livestock farmers (Chia *et al*., 2019), and on externally derived fertilisers (Beesigamukama *et al*., 2022). Considering all these aspects, edible insect farming and consumption could have an important role in food security and the promotion of zero hunger (Bao and Song, 2022). Besides these many advantages, wider adoption is dependent of the legislation framework and consumer attitude.

Legal framework and implications

Firstly, legal regulations are the essential prerequisite to develop insect farming and the effective marketing of edible insect-based food. Since 2015, legislation has been progressing rapidly (Delgado *et al*., 2022). As of June 2023, 23 applications have been submitted, covering seven insect species, six applications have been authorised, and seven applications have been granted a Positive Assessment by EFSA.

Six edible insect products are already authorised as novel food, including four insect species: *Acheta domesticus* (house cricket), *Tenebrio molitor* larva (yellow mealworm), *Locusta migratoria* (migratory locusts), and *Alphitobius diaperinus* (lesser mealworm). Currently, another eight novel food applications are being assessed by EFSA, including at least two additional insect species: *Hermetia illucens* larvae (black soldier fly) and *Apis mellifera* male pupae (honeybee drone brood) (IPIFF, 2022). The EU authorises the use of insect proteins originating from the aforementioned insect species in feed for aquaculture, poultry, and pigs.

However, despite the progress, there still are some gaps in regulation associated with policy making, legislative solutions, standardisation and certification of mass-produced edible insects, including interdisciplinary regulations that address the production of edible insects integrating food sciences, agriculture, animal production, conventional medicine, forestry, and socioeconomic and environmental sciences; microbiological concerns and management of insect diseases; genetic modifications for specific traits; safety of insect-based food in the case of products derived from insects that are fed with organic waste; functionality and shelf life of insect-based food; health benefits for consumers, including the digestibility, toxicity, allergenicity of insect-based products; long-term impact of insect protein consumption on human and animal health; introduction of universal standards and certification requirements for edible insect farming and industrial production; and logistics operation (Żuk-Gołaszewska *et al*., 2022).

Consumer behaviour and attitude

Behavioural interventions and tools are necessary to change consumer perspective and promote entomophagy in Western countries (Bao and Song, 2022). A case study conducted in 2022 in Finland, via a consumer survey and expert interviews, recognises four pathways to increasing the use of edible insects in countries without a tradition of entomophagy:

- Producing a variety of insect-based food products, especially processed food in a familiar form in which insect are not recognized as such.
- Producing edible insect food products remaking the possibility to replace greenhouse gas emission-intensive animal proteins.
- Focussing on the price, taste, and availability of insect-based food products.
- Using insects in animal feed.

They suggest that technological progress is expected to decrease the price of insect-based food, but at the same time, the increased use of edible insects faces challenges related to eating habits, contradictory perceptions about the sustainability implications of insect farming, and the availability of insect-based products (Halonen *et al*., 2022). Moreover, the acceptance of edible insects depends on some positive motivators, including not only concerns about sustainability, but also the desire to try new food and curiosity (Florença *et al*., 2022).

Processing edible insects increases consumer acceptance as are already used in the production of various types of bread, pasta, chips, protein bars and other products in the rapidly growing insect industry (Jeong and Park, 2020).

Finally, flavour is directly correlated with the potential acceptability of insect-based food products, which is nowadays under investigation, e.g., with the study of volatile compounds that directly influence the aroma (Żołnierczyk and Szumny, 2021). Some processing techniques, such as defatting or fermentation, could be also useful to remove or reduce unpleasant odours specific to some insects (Perez-Santaescolastica *et al.*, 2022).

Opportunities and challenges for small- and medium-sized enterprises

Novel food authorisation is the first step needed for an agricultural and food manufacturer willing to enter the sector to place a new product on the market. It is important to consider that presenting a scientific dossier to the European Commission is not an easy task, particularly for a small- and medium-sized enterprise (SME).

R&D expenses represent a real challenge from the very beginning. Investors, even if focussed on pre-seed start-ups, are usually looking for traction, which cannot be robust until the sector starts growing, and more products become available on the market. However, this phenomenon is an oxymoron, since, currently, the volumes of insect food available are still low, and the costs of those novel food are relatively high. For this reason, more product availability on the market and product technological innovation, boosted by novel food procedure, will help segmentation, lower costs, and product differentiation.

In the farm-to-fork value chains of an SME insect farm, sustainability can have a significant role in the rearing activities, although a complete life cycle analysis of the entire process is one of the main challenges and objective for the sector (FAO, 2021). Rearing and transforming insects, as with most of the food technological processes, are energy intensive. Green and renewable sources, together with circular economy activities, have a key role to determine genuine sustainable claims for the entire production chain (United Nations, 2015).

The business model of a company aiming to sell insect-based novel food cannot exclude any channel, even if online sales seem to be the more common entry point. Having enough volumes and financial resources to enter large retailers might take some time, but it will represent the most effective segment growth. Honest and complete communication on the label should be essential for all producers, to allow consumers to make informed choices: Insects must be clearly highlighted on labels, and there must be no confusion between 'normal' food and 'insect based' novel food (Pölling *et al.*, 2017).

Novel food regulation allows, case by case, different percentages of use of the novel food in different food categories. It is possible to indicate the presence of insects within a food product through insect-related nutritional claims on the label. The higher the percentage of authorised novel food, the easier it is for the consumer to associate the nutritional beneficial properties of the food to the presence of the insect-based ingredient. Normally, there is a very low amount of insects in the ingredient list; this does not imply any relevant impact on the nutritional profile, but it reports the claim on the label.

A company entering the sector needs to consider the proper preparation of the product launch with an appropriate stakeholder management approach and a consumer centric business model. Part of the political reluctance towards this niche sector might be overcame if local authorities recognise that new insect farms are not competitors for traditional farmers and local production. In fact, insect farming might economically help traditional farmers, adding extra revenues to their models, encourage innovation and new products in local agri-food industries, and build national expertise in processing and cooking this new ingredient.

Insect-based novel food should not be positioned as a mere alternative to other traditional meat sources, but they can gain broader consensus, if positioned as an innovative alternative food to increase variety in a balanced and healthy diet (Bessa *et al.*, 2018; Cajas-Lopez and Ordoñez-Araque, 2022).

Conclusions

There is no denying that there is a global protein gap caused by the continuous population rise, the global food crisis, and the rising demand for high-quality alternative protein. This should motivate and support the growth of the edible insect market. It is evident that a variety of animal and fish feed are currently being reformed with some inclusion of insect protein.

Under a continuously evolving legal framework, farmers and consumers show positive attitudes, mostly motivated by the increased awareness of sustainability implications and benefits. Despite this, there are still a few limitations regarding the adoption of insects in certain animal feeds, primarily for safety reasons, such as for ruminants, and the acceptance in human food in countries without entomophagy tradition, mainly related to their perceptions.

In this trajectory, the roles of the public sector, scientific community, local authorities, and legislative bodies are extremely important. Our review indicated that governments should focus on well-structured communication campaigns with an aim to inform and educate consumers on the benefits of entomophagy, avoiding misleading information and non-science-based communication. Education and marketing campaigns should also target farmers to promote the awareness that edible insects offer extra revenue models in addition or as an alternative to conventional livestock rearing.

On the legislative side, more novel food authorisations will favour market growth in the EU. Food process innovation will boost higher volumes and product segmentation. Entry barriers are still high and new investments in the seed and pre-seed SMEs are crucial to increase the number of companies entering the sector. Stakeholder management and engagement can help operators spread the scientific evidence behind insect food safety and beneficial effects. ❖

This article was condensed for publication in *AFMA Matrix*. To read the full article, visit *www.doi.org/10.1016/j.foohum.2023.09.011* or email Anastasios Koidis at t.koidis@qub.ac.uk.

Evonik Analytical Services:
The key to making informed decisions about your raw materials

By Zenani Shozi, Analytical Services Specialist, Evonik Africa (Pty) Ltd

Evonik is one of the world's leading specialty chemical companies. It has the largest worldwide network of laboratories conducting amino acid analysis. Our master amino acid laboratory, AMINOLab®, is situated in Hanau, Germany and has been operational since 1960. It has an integrated laboratory network at 13 sites on all continents.

Our services using near-infrared (NIR) reflectance scanning technology are designed for ongoing monitoring of often variable raw feed materials. Once amino acid variability in key ingredients is reduced, feed mills and livestock production facilities can confidently lower the safety margins in their feed mix, leading to considerable cost savings while maintaining consistent animal performance. The predictive calibrations are based on findings from Evonik's state-of-the-art wet chemistry solution, AMINOLab®.

Evonik offers a wide range of data-driven analytical solutions at a world-class quality standard. We currently have more than 800 NIR spectrometers actively utilising our NIR calibrations with over one million samples analysed each year. Evonik predictive calibrations are built from over 60 years of wet chemistry conducted at our AMINOLab®, giving you accurate information on your raw materials within three to five minutes.

For peace of mind, our NIR calibrations were developed using a wide range of growing conditions, cultivars and qualities around the world, and are continuously updated to ensure that you are getting information which is accurate.

AMINOProx® and AMINONRG®

AMINOProx® looks at a range of crude nutrients in feed ingredients, as well as in broiler, turkey, duck, layer, fish, shrimp, cow and pig feed. This is our NIR service which accurately predicts proximate parameters such as dry matter, crude protein, crude fibre, sugars, starch, neutral detergent fibre, acid detergent fibre, phosphorus and phytic phosphorus (derived from Weende analysis).

Calibrations are based on representative sets of globally collected samples. Customers with in-house NIR systems can upload data to our web portal for evaluation, while those without equipment can submit samples for swift processing and turnaround.

AMINONRG® draws on data from AMINOProx® to enable quick and reliable estimates of important energy parameters in feed ingredients. It provides energy values for pigs and poultry calculated based on the AMINOProx® results. These parameters are gross energy, apparent metabolisable energy for poultry, and digestible energy, metabolisable energy, and net energy for sows and growing pigs.

AMINORed® 2.0

AMINORed® is a unique service offering by Evonik and we have been perfecting this service since 1990. This service allows you to gather information about the processing of raw materials such as soya products.

Adequate processing of soya bean products is of particular importance, as the antinutritional factors (ANFs) present in raw soya beans (such as trypsin inhibitors and lectins) have a strong negative impact on performance. Luckily, these ANFs are heat sensitive and can be deactivated by a certain level of heat.

Overprocessing also needs to be avoided since it can affect the nutritional value of soya, with particular reference to the digestibility of individual amino acids. Reactive lysine can be used to measure the level of digestibility of amino acids present in soya. This is because lysine forms Maillard reaction products when subjected to overprocessing, which reduces the digestibility. AMINORed® gives accurate results for potassium hydroxide, trypsin inhibitor activity, reactive lysine and processing conditions indicator (PCI).

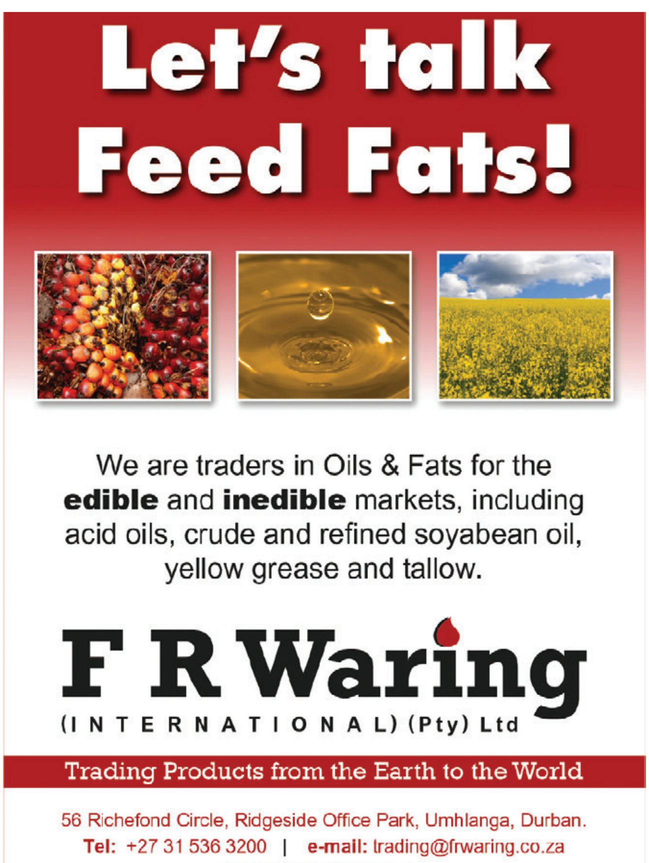
PCI is an Evonik-developed parameter which essentially allows you to see the degree of processing with one parameter. The PCI is expressed on a colour scale with a range of 0 to 30, where 0 to 10 indicates overprocessing, 10 to 20 adequate processing, and 20 to 30 underprocessing (*Figure 1*).

These tools support the new digitalised world in which quality control becomes more manageable and allows you as the feed producer to pay the right price for your raw materials and make informed decisions regarding each supplier. In addition, you will be able to improve your feed formulations with more updated matrix values and reduce safety margins, resulting in overall savings in feed costs.

AMINONIR® Fatty Acid

In animal nutrition, it is all about designing a feed which meets every nutritional


Farming the rumen with VistaPre-T improves digestion, decreases emissions and increases productivity
VistaPre-T boosts the rumen's natural ability to digest forage allowing for smarter use. That not only lowers feed costs but lowers emissions by up to 15%*. Less pressure on the pocket and less pressure on the environment. It's win-win. Contact us to learn more and to help the food chain make better use of forage. Find out more at www.abvista.com/products/Vistapre-t
vistapre T
Energy-smart. Human-kind.
*Data on file. View at www.abvista.com
ABVista


Let's talk Feed Fats!
We are traders in Oils & Fats for the edible and inedible markets, including acid oils, crude and refined soyabean oil, yellow grease and tallow.
F R Waring
(INTERNATIONAL) (Pty) Ltd
Trading Products from the Earth to the World
56 Richefond Circle, Ridgeside Office Park, Umhlanga, Durban.
Tel: +27 31 536 3200 | e-mail: trading@frwaring.co.za
www.frwaring.co.za

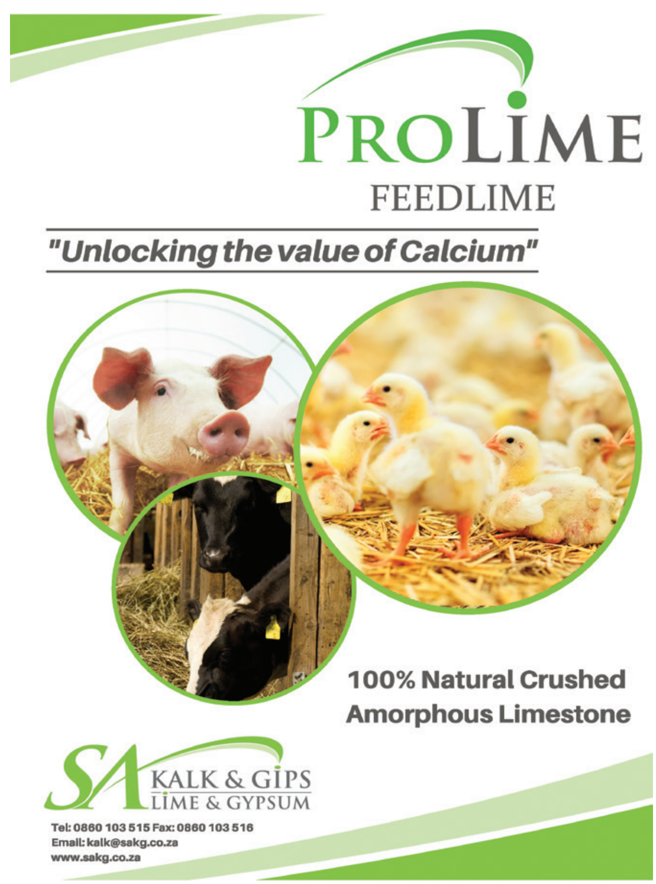
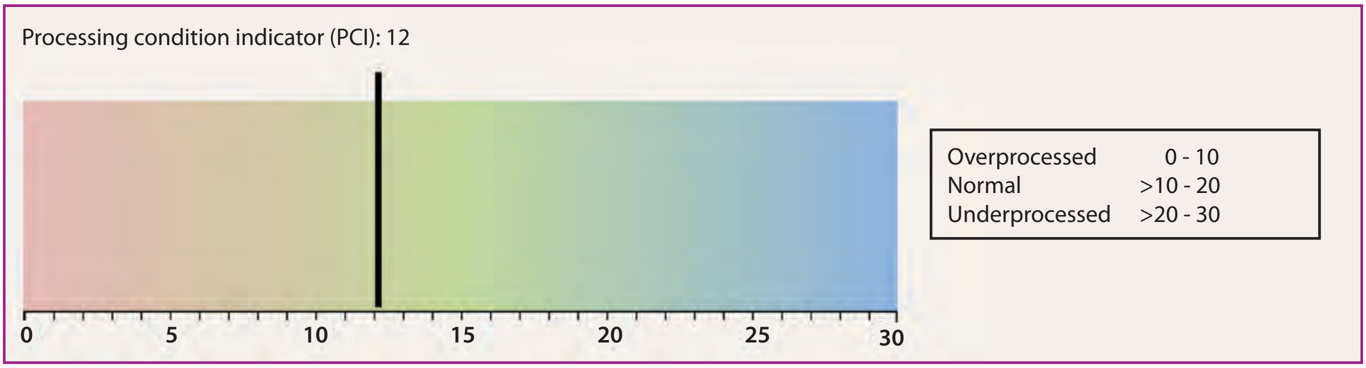

PROLIME
FEEDLIME
"Unlocking the value of Calcium"
100% Natural Crushed Amorphous Limestone
SA KALK & GIPS LIME & GYPSUM
Tel: 0860 103 515 Fax: 0860 103 516
Email: kalk@sakg.co.za
www.sakg.co.za

Figure 1: Overall evaluation of processing conditions.



need of the animal. With AMINONIR® FA, Evonik developed NIR calibrations for the prediction of fatty acids in feed ingredients. Fatty acids are important nutrients for animals and are not only used as building blocks for fat, but also for the synthesis of important hormones which are needed for growth and reproduction.

The fatty acid composition between and within feed ingredients differs substantially and requires analytical tools applicable for daily routine. Reach the next level of precision with AMINONIR® FA and terminate the guess work.

AMINONIR® Advanced

For faster-than-ever sample analysis, Evonik has developed the onsite system AMINONIR® Advanced. Like its counterpart AMINONIR®, the service evaluates all major feed ingredients, but with one big difference: The customer owns and operates the NIR device. That means you can scan samples, upload the data to the AMINONIR® web service interface and receive a complete evaluation within three minutes.

A further advantage of AMINONIR® Advanced is that, if you need data in a hurry, it allows you to scan feed ingredients as they are – no grinding required. This is an asset when quick decisions are required, like on delivery of feed ingredients. If precision is a key factor, for example when updating the nutritional matrix of a feed ingredient in your feed formulation software, the sample should be ground before scanning.

Unground calibrations

In the many years of NIR analysis there has always been a lot of emphasis on grinding samples for increased accuracy. Evonik has taken heed to the demand for unground calibrations for rapid analysis of incoming raw materials. Unground raw material calibrations combine sample processing speed with prediction accuracy. At Evonik we strive to have services that are continuously updated and remain relevant to our customers.

There are many advantages of this unground service which include:

- No time-consuming grinding required.
- Rapid amino acid and proximate results, which enable you to store different qualities of incoming raw materials separately.
- Reduction in the need for expensive wet chemistry.

Time efficiency is very important if one is working on a schedule and this tool will reduce waiting periods for incoming raw material trucks, enabling you to utilise time more wisely.

AMINODat® 6.2

AMINODat® 6.2 is the most comprehensive raw material database in the world. It consists of nutritional data from more than 31 000 000 analytical results. It offers fresh data on more than 150 global feed ingredients, and the number of quality groups increased to 78 to provide you as specific data as possible and more than 520 data sets on country specific feed ingredients. In total, AMINODat® 6.2 includes more than 1 800 feed ingredients and more than 600 000 samples.

This powerful platform provides nutritional profiles, regression equations, amino acid digestibility coefficients and amino acid recommendations for different species. The AMINODat® 6.2 database is continuously updated and is the perfect tool to optimise your feed formulations and benchmark incoming feed raw materials.

This service gives you quick feedback on the amino acid content of animal diets. Using the 'diet evaluation' functionality in combination with 90 ready-to-use species- and phase-specific amino acid recommendations, you can easily determine whether the amino acid content of a diet fulfils the animal's needs and if the amino acid pattern is balanced. The inbuilt amino acid recommendations reflect the latest scientific developments and cover, for example, glycine equivalents for broilers.

The tool also supports you in identifying which of the utilised feed ingredients contributes the most to dietary variation by illustrating the impact of variable feed ingredient quality on the combination of nutrients in the finished feeds. This helps you to fine-tune sampling schedules and improve quality control.

Conclusion

Evonik is a global leader in animal nutrition with tools that can support you to better manage your raw materials and feed samples. With superior quality and reliability of Evonik Analytical Services, combined with our dedicated team of experts who are ready to help you achieve the next level of animal performance, you will ultimately increase the profitability of your operation.

Send an email to Zenani Shozi at zenani.shozi@evonik.com for more information.

ADM

ADM's Three Core Businesses

Ag Services & Oilseed	Carbohydrate Solution	Nutrition
		

Mega trends	HEALTH & WELL-BEING	SUSTAINABILITY	FOOD SECURITY
Consumer insights	54% — 54% of consumers want for animals not to be given **hormones/antibiotics**	55% — 55% of consumers want for animals to be raised in a way that is **not harmful to the environment**	>65% — Consumers prioritise **quality** and **safety** when they make choices about meat and fish
Consumer trends expressed in AN	HEALTH through NUTRITION	SUSTAINABILITY	PERFORMANCE AND PROTEIN QUALITY
Growth drivers in AN	 Organic Free range; Expanded Protein Choices;  Balanced Wellness	 Earth-Friendly Production;  Trust & Traceability;  Social Impact	 Expanded Protein Choices

Why ADM?

From the seed of the idea to the outcome of the solution, ADM provides access to nutrition worldwide.

- We are a **global leader** in nutrition, serving the needs of emerging and developed markets.
- We are the **world's most diversified** oilseeds company and largest corn processor.
- We are the **world's premier** agricultural supply chain company.

One ADM brand for a winning portfolio

ADM South Africa - Little Fourways Office Park Block B, First Floor 1
Leslie Avenue, Cnr William Nicol Drive, Fourways, Magaliessig - Sandton 2067 Tel: 011-467-5915

Underutilised feed sources for ruminants

By Salah Hamed Esmail, independent freelance journalist

In this article, unusual feeds and their nutritional value and effects on ruminant production are investigated and compared to conventional feed ingredients.

Feed ingredients that were studied are kitchen and restaurant disposals, newsprints, silage effluent, rumen contents, poultry litter, cattle wastes, and wood residues, all of which may have a promising future in the livestock industry, particularly in areas where the supply of conventional feeds is scarce.

Kitchen and restaurant disposals

These wastes contain valuable materials such as vegetables, fruits, meat, fish, eggs, etc., and are produced at an annual rate of around 45kg per inhabitant worldwide. The average composition of these wastes is shown in *Table 1*.

Recently, attempts were made to utilise waste in cattle feeding. The first experiment was conducted in Germany, where more than 9 000 tonnes of kitchen and restaurant disposals are processed annually into animal feed by sanitisation, grinding, supplementation with flavouring agents such as molasses, pelleting, and eventually offering the product to the animal.

Studies have shown that the use of these wastes in this way leads to a remarkable improvement in beef cattle production. The average daily gain of beef cattle fed on the processed wastes was 0,98kg, which is much greater than the growth rate obtained with many other traditional feed sources.

Newsprints

A study was conducted to examine feed intake, digestibility, and performance of dairy cattle that were fed diets containing 10% shredded, ground, or pulped newsprints compared to the control diet (*Table 2*). The actual milk yield decreased when newsprints were incorporated into the diet.

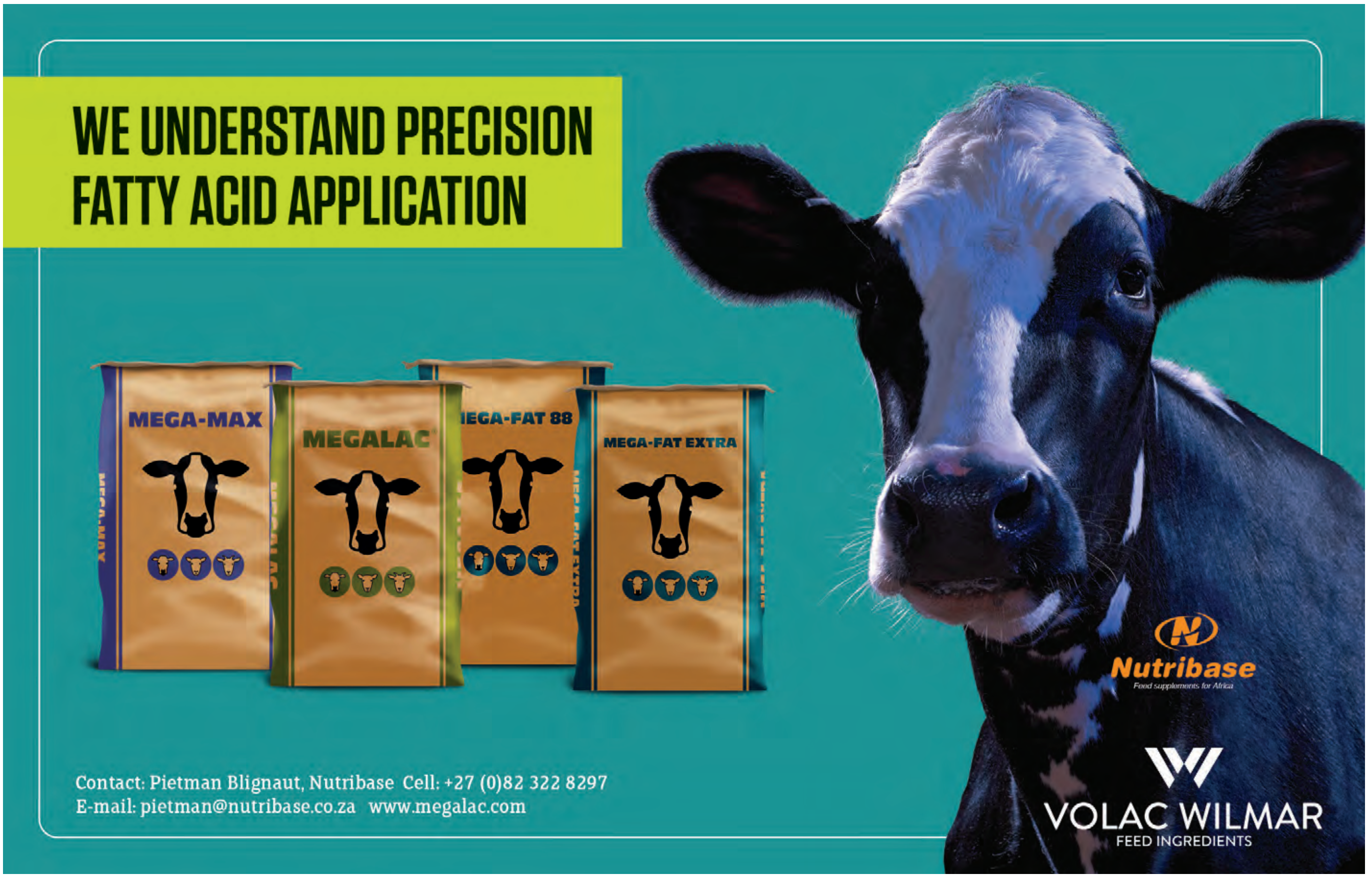
However, considering the greater amounts of milk fat produced in these cases, the fat-corrected milk values (FCM) were greater for the newsprint diet. This is probably due to the high fibre content of the newsprints (roughly 15%) which is needed by the cow to maintain high levels of FCM (*Table 3*).

Silage effluent

Fresh, uncontaminated, undiluted effluent from well-preserved silage can be fed to cattle. Daily intake can be up to 45 litres

Table 1: Average composition of kitchen and restaurant disposal wastes. (Source: MA Hanafi, 1989)

	% on dry matter (DM) basis
Dry matter	92,51
Crude protein	21,61
Fats	16,09
Crude fibre	4,6
Calcium	5,25
Phosphorus	1,36


WE UNDERSTAND PRECISION
FATTY ACID APPLICATION
MEGA-MAX
MEGALAC
MEGA-FAT 88
MEGA-FAT EXTRA
Nutribase
Contact: Pietman Blignaut, Nutribase Cell: +27 (0)82 322 8297
E-mail: pietman@nutribase.co.za www.megalac.com
VOLAC WILMAR
FEED INGREDIENTS


CHEM NUTRI
ANALYTICAL
sanas
Testing Laboratory
T0713
Chem Nutri Analytical is an independent contract laboratory specializing in a range of tests vital to the agricultural sector.
IN-FEED MEDICATION
PLANT GROWTH SUBSTANCES
MINERALS
LEAF ANALYSIS
PHYTASE ACTIVITY
FEED & FOOD NUTRIENTS
MYCOTOXINS
SOYA QUALITY
OIL QUALITY
+27 84 341 2213
+27 11 316 8800
www.chemnutri.co.za
info@chemnutri.co.za
Cedar Lake
C/O M57 & Porcelain Rd
Olifantsfontein
AWARDED by industry for Our Professional performance.
CHOSEN by clients for Our personal service.

Table 2: Composition of the diets used in the dairy cattle feeding experiment.

Ingredients	Control	Newsprint 10%
Newsprints	0	10
Cottonseed hulls	20	10
Corn grain	50	50
Soya bean	15	15
Molasses	14	14
Mineral premix	1	1
Total	100	100

Table 3: Feed intake, digestibility, and milk production responses of dairy cows fed different levels of newsprint.

Item	Control	10% newsprint
Feed intake (kg of DM)	21,5	17
DM digestibility (%)	77,4	77,4
Actual milk yield (kg/day)	20,2	19,7
Milk fat (%)	2,6	3,1
FCM (kg/day)	15,9	16,9

(3,3kg DM) per day, which has a nutritional value of approximately 2,5kg of barley. In terms of animal performance, it was reported that milk yields and fat, protein, and lactose contents tended to increase for cows receiving effluent with concentrates. The increases in milk yield were small, however, relative to the amount of DM consumed, indicating reduced feed conversion efficiency when effluent was fed. Intakes of silage stored in the presence of effluent tended to be lower than those of silage from which effluent had been drained, but milk yield and milk composition were unaffected.

Rumen contents

Rumen contents are important waste produced by cattle and sheep slaughterhouses. Each animal produces roughly 25kg of waste (on a fresh weight basis), which means that millions of tonnes of these materials are wasted except for use as fertiliser for agricultural lands and grazing areas.

Rumen waste contains approximately 12,5% high-quality crude protein, containing all the essential amino acids in the same proportions as in other standard proteins such as egg yolk or corn gluten. These wastes also contain approximately 5,2% fat, 25% crude fibres, high levels of calcium and phosphorous, and some vitamins such as vitamin B complex, which is naturally manufactured in the rumen by micro-organisms such as bacteria and protozoa.

It should be noted here that these components are not significantly affected by environmental, dietary, or manufacturing factors. That is, they are more chemically stable under different conditions compared to other materials, which better helps in planning nutrition programmes and the nutritional needs of animals when using these wastes in their diets.

Studies have indicated that adding rumen contents by up to 15% of the total animal diet, did not adversely affect the feed intake, daily growth rate, or feed efficiency. Rather, animal production, in this case, was equal to production in the case of feeding oats or hay made from pasture plants.

Poultry litter

Studies comparing the performance of beef cattle that were fed poultry litter or corn silage showed an improvement in daily weight gain and dressing percentage. The increased animal performance could be attributed to the increased values of protein and essential minerals and the changes occurring in the volatile fatty acids profile in the rumen. Animals fed poultry litter frequently had a higher ratio of propionate-to-acetate in the rumen, so the performance should be improved.

Dairy cows also responded positively to being fed poultry litter. The amount of litter to be included in the diet should, however, vary depending on the level of milk production. Low-producing cows could be fed poultry litter as a sole source of nitrogen without adversely affecting milk yield, flavour, or composition. For high-yielding cows producing over 28kg of milk daily, the amount of poultry litter to be fed should not exceed 30% of the total nitrogen source in the diet.

Sheep were, in some cases, unable to utilise poultry litter effectively. The growth rate of lambs was 150g when fed poultry litter compared to an average daily gain of 210g when other nitrogen sources were included in the diet. In other cases, however, sheep proved to be good utilisers of poultry litter.

Cattle wastes

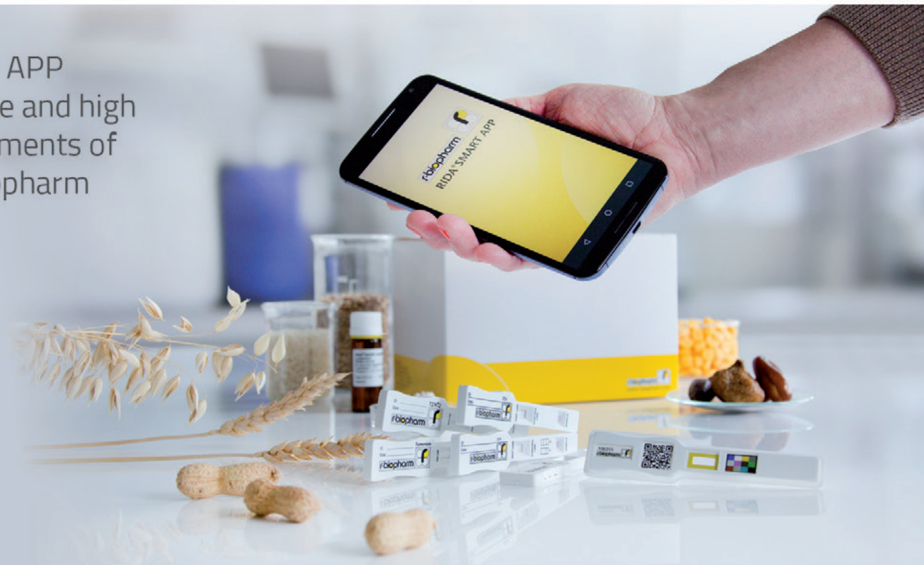
The amount of manure produced by 1 000 dairy cows is roughly 37 tonnes/day, which poses potential pollution threats to air and water, though they represent potential feed sources when properly processed, formulated, and preserved for this purpose.

In one study, cattle manure was washed, screened, and treated with sodium hydroxide, calcium hypochlorite, or sodium chlorite to increase the DM digestibility of the waste. It was then mixed and ensiled with grass hay. The ensiled mixture was termed 'wastelage' and consisted of 57 parts manure and 43 parts hay. Feeding a diet formulated to contain 40% 'wastelage' and maize to steers produced the rate and efficiency of gain similar to feeding conventionally formulated high-concentrate diets. Further, the waste did not have any harmful effect on the carcass quality of beef cattle or the composition or taste of the milk when fed to dairy cows.

Wood residues

It has been shown that aspen sawdust can replace 30% of a conventional diet in dairy cows producing 20kg of milk daily without reducing the intake of digestible DM or the production of milk. Cows consuming the aspen sawdust also maintained a normal milk fat level. At certain stages in the life cycle of dairy cows, the dilution of the diet with wood allowed regulation of energy intake and hence prevented unwanted fattening. In one study, grain intake was controlled by including up to 45% wood fibre with grain in the diets of dairy cows.

Article courtesy of *All About Feed*. Visit *www.allaboutfeed.net* for more information.



Composition and utilisation of feed by monogastric animals in the context of circular food production systems

By P Bikker and AJM Jansman

Food production has a major impact on environmental emissions, climate change and land-use. To reduce this impact, the circularity of future food production systems is expected to become increasingly important.

In a circular food system, crop land is primarily used for plant-based food production, while low-opportunity cost feed materials (LCF), i.e. crop residues, co-products of the food industry, grass from marginal land and food waste form the basis of future animal feeds. Animal diets thus contain much less cereals and soya bean meal and include a higher proportion of diverse co-products, residues and novel human-inedible ingredients. These diets are characterised by a lower starch content, and a higher content of fibre, protein, fat, and phytate compared to present diets.

In this review, possible consequences of the development towards a more circular food system for the type, volume and nutritional characteristics of feed materials and complete feeds are addressed and related research questions in the area of animal nutrition, physiology and metabolism are discussed. Additional attention is given to possible effects on intestinal health and gut functionality and to (bio)technological processing of LCF to improve their suitability for feeding farm animals.

It is concluded that an increased use of LCF may limit the use of presently used criteria for the efficiency of animal production and nutrient utilisation. Development of characteristics that reflect the efficacy and efficiency of the net contribution of animal production in a circular food system is required. Animal scientists can have an important role in the development of more circular food production systems by focussing on the optimal use of LCF in animal diets for the production of animal-source food, while minimising the use of human-edible food in animal feed.

Feed material availability

The volume of LCF, in particular crop residues, co-products, food losses and waste, is determined by the human diet. In a circular food system, the composition of the human diet should aim to minimise the environmental impact of food production and consumption. In the long term, this may imply a development into the direction of a sustainable, largely plant-based human diet, as suggested by international advisory bodies.

In the study of Van Selm *et al.* (2022) based on the EAT-Lancet reference diet, available feed materials included a varying fraction of cereal grains, tubers, legume seeds, oilseeds, sugar beet and sugar cane, and fruit, derived from the processing for human food, animal- and fish byproducts, and grass-derived products. Furthermore, a varying portion of the food products was adopted as consumption loss and allocated to animal diets. In addition to the food crops used, the fraction used in the human diet, e.g. whole cereal meal or white flour for bread, has a major impact on the availability of co-products for feed.

Although optimisation of the human diet for sustainability and health is an essential part of the future food system (Van Selm *et al.*, 2022), this is largely beyond the influence of the animal production sector. Hence, at short notice, it seems realistic to take the present human consumption pattern, processes used in the food industry and the production and use of biofuels as starting point for the availability of LCF.

The production of refined carbohydrates (e.g. flour, starch, and sugar), industrial fermentation and oil crushing contribute to a large volume of co-products from cereal grains, sugar beets and oilseeds as the major groups included in animal diets in Europe. From the European Union (EU) protein balance sheet, the relative contribution to the volume of compound feed in the EU was estimated as 19% for oilseed co-products, 12% for cereal grain and sugar beet co-products, 2% for former foodstuffs, and 1% for meat and dairy coproducts.

At present, the majority of compound feed (including on farm mixed) is provided by intact cereal grains (64%), with a limited contribution by intact oilseeds and legume seeds (2%). In addition to the total use of 276 million tonnes of compound feed in the EU, there is an estimated annual production of approximately 1 000 million tonnes of grass, 250 million tonnes of maize silage, and 65 million tonnes of fodder legumes, all on fresh basis.

Evaluation of feed ingredients

Although animal performance is determined by the composition and intake of the complete diet, it is important to consider specific characteristics of individual feed materials, including the nutritional value and potential adverse effects, prior to inclusion in the diet (*Figure 1*). In a circular food system, animals consume primarily the co-products and residues of food and non-food production. The availability, composition, and quality of these feed materials are largely determined by the consumer demands affecting the volume and properties of food products and the production processes involved.

Because of the variation, e.g. between production factories and over time, it is essential to adequately determine the nutritional value of different batches of feed materials. Table values and regression equations commonly used for coproducts may not accurately reflect the nutritional value after changes in processes to obtain them, as for example recently shown for co-products of ethanol production (Yang *et al*. 2021). The question should be addressed whether present feed evaluation systems and their application are adequate for the use of future feed materials which can vary widely in composition and nutritional value.

Moreover, since processes are generally optimised for food and fuel production, a negative impact of (over) processing on the co-products used for feed may occur. For example, heat damage to amino acids as indicated by a loss of reactive lysine has been demonstrated in numerous co-products, including oilseed meals, spray-dried dairy products, and ethanol co-products (Salazar-Villanea *et al*., 2016) while bioavailability of methionine may be overestimated by the ileal digestibility in processed meal of black soldier fly (Cargo-Froom *et al*., 2022).

Because of their nature, certain plants contain antinutritional factors (ANFs), e.g. glucosinolates in rapeseed, gossypol in cottonseed, polyphenols and saponins in a wide range of plants. These ANFs may concentrate in the co-products during processing and hamper feed intake, performance and health of the animals. The same holds for mycotoxins and particular pesticides mainly present at the outside of grains and seeds that may concentrate, in bran, distillers' grain and meal fractions after starch and oil extraction (Schaafsma *et al*., 2009).

The potential toxins in food waste and aquatic proteins (especially macroalgae) require more research and adequate solutions before use (Van der Spiegel *et al*., 2013). It goes beyond the scope of this review to address these aspects in any more detail. Rather, it emphasises that when well-known ingredients as wheat, maize and soya bean meal are replaced by LCF, it will be increasingly important to evaluate the quality and safety of each batch of LCF prior to its use as animal feed and implement quality assurance plans, to assure animal health and food safety in circular food production systems. This requires the development of adequate and rapid assays, e.g. using near-infrared spectroscopy, to determine the composition of the feed materials (Zijlstra and Beltranena, 2013).

Impact of feeding LCF materials

Feed intake

It is assumed that the feed intake of pigs and presumably other farm animals is determined by the nutrient requirements to allow the potential performance or maximum biological efficiency to be achieved, unless it is constrained by other factors, including gut capacity and imbalance of nutrients (Whittemore *et al*., 2001). In circular food systems, available feed materials are generally lower in starch and energy content and higher in NSP content than cereal grains. Hence, unlike commonly used commercial diets, future diets may have a lower energy and nutrient concentration, unless a large amount of supplementary fat is used.

This raises questions related to the feed intake regulation and capacity of animals to ingest these bulky diets, e.g. what are the main factors of (bulky) diets that regulate or limit feed intake, to what level are animals able to compensate for the reduced energy and nutrient density by increasing the volume of feed intake, what adaptive mechanisms play a role and what is the influence of age and relevance of early life experiences?

Better understanding of the reduction of feed intake and performance and duration of adaptation after the introduction of a bulky diet, will allow to develop feeding strategies that will account for or even minimise the effects of adaptation.

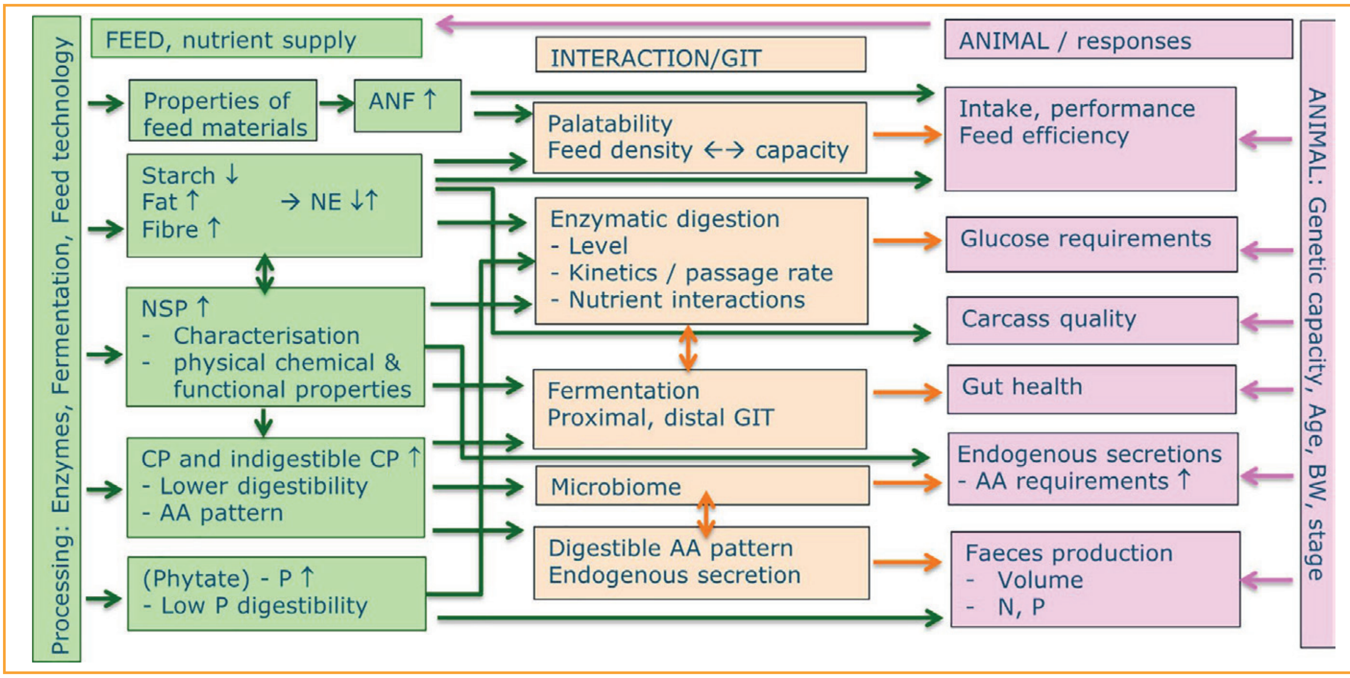
Dietary energy supply

In circular food production systems, cereal grains, currently the most important source of starch in animal feeds, will primarily be used as an ingredient for

Table 1: Major forms of industrial food processing and derived co-products available for use in monogastric animal feed in Europe (FEFAC, 2019; Giner Santonja *et al*., 2019).

Industry	Crop, raw material	Main products	Co-products
Grain milling	Cereal grain	(White) flour	Wheat bran, middlings
	Rice	Rice, flour	Rice bran
Sugar production	Sugar beet	Sugar	Pulp, molasses
Starch production	Wheat	Starch	Wheat gluten feed, gluten meal, germ meal
	Maize	Starch	Maize gluten feed, gluten meal, germ meal
	Potato	Starch	Potato protein, potato pulp
Ethanol production	Cereal grains	Ethanol	(Dried) distillers' grains, condensed distillers' solubles
Brewing	Barley	Beer	Brewers' grain
Fruit processing	Citrus fruit	Juice	Citrus pulp
Industrial fermentation	Sugar, molasses	Alcohol, additives	Microbial biomass, single-cell proteins
Oil crushing	Oilseeds	Vegetable oils, biodiesel	Oilseed meal and cake, e.g. of soya bean, rapeseed, sunflower seed, palm kernel, linseed, olives, groundnut
Slaughter and rendering	Animal carcasses	Meat and animal products	Processed animal proteins, feather meal, animal fat
Gelatine production	Hides, bone	Gelatine	Animal fat, dicalcium phosphate
Dairy industry	Milk	Dairy products	Whey products, skimmed milk powder
Food industry	Manufactured food	–	Processed former foods, e.g. bread and biscuit waste

Figure 1: Schematic representation of characteristics of diets based on low-opportunity cost feed materials (mainly co-product and former foods) in a circular food system, interactions in the digestive tract and influence on farm animal performance and health.



**ANFs = antinutritional factors; NE = net energy; NSPs = non-starch polysaccharides; AAs = amino acids, GIT = gastro-intestinal tract.*

human food. Hence, the starch content of animal feed will be lower and other energy-suppling ingredients, such as animal fats and by-products from oil processing, will be included as an alternative source of energy (*Figure 1*). In addition, particular LCF of human food origin can have high concentrations of sugars, which could cover part of the requirement for glucose.

In addition to the effects of dietary starch content, the effect of starch digestion rate on the availability of glucose for the intestinal mucosa of poultry can be relevant. Continuous presence of a certain amount of slowly digestible starch in the gut lumen might spare the use of amino acids as a source of energy in gut tissue, which might otherwise be lost for body protein synthesis (Weurding *et al*. 2003). Use of low-starch diets could enhance the use of amino acids as energetic substrate by the intestinal mucosa relative to glucose. Van den Borne *et al*. (2007) demonstrated the influence of synchronisation of amino acids and glucose on protein synthesis in pigs.

Dietary fibre content and gut health

In LCF-based diets with a high-fibre content, a larger part of the dietary energy can only be released by fermentation of the organic matter by the intestinal microbiome, in particular in the hindgut (*Figure 1*). The capacity to extract energy from the diet via fermentation in the digestive tract is high in ruminants and low in poultry, with pigs having an intermediate position. The fermentation capacity largely determines the maximum inclusion of fibre rich LCF in feeds for the different animal species.

Dietary content and physical-chemical characteristics of fibre additionally affect feed intake, passage rate of digesta in the various compartments of the GIT and extent and rate of fermentation of fibre fractions by the intestinal microbiome. As the intestinal microbiome is part of the barrier function of the gut in humans and animals (Fassarella *et al*. 2021; Barko *et al*. 2018), the effects of diet composition on the microbiome composition and activity also need to be considered from gut health and gut functionality perspectives.

Dietary protein content

Future LCF-based diets will contain more fibrous ingredients in which part of the protein is physically associated with the fibre fraction. As a result, this protein might be less accessible for digestive enzymes (proteases) in the proximal part of the intestinal tract of pigs and poultry thereby reducing the digestibility of protein. This would not only increase the faecal losses of protein and nitrogen but also increase the risk for protein fermentation by the intestinal microbiome, primarily in the hind gut. This may result in the release of branched-chain fatty acids, ammonia, phenolic and indolic compounds, biogenic amines, hydrogen sulphide and nitric oxide, which can be harmful for the intestinal mucosa and its functionality.

Protein fermentation is regarded as risk factor for pathological intestinal disease in pigs (e.g. post-weaning diarrhoea) and poultry (necrotic enteritis and wet litter-associated health problems). However, the effect of protein fermentation end products on gut functionality has been studied mainly in in-vitro and in-situ models rather than in vivo (Gilbert *et al*., 2018). An interaction between protein fermentation in the hindgut and the presence of fermentable carbohydrates from the diet in the hindgut has been suggested (Jha and Berrocoso, 2016; Jha and Leterme, 2012) and affects the profile of fermentation metabolites in the gut.

Fermentation shifts from a saccharolytic to a proteolytic nature when a low amount of fermentable carbohydrates is available (Piva *et al*., 1996), resulting in the production of harmful metabolites such as ammonia and amines (Cone *et al*., 2005). Future LCF-based diets would likely provide both more fermentable protein and more non-enzymatically digestible carbohydrates. The fermentability of the latter fraction largely depends on the origin and chemical nature of the carbohydrates (Williams *et al*., 2017; Tiwari *et al*., 2019).

Moreover, the use of LCF-based diets with higher fibre contents might increase the secretion of endogenous protein in the GIT (Nyachoti *et al*., 1997; Souffrant, 2001), which in part might not be reabsorbed in the small intestine and serve as a potential substrate for protein fermentation in the hindgut (*Figure 1*).

Opportunities to improve availability and utilisation of low-opportunity cost feed materials

Compared to cereal grains and soya bean meal, LCFs generally have a lower nutritive value and other characteristics that limit their use in animal diets. An essential step in the utilisation of LCF is the appropriate treatment through various technologies. Feed technology is applied to upgrade low-quality ingredients to higher-value feed components and improve nutrient utilisation of compound feeds (Van der Poel *et al*., 2020).

An important start would be to take into account in an early-stage consequence for the nutritional value of the co-products and residues, when processing an ingredient (e.g. arable crop) for human food or non-food application, e.g. ethanol production, in a way that the total production of plant-based food and ASF per unit of resource, e.g. cropland, is optimised. For example, processing of cereal grains and oilseeds should minimise the risk of protein damage due to adverse conditions during processing with heat.

Subsequent processing and biotechnological treatments will need to be developed or refined for application on specific ingredients to increase nutrient availability, reduce ANFs and assure feed and food safety (e.g. for animal by-products and food waste). Indeed, numerous options are available or being explored to realise these aims.

We referred to fractionation as a means to produce feed ingredients with different characteristics for different target species, e.g. the extraction of protein from grass or other leafy products to be used as feed material for monogastric species. Application of cell wall rupture techniques may contribute to increasing nutrient availability from single-cell proteins (Van der Poel *et al*., 2020).

The use of microbial enzymes to facilitate the degradation of carbohydrates, protein and phytate has been extensively studied. While the efficacy of phytase to improve P digestion in monogastric species is beyond doubt, the efficacy of other enzymes supplemented to animal feed varies between studies and depends on a number of factors, in particular enzyme and substrate characteristics and animal species.

It can be anticipated that with increasing urgency to make optimal use of LCF, these feed materials will be further characterised and novel and improved enzymes will be developed that contribute to the degradation of low-digestible components (Kiarie *et al*., 2021). In addition, attention should be paid to the complex interaction between dietary components and gut health and the role of feed enzymes on substrate availability and microbial metabolism (Kiarie *et al*., 2013; Bedford and Apajalahti, 2022).

Since the transit time of digesta and conditions in the digestive tract are limiting factors for the degradation of recalcitrant dietary components, treatment of feed materials prior to feeding has gained renewed interest. Recently, Sun *et al*. (2021) observed an increase in digestibility of DM and amino acids and in degradation of phytate in a mixture of fermented wet maize distillers' grains and solubles with fungal pretreated soya bean hulls in swine.

Earlier studies have demonstrated the benefit of soaking or pre-fermentation of diets with supplemented enzyme treatment on animal performance and health (Canibe and Jensen, 2012; Wiseman *et al*., 2017). The potential benefits of these wet processes, the availability of LCF in wet form and the costs and environmental impact of drying may indicate that liquid feeding of animals becomes increasingly important.

Since the EU-ban on the use of animal proteins in feed, processes have been developed to assure the production of safe and species-specific processed animal proteins that have now been accepted for use in diets for pigs, poultry and fish in EU. While the use of human-inedible by-products of meat, milk and egg production fits very well in a circular food production system, numerous studies have confirmed the value of these products in farm animal diets (Alao *et al*., 2017; Jedrejek *et al*. 2016). The use of food leftovers and kitchen waste, previously called swill, for animal feed is banned in the EU for safety reasons. Research is conducted into the collection and processing of food waste for use as animal feed.

Experience from other countries and small-scale pilot studies indicate that thermal processing can adequately reduce microbial hazards of feed safety (Shurson, 2020). The impact of these treatments on nutritional value is poorly documented and will be largely determined by the composition of the waste stream. Moreover, other potential hazards, e.g. contamination with harmful substances are difficult to exclude, while the application of the legislation for use of animal by-products complicates the application of waste streams.

Because of the complexity of this waste stream and the related legal framework, application of targeted processing technology is only a part of the solution to safely allow the use of food waste in animal feed. It can be anticipated that at least in the EU, only small steps for the use of clearly specified segments of food waste under restricted conditions will be made.

This article was condensed for publication in *AFMA Matrix*. Visit *www.doi.org/10.1016/j.animal.2023.100892* for the full article or email P Bikker at paul.bikker@wur.nl.

Nutritional strategies to diminish aquafeed wastes

By Samaneh Azarpajouh, veterinarian

Aquaculture makes a significant contribution to meeting the nutritional demands of a growing world population. However, waste derived from intensive aquaculture production systems leads to environmental challenges and an ecological footprint. This article discusses major aquafeed dietary composition and strategies to minimise the environmental impacts of aquaculture, including proper diet formulation, appropriate choice of ingredients, feed processing, use of phytase enzyme, and reduction of antinutritional factors.

Aquafeed composition, including nitrogenous and phosphorus compounds, determines the quality of aquafeed waste, which impacts water quality and pH, algal turbidity, biological oxygen demand, and fish mortality rate. Therefore, it is required to set up nutritional strategies to promote aquaculture sustainability and reduce the negative environmental impacts of aquafeed waste.

Aquafeed dietary composition

Aquafeed wastes are divided into:

- **Solid wastes** – derived from uneaten feed and droppings of cultured fish and dead fish carcasses.
- **Dissolved wastes** – products of feed metabolism in fish or decomposed, uneaten feed. Dissolved waste mainly comprises of nitrogen and phosphorus as the major components of proteins in aquafeed.

Fish utilise proteins and generate a large amount of nitrogenous metabolite that is essential for algae growth. However, high nitrogen concentration causes a dense growth of plant life and death of aquatic life from a lack of oxygen. Phosphorus is involved in all energy-producing cellular reactions and is required for carbohydrate, lipid, and amino acid metabolism. However, due to a low phosphate level in natural waters, aquafeed needs to provide an adequate concentration of phosphate for fish. Dietary phosphorous excretion is about 68 to 86%, which is the main cause of plant growth, impaired water quality downstream, and oxygen reduction in the body of water.

Nutritional strategies to apply

Proper diet formulation provides well-balanced ingredients to support maintenance, growth, reproduction, and health.

Diet formulation

One of the key factors determining fish feed quality is the number of essential amino acids and the balance among the respective amino acids. Feeding excessive amino acids increases ammonia excretion and loss of energy. The balance between protein intake and energy utilisation decreases dissolved nitrogen waste.

Diet formulation based on the availability of adequate phosphorus lowers phosphorus excretion and improves water quality. Formulating a fish diet with a combination of synthetic amino acids such as crystalline amino acids that precisely meet amino acid requirements will reduce nitrogen excretion.

The composition and physical characteristics of feedstuff are important for the development of sustainable aquaculture. For example, highly digestible feedstuff decreases solid waste excretion and increases water quality. Therefore, it is recommended to select appropriate feed ingredients with sufficient digestible phosphorus and nitrogen level to minimise phosphorus and nitrogen excretion without compromising growth performance.

Feed processing

Feed processing is another important aspect of decreasing aquafeed waste.

- **Extrusion** is a short-term process in fish feed manufacturing in which the dry feed ingredients are moistened and heated by the addition of steam and water and then subjected to thermomechanical treatment in extruder screws.
- **Extruded** diets have higher stability and digestibility which significantly reduce the amount of nutrients excreted into the water.
- In addition, using **free-floating feed** which is easier for the fish to see and eat compared to sinking pellets reduces water pollution.
- **Proper grinding, pelleting, and steam flaking** of feed ingredients enhance nutrient availability, reduce the amount of undigested feed and faecal loss, and improve water quality.

Phytate and phytase

Phytate is the main form of storage for phosphorus in protein-rich plants; however, fish lack the digestive enzyme phytase to hydrolyse indigestible phytate which limits its bioavailability.

Phytase is present in some plant ingredients or is produced by micro-organisms. Supplementing phytase in fish feed improves the utilisation of plant phosphorus by fish and water quality.

Antinutritional factors

Some plant ingredients used in aquafeed have one or more antinutritional factors. Antinutritional factors are substances that interfere with protein utilisation and absorption and affect fish health and production. Therefore, it is necessary to remove antinutritional factors from the feed during processing conditions to increase nitrogen utilisation and reduce nitrogen excretion.

Concluding remarks

Aquafeed wastes including nitrogen and phosphorus components affect water quality and pH, algal turbidity, biological oxygen demand, and fish mortality rate. There are several strategies such as proper diet formulation, appropriate choice of ingredients, feed processing, use of phytase enzyme, and reduction of antinutritional factors to minimise the detrimental environmental impacts of aquaculture wastes. However, further research is needed to improve the sustainable development of the aquaculture sector.

Article courtesy of *All About Feed*. This article is based on a review: Aqua-Feed Wastes: Impact on Natural Systems and Practical Mitigations published in the *Journal of Agricultural Science*.

Harnessing extant energy and protein requirement modelling for sustainable beef production

By LO Tedeschi

Numerous mathematical nutrition models have been developed in the last 60 years to predict the dietary supply and requirement of farm animals' energy and protein. Although these models, usually developed by different groups, share similar concepts and data, their calculation routines (i.e., sub-models) have rarely been combined into generalised models.

This lack of mixing sub-models is partly because different models have different attributes, including paradigms, structural decisions, inputs/outputs, and parameterisation processes that could render them incompatible for merging. Another reason is that predictability might increase due to offsetting errors that cannot be thoroughly studied.

Alternatively, combining concepts might be more accessible and safer than combining models' calculation routines because concepts can be incorporated into existing models without changing the modelling structure and calculation logic, though additional inputs might be needed. Instead of developing new models, improving the merging of extant models' concepts might curtail the time and effort needed to develop models capable of evaluating aspects of sustainability.

We believe that generalised models developed by merging different models' concepts might improve our understanding of the relationships of existing variables that were known for their importance but not included in extant models because of the lack of proper information or confidence at that time.

The objective of this paper was to spark discussions of two critical areas in beef cattle production (energy requirements of grazing animals and efficiency of use of energy) to ensure adequate diet formulation by borrowing concepts used in different mathematical models. Tedeschi (2022b) presented and documented the preliminary analyses of this study.

Prediction of energy requirements

Grazing animals produce more methane per weight gain than confined animals (Pelletier *et al.*, 2010). In part, the discrepancy arises because low-quality, high-fibre diets (e.g., forages) yield about four times more methane than high-quality, low-fibre diets (e.g., feedlot), respectively 0,23 vs 0,07kg CH_4/animal/day (Harper *et al.*, 1999). Furthermore, about 80% of total GHG emissions and 84% of methane emissions come from the cow-calf phase, whereas only 20 and 16%, respectively, come from the feedlot phase (Beauchemin *et al.*, 2010). Therefore, accurately determining grazing animals' energy requirements is critical to ensure that strategic energy and protein supplementation is delivered to optimise animal growth and development (Tedeschi *et al.*, 2019).

Grazing animals have an additional energy requirement associated with grazing activity compared to confined animal requirements. It comprises the additional energy needed for body movements (i.e., locomotion) and forage browsing, selection, and prehension. The non-activity maintenance requirement of energy between grazing and confined growing or finishing animals might be identical on a metabolic weight basis as long as animals are at the same degree of maturity (i.e., same composition of gain) (Tedeschi and Fox, 2015). However, because the diet consumed by grazing animals (i.e., essentially forage) has a lower partial efficiency of energy use for growth (kg), grazing animals would require a greater DM intake (DMI) to achieve the same average daily gain (ADG).

Assessing the nutritional value of the feeds consumed by the animal is an essential step in determining the animal's energy and protein requirements, and it is not a trivial task. Tedeschi and Fox (2015) and Tedeschi and Dias Batista (2021) discussed existing techniques to determine feedstuffs' nutritive value. Given our inability to definitively and accurately assess the consumption of digestible energy (DE) by grazing animals when a digestibility trial cannot be carried out, some have proposed the use of mathematical modelling or empirical predictions to predict DE or its equivalent, total digestible nutrients (TDN), given the chemical composition of the diet in addition to other factors (Tedeschi and Fox, 2020a; 2020b), especially for those under grazing conditions (Tedeschi *et al*., 2019; Woli *et al*., 2020).

In part, the problem arises not only because the DE content is unknown with a high degree of certainty but because of inadequate predictions of feed intake and selection. Additional problems exist when converting DE to metabolisable energy (ME) (Galyean *et al*., 2016; Seo *et al*., 2021) for grazing animals given the highly variable contribution of energy loss via methane production. Thus, the question remains, can the intake of DE be accurately determined so energy partitioning can be estimated to assess animals' energy requirements under grazing or confined conditions?

Predicting EE for grazing cattle

The Agricultural Research Council (ARC, 1980) developed a factorial approach to estimate the energy expenditure, or EE (kcal/d) (*equation 1*) associated with physical activities by assigning coefficients to the number of hours animals spent standing (h/day), the number of daily body changes (laying down and standing), and walking horizontal and ascent distances (km/day). Assuming the typical values for feedlot and continuous grazing of 12 and 18h/d for standing, six daily position changes, 0 and 2km/d for horizontal distance, and no vertical distance, the EE values for animals' physical activity with 300kg of BW, usually assumed to be shrunk BW (NASEM, 2016), are 471,6 and 1 024,6kcal/d.

If the required net energy (NE) required for maintenance is assumed to be 70kcal/kg^{0,75} BW/d, these EE values for physical activity become an additional 9,35 and 20,3%, respectively. That means the daily required NE for maintenance becomes 1,0935 x (70 x BW^{0,75}) and 1,203 x (70 x BW^{0,75}) for animals under feedlot and continuous grazing conditions, respectively. Fox and Tylutki (1998) proposed to change the basal metabolic energy requirement from 77kcal/kg^{0,75} of BW, devised by Lofgreen and Garrett (1968), to 70kcal/kg^{0,75} of BW because of about 10% (i.e., 9,35%) needed for physical activity under typical feedlot conditions in the United States.

$$EE_{PA} = \left(\begin{array}{c} 0{,}1 \times Standing + 0{,}062 \times Position\ changes + \\ 0{,}621 \times Distance_{Flat} + 6{,}69 \times Distance_{Vertical} \end{array} \right) \times FBW \quad (1)$$

where $Distance_{Flat}$ is the distance travelled by the animal on a horizontal, flat surface, km/d; $Distance_{Vertical}$ is the equivalent ascending distance travelled by the animal, km/d; EEPA is energy expenditure for physical activity, kcal/d; FBW is full (unshrunk) BW, kg; *Position changes* is the number of standing and lying changes per day; and *Standing* is the number of hours standing, h.

Energy use for growing cattle

The EE for physical activity and chewing accounts for nearly all the differences between confined and grazing ruminants, and yet, our incomplete understanding of these components has delayed the development of a more definitive solution. In part, data collection of plant and animal interaction (forage selection, grazing behaviour, pasture growth/regrowth, pasture quality, nutrient digestion and absorption volatile fatty acids production and profile, and energy requirement) remains a critical bottleneck for adequate knowledge of forage intake by ruminants (Tedeschi *et al*., 2019).

The second bottleneck in ensuring adequate diet formulation is the accurate determination of the efficiency of ME use for growth. There is no shortage of growth model development, but perhaps combining the quintessence of extant growth models to improve the predictability of the gain composition is warranted. Once the gain composition is known, the energy and protein requirements are straightforward calculations.

The retained energy (RE) and ADG have been the heartbeat of many theoretical growth models (Lofgreen and Garrett, 1968; Garrett, 1980a; Loewer *et al*., 1983; Fox and Black, 1984; NRC, 1984; 2000; Fox *et al*., 1992), including stochastic models (Parks, 1973). Some growth models used ADG and specific characteristics of animal growth (Keele *et al*., 1992; Williams *et al*., 1992; Williams and Jenkins, 1998; Kilpatrick and Steen, 1999) and combined mechanistic or dynamic modelling to predict body composition (Hoch and Agabriel, 2004a; 2004b), or used DNA (deoxyribonucleic acid) accretion curves and protein-to-DNA ratio (Oltjen *et al*., 1986b; Bywater *et al*., 1988; Di Marco *et al*., 1989; Oltjen *et al*., 2000).

Primary biochemistry pathways associated with the development and growth of different tissues (e.g., viscera, muscle, and adipose) have been developed for sheep (Oddy *et al*., 1997; Oddy *et al*., 2019). Most mechanistic and dynamic conceptual growth models are based on metabolic processes (Gill, 1984; France *et al*., 1987; Gill *et al*., 1989; Gill, 1996), but such models rely heavily on the principle that substrate availability and saturation enzyme kinetics control the distribution of nutrients in body tissues (Baldwin, 1995).

Some growth models rely on empirical concepts and some elements of teleonomic behaviour (Tedeschi and Fox, 2020a). Others possess some elements of mechanistic modelling, and very few or none adopted stochastic components (i.e., probabilistic theory). Because of the different modelling approaches to predict energy and protein requirements among existing growth models and their different variables, some critical limitations arise when comparing existing growth models.

For instance, Arnold and Bennett (1991a and 1991b) compared four growth models developed in the early to mid-1980s: Roman L Hruska US Meat Animal Research Centre (Notter *et al*., 1979a; Notter *et al*., 1979b; 1979c), Texas A&M University (Sanders and Cartwright, 1979a; 1979b; Oltjen *et al*., 1986a), BEEFS156 (Loewer *et al*., 1983; Loewer *et al*., 1987), and UCDavis (Oltjen *et al*., 1986a; Oltjen *et al*., 1986b). They reported that two problems caused these models to yield inconsistent results: The definition of mature BW is different among growth models and different predictions of DMI. When these two variables were assigned independently within each model, the models simulated the animal's BW successfully but failed to predict body composition.

Similarly, Garcia *et al*. (2008) compared the growth model developed by Institut National de la Recherche Agronomique (Hoch and Agabriel, 2004a; 2004b) and UCDavis (Oltjen *et al*., 1986a; Oltjen *et al*., 1986b), and reported that both models, developed with entirely different concepts and equations, could produce similar predictions of body composition (protein accretion), but they behaved differently under distinct growth trajectories. These evaluations reinforced the hypothesis that each model has to be evaluated within the purpose of its development, and intrinsic errors may offset each other within each model. Therefore, model comparisons should be carried out under various production conditions to accommodate each model's assumptions and purposes. Consequently, a generalised growth model is still needed.

Such limitations may hinder the predictability of growth models when different production conditions exist other than those established conditions in which the models were developed or calibrated (Tedeschi, 2022b). They may also prevent incorporating different modelling concepts from one model to another. For instance, for growing cattle, the partial efficiency of energy use for growth (i.e., k_g) in the American systems (e.g., NRC, NASEM, CNCPS, and RNS) is frequently computed based on an empirical (cubic) equation that estimates the NE for growth (NEg, Mcal/kg) based on the dietary concentration of the ME (Mcal/kg).

Similarly, in the British and Australian systems (e.g., ARC, Agricultural and Food Research Council [AFRC], and CSIRO), the k_g also exclusively depends on dietary energy through the metabolisability of the diet (M/D), though a linear equation is applied. In addition to the diet characteristics, more specifically its digestibility, CSIRO (2007) proposed adjusting k_g for the legume proportion relative to grass.

Predicting partial efficiency of using energy for growth

Although the dietary ME is related to the dietary contents of carbohydrates, fat, and protein and their digestibility, the efficiency to which energy is deposited in the tissue depends on the tissue gain composition (Reid *et al*., 1980; Tedeschi *et al*., 2004). Growth models rarely acknowledge this fact and still use dietary characteristics to estimate k_g and NEg; thus, incorrectly rendering k_g independent of carcass composition. If the protein proportion of RE is known, k_g can be estimated using *equation 2*, and assuming fat and protein deposition efficiencies of 75 and 20%, respectively, it yields *equation 3* (Tedeschi, 2001; Williams and Jenkins, 2003; Tedeschi *et al*., 2004).

$$k_g = k_F \times k_p / (k_p + RE_p \times (k_F - k_p)) \qquad (2)$$

$$k_g = 3/(4 + 11 \times RE_p) \qquad (3)$$

where k_F is the efficiency of fat deposition, Mcal/Mcal; k_g is the partial efficiency of converting metabolisable energy into net energy for growth; k_P is the efficiency of protein deposition, Mcal/Mcal; and RE_P is the proportion of protein in the RE.

Impact of growth rate on deposition efficiencies of fat and protein

These deposition efficiencies are not fixed, however, Cannas *et al*. (2006) and Tedeschi *et al*. (2010) reported values of 68 and 27% for fat and protein, respectively, for growing sheep, and Chizzotti *et al*. (2008) reported different deposition efficiencies of fat (79%) and protein (34%) for Nellore and Nellore x *Bos taurus*. Marcondes *et al*. (2013) empirically derived a non-linear relationship between k_g and the proportion of RE as protein (RE_P), and when solving their empirical equation, the deposition efficiencies for fat and protein are 60,7 and 21,2%, respectively. These studies suggest that deposition efficiencies of fat vary from 60,7 to 79% and of protein vary from 21,1 to 34%.

Perhaps the most exciting finding elucidated by Marcondes *et al*. (2013) was that fat and protein deposition efficiencies are not constant; they increase linearly with ADG (*equation 4* had r^2 of 0,916 and *equation 5* had r^2 of 0,951). Their values suggested that fat and protein deposition efficiencies increased by about 1,84 and 1,76% for each 100 g/d increase in ADG, respectively. Interestingly, based on *equations 4* and *5*, fat and protein deposition efficiencies are 69,1 and 19,8%, respectively, when ADG (i.e., empty weight gain, EWG) is zero. These values are close to their respective values reported above, suggesting these efficiencies are only valid when ADG approximates zero: Body composition of low-gaining animals might be better estimated than high-gaining animals.

$$k_F = 0{,}1836 \times EWG + 0{,}691 \qquad (4)$$

$$k_P = 0{,}1764 \times EWG + 0{,}198 \qquad (5)$$

where *EWG* is empty weight gain, kg/d; k_F is the efficiency of fat deposition, Mcal/Mcal; and k_P is the efficiency of protein deposition, Mcal/Mcal.

Combining *equation 2* with EWG-dependent fat (k_F) and protein (k_P) deposition efficiencies (*equations 4* and *5*) yields *equation 6*, without restricting the maximum k_g to 79%.

$$k_g = \frac{19{,}0025 + EWG(21{,}9785 + 4{,}4982 \times EWG)}{27{,}5 + 24{,}5 \times EWG + RE_P(68{,}4722 + EWG)} \qquad (6)$$

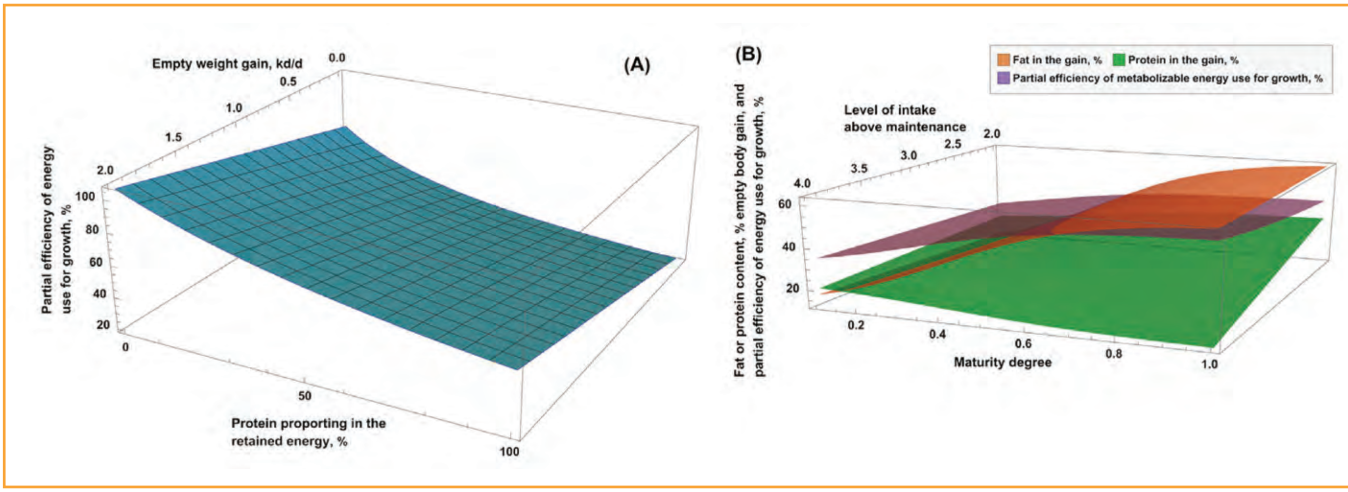
where *EWG* is empty weight gain, kg/d; k_g is the partial efficiency of converting metabolisable energy into net energy for growth; and RE_P is the proportion of protein in the RE.

Impact of maturity stage rate on deposition efficiencies of fat and protein

The rate of fat accretion also increases with maturity (Owens *et al*., 1995; Tedeschi, 2019b), assuming empty body fat as a proxy for maturity. Thus, one would expect that k_g should also increase with maturity. Nevertheless, which variable (EWG or maturity) impacts k_g the most is unknown. The British and Australian systems (e.g., ARC, AFRC, CSIRO) developed non-linear equations to compute the proportion of protein and fat in the gain as animals mature. That means these feeding systems assumed correctly that the animals' maturity stage could be used to adjust changes in body composition, i.e., fat content increases with maturity. These feeding systems adopted the logistic (sigmoidal) function to estimate fat or protein content in the gain for large lean breeds (Charolais, Chianina, Blonde d'Aquitane, Limousin, Maine Anjou, and Simmental) and other breeds, including crossbreds.

Therefore, combining such information (fat and protein in the gain with partial efficiency of energy use for growth) is interesting to enhance our ability to estimate the carcass composition of growing animals more accurately. Such enhancements would allow us to estimate better their requirements of energy and protein (and other nutrients), aiming to produce more resilient and sustainable production systems (i.e., less use of the resource, lower environmental pollution via an excess of nutrients, betterment of the quality of the animal

Figure 1: (A) Relationship between empty weight gain (kg/d) and protein proportion in the retained energy on the partial efficiency of energy use for growth in cattle. Adapted from Tedeschi (2019b). (B) Relationship between fat (orange plane) or protein (green plane) content in the empty body gain (g/100 g) and the partial efficiency of use of metabolizable energy for growth (x100) (purple plane) vs degree of maturity. Replicated with permission from Tedeschi (2022b).



product, fewer emissions of greenhouse gas due to precise nutrition and days on feed to achieve profitability).

Equations 7 and *8* developed by CSIRO (2007) are used to predict fat and protein RE in the empty body gain, using the coefficients for non-large, lean animal breeds. These equations use the intake level above maintenance (L) and degree of maturity (Z), assuming that protein contains 5,7 Mcal/kg and fat contains 9,4 Mcal/kg to compute RE. *Equation 9* combined *equation 3* with *equations 7* and *8*.

$$E_F = 0{,}94 \times \left((43 + 28 \times (L-2)) + \frac{601 - 28 \times (L-2)}{1 + e^{(-6 \times (Z - 0{,}4))}} \right) \quad (7)$$

$$E_P = 0{,}57 \times \left((212 + 4 \times (L-2)) + \frac{140 - 120 \times (L-2)}{1 + e^{(-6 \times (Z - 0{,}4))}} \right) \quad (8)$$

$$k_g = \frac{3}{4 + 11 \times (E_P / (E_P + E_F))} \quad (9)$$

where E_F is the RE as fat, Mcal/d; E_P is the RE as protein, Mcal/d; k_g is the partial efficiency of converting metabolisable energy into net energy for growth; *L* is the level of intake above maintenance, dimensionless; and *Z* is the degree of maturity, dimensionless.

Figure 1B depicts the predicted RE as fat and protein, and k_g for the degree of maturity (BW basis) varying from 0 (born) to 1 (mature) and intake above maintenance varying from 2 to 4. As the degree of maturity increases, the proportion of fat and protein in the gain increases and decreases, respectively, as expected, given the shape of the non-linear logistic curve adopted by the CSIRO (2007). The k_g also increased from approximately 0,3 to 0,58 as maturity increased. The k_g values are within acceptable limits (Reid *et al*., 1980). However, *Figure 1B* provides additional information regarding the interactions between the degree of maturity and level of feed intake above maintenance.

When we combined *equations 4* and *5* (growth rate effect) with *equations 7* and *8* (maturity stage effect) to estimate k_g (*equation 2*), it became evident that k_g increases faster with increases in EWG (same degree of maturity) than with increases in the degree of maturity (same growth rate). Furthermore, k_g seems to increase slowly as the degree of maturity increases for animals above 50% maturity compared to those animals below 50% maturity.

Combining mathematical models

Ensemble models

Another field in data analytics that has received greater attention lately is the development of ensemble models. Ensemble modelling is often adopted for artificial intelligence (e.g., machine learning) models to increase prediction accuracy, and it combines the outputs of unrelated models developed using different methods or algorithms but with similar scopes and purposes. Ensemble techniques include bagging (e.g., random forest, bootstrapping, decision trees), boosting (e.g., gradient boosting, adaptive boosting), stacking, and blending (Kyriakides and Margaritis, 2019).

The prediction errors are expected to decrease when an ensemble approach is utilised despite contradicting the principle that the simplest solution is often the best (Elder, 2018). In the case of ensemble modelling, models (or sub-models) per se are not combined or merged; their outputs are exploited. Examples of ensemble modelling exist for the impact of climate-related issues on crop (maize, wheat, soya bean, and rice) yield (Jägermeyr *et al*., 2021), detection and management of emergent disease by integrating outputs from multiple models (Webb *et al*., 2017), and classification of cattle behaviour (grazing, ruminating, resting, walking) using different machine learning techniques (Dutta *et al*., 2015) to list a few.

This article was condensed for publication in *AFMA Matrix*. Visit *www.doi.org/10.1016/j.animal.2023.100835* to read the full article or email luis.tedeschi@tamu.edu.

AFMA SAFE FEED FOR SAFE FOOD
Animal Feed Manufacturers Association

AFMA INTERVARSITY WRITER'S CUP 2024: WINNER ROUND 1 / LITERATURE REVIEW

THE PROTEIN REVOLUTION:

Rethinking broiler nutrition for a sustainable future

By Kyle Coetzee

Protein nutrition has long been a focal point in broiler production, but it is a subject that often flies under the radar, leading to excessive and unnecessary protein levels in diets. Paradoxically, this overabundance of protein, aimed at complying with specific safety margins, might be causing more problems than a slightly insufficient protein intake would.

By delving deeper into the complexities of protein digestion and harnessing the power of exogenous enzymes, we have the potential to significantly reduce protein content in diets without sacrificing performance. In this article, we will explore critical considerations for crafting more protein-efficient diets and discuss some innovative methods to boost protein efficiency.

Dietary inclusion of protein

Protein is mostly formulated on a crude protein basis (calculated as the amount of nitrogen in the feed or feed ingredient multiplied by 6,25), but this does not account for non-protein nitrogen or the undigested fraction of the protein source. The 2021 edition of the CVB feed table shows that the undigested fraction of crude protein may be as high as 22% in poultry by-products and up to 29% in barley. These undigested fractions often lead to issues in the form of animal welfare concerns and nutritional issues, as shown in *Figure 1*.

The excessive use of protein and protein-rich feed ingredients such as soya bean has also caused environmental issues, with high-producing countries such as Brazil and Chile facing ongoing concerns regarding deforestation to maintain production for export to Europe (Fehlenberg *et al*., 2017). The overfeeding of protein has also been linked to the eutrophication of water bodies around the globe, with high-ammonia and high-nitrogen litter being used as fertiliser, which leads to excessive run-off of nitrogen into rivers, streams, and dams (Khan and Ansari, 2005).

The efficiency of protein utilisation is dependent on multiple factors pertaining to digestibility and absorption. This can be aided by improving our understanding of the feed ingredients themselves, as well as by the addition of exogenous enzymes or processing of ingredients.

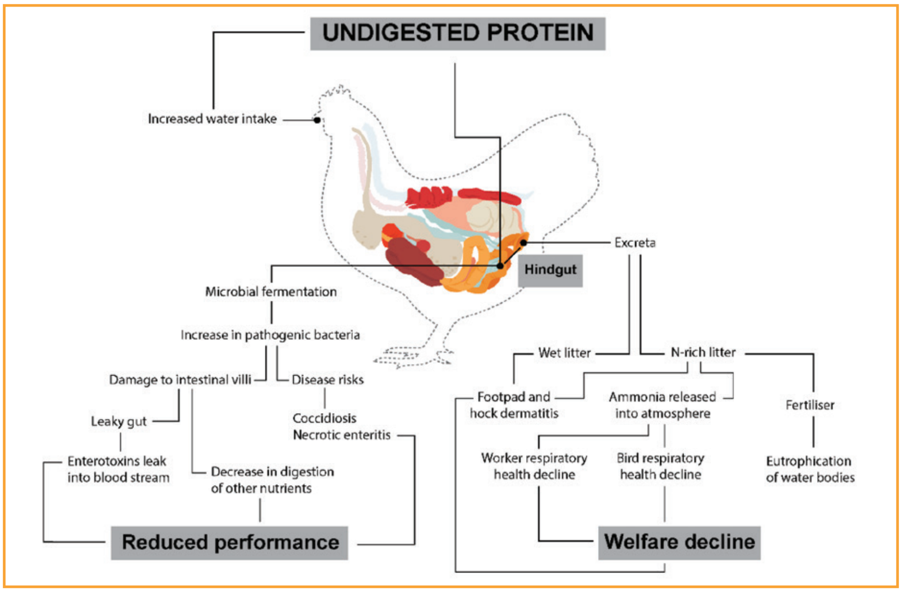
The issues at hand

Soya bean oilcake is most often used to provide protein in South African broiler diets because of its favourable amino acid profile and high protein content (Rada *et al*., 2017). However, it often falls short of the expected protein value due to anti-nutritional factors (ANF) such as trypsin inhibitors that affect the amount of protein available for digestion. Trypsin inhibitors and, more specifically the Bowman-Birk and Kunitz types, considerably decrease the activation of proteolytic enzymes and thus significantly decrease protein digestibility by endogenous proteases (Aderibigbe *et al*., 2020).

Acid-binding capacity (ABC) is described by the ability of a feed ingredient to resist a change in pH or thus to buffer acids. This is of importance to protein digestion as pepsin is released in the proventriculus and functions optimally at a low pH (usually around pH 2). The ABC of feed is thus of crucial importance since a high ABC value would cause reduced pepsin activity, leading to a decline in protein digestion (Venter, 2020). This is especially true in young birds, which have a reduced ability to regulate their gut pH.

Phytic acid and its effects on calcium and phosphorus availability have been well documented, but a factor that is often overlooked is the effect of phytate on protein and amino acid digestibility. It is accepted that binary protein-phytate complexes are formed by negatively charged phytate molecules and positively charged protein molecules at low pH. In addition, at a higher pH, calcium also acts

Figure 1: Schematic showing undigested protein's role in reduced performance and welfare decline.



as a salt bridge to link phytate and protein in ternary complexes (Selle *et al*., 2012).

Current solutions

One potential strategy to reduce the undigested protein fraction is by the addition of exogenous enzymes. This often leads to increased productivity and efficiency in the use of protein together with other feed ingredients.

Exogenous protease enzymes allow for the protein that is often left undigested by endogenous enzymes such as pepsin to be digested, cleaving peptide bonds and thus allowing for increased digestibility of amino acids that would often be wasted (Philipps-Wiemann, 2018). Proteases can be subdivided into two main functional groups: alkaline and acidic. These groups describe the pH range in which the enzyme functions optimally and describe the way in which they act to digest the undigested fraction of crude protein. Acidic proteases are often of fungal decent and function alongside endogenous proteolytic enzymes in the acidic conditions of the gizzard-proventriculus, while alkaline proteases are often obtained from bacteria and function as a so-called 'catch net', working on the proteins or long polypeptides left undigested by endogenous enzymes in the alkaline conditions in the small intestine (Moo-Young, 2019). These enzymes can also be used in combination, as a multi-protease additive that allows for significant reductions in the protein and amino acid content of diets while maintaining performance and carcass weights in broilers (Cho *et al*., 2020).

Kyle Coetzee.

Phytase is another exogenous enzyme that may increase the efficiency of protein digestion and absorption by specifically targeting the protein-phytase complexes mentioned. Phytase is a phytate-hydrolysing enzyme, which deactivates the phytic acid before it is able to form complexes that would render the proteins of amino acids undigestible. There is also an increased benefit to phosphorus digestibility, which increases with the use of a good quality phytase. This allows for a reduction of inorganic phosphorus, further increasing sustainability and efficiency. The effect of variable doses of phytase and its effects on amino acid digestibility has been well documented (Cowieson *et al*., 2017). ABC is a crucial factor to consider not only in the digestion of protein but also in the use of phytase enzymes. Phytase enzymes are most effective at acidic conditions ranging from pH 4,0 to pH 5,0 (De P Naves *et al*., 2012). Feedstuffs with a high ABC value would thus cause less efficacious phytase activity as well as a reduction in amino acid digestibility.

Looking to the future

The predigestion and/or fermentation of feed ingredients is showing promise in improving protein digestibility through the reduction of ANF. Fermented soya bean meal (FSBM) has been shown to increase broiler performance due to its effects on protein and amino acid digestion in the early stages of gut development. The fermentation of soya bean meal has multiple benefits in the efficiency of protein digestion, including the elimination of trypsin inhibitors, increased crude protein content, and an increase in short peptide chains which are easier to digest (Hong *et al*., 2004).

The effects are clear in the pre-starter and starter phases, including increased feed intake, increased average daily gain, reduced feed conversion ratio, and an increase in final body weight. In addition, some research shows that the effects of FSBM may be more pronounced in diets containing lower levels of crude protein in these phases (Chah *et al*., 1975; Guo *et al*., 2020).

Conclusion

The efficiency of protein usage in broilers is of critical importance to increasing bird welfare, improving the overall efficiency of production, and reducing our environmental footprint. By reviewing the issues mentioned in this article we not only better understand the issues regarding excess protein, but also how we can improve the efficiency by which we use expensive feed ingredients to provide protein to the animals. There are simple solutions at our disposal that we could employ to push efficiency, welfare, production, and sustainability to new heights.

References available on request. For more information, send an email to Kyle Coetzee at kyle.c@chemunique.co.za.

AFMA
SAFE FEED FOR SAFE FOOD
Animal Feed Manufacturers Association

2024 AFMA INTERVARSITY WRITER'S CUP COMPETITION

The AFMA Intervarsity Writer's Cup competition allows you to share your research in the *AFMA Matrix* magazine, a quarterly publication dedicated to the animal feed industry in South and Southern Africa, with articles based on scientific research and the latest industry news.

DEADLINES

ROUND 1 Article submission date: **The deadline has expired**
Publication date: **January 2024**

ROUND 2 Article submission date: **12 February 2024**
Publication date: **April 2024**

ROUND 3 Article submission date: **7 May 2024**
Publication date: **July 2024**

Who may enter?

Final year Animal Science students or Postgraduate Nutrition Science students, studying at a South African university.

Article themes

- Feed industry: Legislative environment; Trade environment (economy/pricing/trade)
- Feed science: Additives
- Nutritional science: All species
- Feed processing: Milling/mixing/formulation/packaging

Competition categories

- Own research
- Literature review

Prizes

AFMA INTERVARSITY WRITER'S CUP CHAMPION:
The university represented by the overall winner of the own research category will receive a cash prize of **R10 000** and a floating trophy as the AFMA Intervarsity Writer's Cup Champion.

OWN RESEARCH CATEGORY:
Authors of winning articles published quarterly will each receive a cash prize of **R2 000**. The author of the overall winning article and his/her promoter will each receive a cash prize of **R7 000**.

LITERATURE REVIEW CATEGORY:
Authors of winning articles published quarterly will each receive a cash prize of **R1 000**. The author of the overall winning article will receive a cash prize of **R3 000**.

PLEASE NOTE:
The highest-scoring articles in each category will be published in the relevant edition of the AFMA Matrix.
The overall winners will be chosen from all the articles that were published in the AFMA Matrix.
Published own research articles will be considered for the AFMA Intervarsity Writer's Cup award.
The overall winners in both categories will be allowed to present their submitted articles at the annual AFMA Symposium.

Stay in the loop with the AFMA Intervarsity Writer's Cup – follow AFMA on social media for the latest competition updates!

For more information contact the AFMA Office ▪ Telephone: +27 (0)12 663 9097 ▪ E-mail: events@afma.co.za
Visit www.afma.co.za/afma-intervarsity-writers-cup for more information.

AFMA
SAFE FEED FOR SAFE FOOD
Animal Feed Manufacturers Association

AFMA INTERVARSITY WRITER'S CUP 2024: WINNER ROUND 1 / OWN RESEARCH

The effect of dietary chitinase on feed quality of extruded abalone pellets

By M van Schalkwyk, JHC van Zyl and LF de Wet

The utilisation of functional ingredients within the aquafeed industry remains an attractive venture. Enzymatic treatment of insect meal (IM) and chitin has been shown to increase the yield of low molecular weight chitosan and increase the functionality of the ingredient. This study investigated the effect of dietary chitinase in extruded abalone feeds and the subsequent effect on water stability (WS).

Dietary chitinase was found to significantly decrease WS at all tested inclusion levels (0,1, 0,16, 0,25, 0,3 and 0,5%). A linear decrease in the 12-hour WS was observed. Due to the deterioration of WS, dietary chitinase is not recommended as a viable feed additive for the hydrolysis of chitin and the use of pre-treated IM is recommended.

Introduction

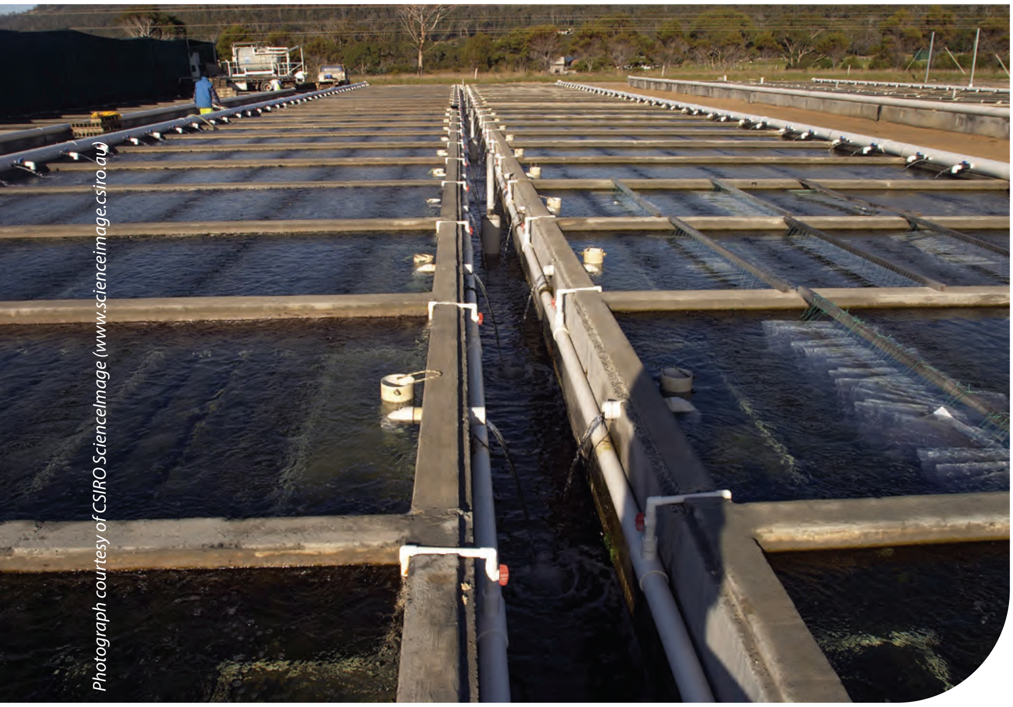
The rapid expansion of the South African abalone industry and the maximum sustainable yield of macro-algae (MA) such as kelp being reached, led to the introduction of formulated feeds in the industry (Troell *et al*., 2006). The industry's reliance on formulated feeds is mainly attributed to the higher growth rates obtained when feeding artificial feeds compared to that of MA (Troell *et al*., 2006).

WS, leaching rate and the use of pellet binders play a pivotal role in abalone diets (O'Mahoney *et al*., 2011). According to O'Mahoney *et al*. (2011), WS and leaching rate are correlated to feed uptake and palatability of abalone diets. Producing a feed with a sufficient leaching rate to stimulate uptake of abalone with passive, slow feeding behaviour (O'Mahoney *et al*., 2011), yet physically stable enough to remain intact and nutrient-dense is a significant challenge within the abalone feed industry (Goosen *et al*., 2014). Aquaculture feed producers employ several techniques to improve WS, which include starch gelatinisation (Romano and Kumar, 2019) and additives such as hydrocolloids (O'Mahoney *et al*., 2011) and alginates (Knauer *et al*., 1993).

Fish meal (FM) replacement in aquaculture has become an increasingly researched topic, with several studies investigating the effects of IM as FM replacement (Swiatkiewicz *et al*., 2015; Xiao *et al*., 2015; Zaki *et al*., 2015; Mohamad-Zulkifli *et al*., 2019). A major compounding factor associated with IM is the high chitin content, which is regarded as undigestible to many monogastric animals (Jha *et al*., 2019). Chitin is a naturally occurring β -1,4 linked polymer and is the major constituent of the exoskeleton of insects (Haynes *et al*., 1999).

The functional benefits of chitosan, a deacetylated form of chitin, and chitosan oligosaccharides (COS) have been extensively researched and include antimicrobial, anti-inflammatory, anti-oxidative, immunostimulatory and hypocholesterolemic properties (Swiatkiewicz *et al*., 2015, Gasco *et al*., 2018; Nogales-Mérida *et al*., 2019). Moreover, the functionality of chitin and COS are influenced by chain length, DD and molecular weight, with various studies reporting increased potency of lower molecular weight COS and shorter chain lengths (Kondo *et al*., 2000; Felt *et al*., 2009; Yousef *et al*., 2012; Muanprasat *et al*., 2015).

One potential avenue to increase the low-molecular-weight chitosan (LMWC) content in abalone feeds is via the inclusion of chitinase to hydrolyse the chitin present in the feeds into chitosan and COS (Poria *et al*., 2021). Enzymatic hydrolysis of chitin offers some potential advantages compared to alternative



Photograph courtesy of CSIRO ScienceImage (www.scienceimage.csiro.au)

methods, such as chemical treatment, including a higher LMWC yield, high specificity, no glucose-ring modification and retaining the original biological properties of chitin and/or chitosan (Wu, 2011; Rokhati *et al*., 2013).

A potential major compounding factor of IM or chitinase inclusion in extruded feeds is compromised WS. Wu (2011) and Rokhati *et al*. (2013) demonstrated the effectiveness of α – and β – amylase toward the hydrolysis of chitin and chitosan. The majority of enzymes that hydrolyse polysaccharides are highly substrate-specific, however, some enzymes have expressed a high affinity towards alternative substrates. Despite the affinity of amylase towards chitin, no studies on chitinase hydrolysis of the glycosidic bonds of starches and subsequent effects on WS could be found.

Considering the effectiveness of amylase towards the hydrolysis of chitin; the reported non-specificity of amylases towards chitin (Li *et al*., 2007) and the β-1,4-glycosidic bonds present in both chitin and starches, compromised WS could be expected should chitinase prove to be an effective hydrolysing agent of the glycosidic bonds in starches.

This study, therefore, aims to investigate the effects of dietary chitinase inclusion on the WS and pellet quality of extruded abalone diets.

Materials and methods

This study was conducted to determine the effect of chitinase on the WS of extruded abalone feeds. β-chitinase was added to a standard commercial abalone diet (SAF3000 grower) at inclusion rates of 0, 0,1, 0,166, 0,25, 0,33 and 0,5%. A single-screw extruder was used for the production of the experimental feeds. Pellets were subjected to WS evaluation by adapting the methods described by Ayoola, (2016).

Analysis of variance tests were performed in Statistica, TIBCO Software Inc (2020) to determine the effect of various chitinase levels on WS and pellet quality. Significance was declared at $P \leq 0{,}05$.

Results and discussion

WS was significantly influenced by dietary chitinase (*Table 1*) and significantly ($P < 0{,}05$) correlated to chitinase inclusion at water exposures of 40 min and longer. The effect of chitinase on WS was further confirmed by conducting repeated measures analyses (*Figure 1*). No apparent deterioration in WS was evident for the control diet over the course of the experimental period, however, WS deterioration was observed for all experimental diets.

Table 1: Mean ± SE water stability (%) of extruded abalone diets with various levels of dietary chitinase inclusion (%) over a 12-hour period.

Water exposure (min)	Treatment						P-value
	C0	C0,1	C0,166	C0,25	C0,33	C0,5	
10	99,2^{a} ± 1	99,3^{a} ± 0,6	99,7^{a} ± 0,9	98,5^{a} ± 0,5	99,35^{a} ± 0,	99,2^{a} ± 5,5	0,97
20	98,9^{a} ± 0,4	98,6^{ab} ± 0,6	98,5^{ab} ± 1	96,0^{c} ± 1,5	98,6^{ab} ± 0,4	97,8^{b} ± 1,1	<0,01
40	99,7^{a} ± 1	96,9^{ab} ± 2,1	94,2^{bc} ± 2,1	92,9^{bc} ± 3,6	93,2^{bc} ± 4,1	89,5^{c} ± 7,6	<0,01
60	100,0^{a} ± 1,3	93,8^{ab} ± 3,3	90,6^{abc} ± ,2	83,0^{cd} ± 7,4	86,6^{bc} ± 1,1	74,2^{d} ± 13,3	<0,01
120	98,9^{a} ± 1,1	83,9^{b} ± 6,9	69,1^{c} ± 10,7	58,6^{cd} ± 0,2	54,9^{d} ± 16,1	22,7^{e} ± 17,2	<0,01
240	97,1^{a} ± 1,3	76,4^{b} ± 10,4	46,4^{c} ± 11,3	26,4^{d} ± 15,6	12,2 ± 5,3	1,5^{f} ± 1,3	<0,01
360	93,9^{a} ± 1,4	71,7^{b} ± 8,2	30,6^{c} ± 4,4	6,02^{de} ± 5,2	8,2^{d} ± 5, ± 2	1,0^{e} ± 1,5	<0,01
480	94,1^{a} ± 0,3	59,6^{b} ± 4,3	28,2^{c} ± 4,1	2,9^{e} ± 1,3	8,0^{d} ± 7,5	0,0^{e} ± 0,3	<0,01
600	92,0^{a} ± 1,2	48,2^{b} ± 22,9	21,4^{c} ± 4,8	2,2^{d} ± 1,7	10,0^{cd} ± 5,1	0,4^{d} ± 0,9	<0,01
720	92,5^{a} ± 1,6	61,7^{b} ± 8,3	19,3^{c} ± 4,2	4,0^{d} ± 5,2	4,3^{d} ± 3,2	0,2^{d} ± 0,4	<0,01

^{a,b,c,d,e,f} Means within rows with different superscripts differ significantly ($P \geq 0{,}05$)

No studies investigating the chitinase hydrolysis of amylose, or the subsequent effects on WS, could be found. However, Wu (2011) reported complete hydrolysis of chitosan by α-amylase following four hours of exposure, when using a 1% chitosan solution and an amylase concentration of 20mg.kg^{-1}. The latter author, along with most other available literature, however, investigated starch gelatinisation in aqueous solutions, i.e. systems with excess water, whereas water content is limited or insufficient in food and feed systems (Schirmer *et al.*, 2015).

Water content is of particular importance when interpreting gelatinisation results, as the degree of gelatinisation is largely influenced by the starch:water-ratio (Fukuoka *et al.*, 2002). It should also be noted that the experimental mesh bags of C0.25, C0.33 and C0.5 were almost completely empty after four hours of exposure, and the assumption of complete hydrolysis after four hours can therefore not be made or correlated with the results of Wu (2011). Moreover, as demonstrated by the latter author, enzyme activity is highly dependent on temperature, pH and enzyme concentration, thus further complicating any extrapolation of their results to the current trial.

Data regarding the WS of both commercial and experimental abalone feeds appear scarce, and benchmarking the observed WS of the experimental diets remains cumbersome. However, Goosen *et al.* (2014) reported 24h WS of 52% for the control diet used in their study. Although the 12h WS observed for the control diet in this study appears significantly higher than that reported by Goosen *et al.* (2014), extrapolation of the 12h stability to 24h remains cumbersome. WS in extruded aquafeeds is largely obtained from the gelatinisation of starches, specifically amylose and amylopectin present in grains, cereals and certain legumes (Tako *et al.*, 2014; Romano and Kumar, 2019). Pre-treating substrates significantly enhances enzyme susceptibility (Poshina *et al.*, 2018), with pre-treatments that decrease crystallinity, such as pre-extrusion, reported as the most effective for glycosidic polysaccharides (Baks *et al.*, 2008; Jaworska and Roberts, 2016; Wu *et al.*, 2020). The utilisation of pre-gelatinised maize starch as raw material within the formulations therefore likely contributed to the high efficiency of chitinase in the current trial.

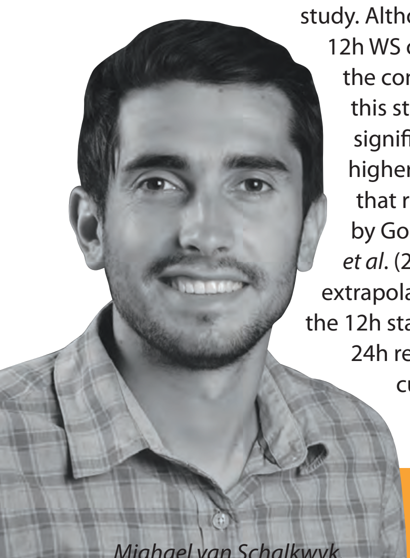
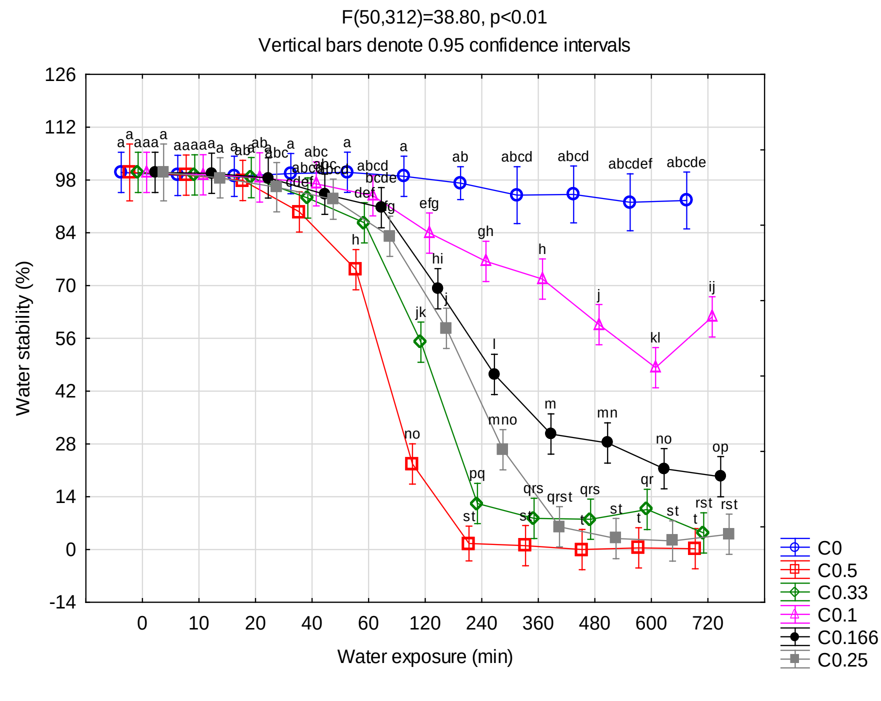

Mighael van Schalkwyk.

Figure 1: Water stability of extruded abalone diets with various levels of dietary chitinase inclusion over 12 hours performed using a repeated measured ANOVA.



Plant polysaccharides exhibit high accessibility to a variety of enzymes due to large monomer diversity and linkage complexity (Poshina *et al.*, 2018). Furthermore, ß-amylase can hydrolyse α-amylose (Elmarzugi *et al.*, 2014; Schirmer *et al.*, 2015; Özcan and Sipahioğlu, 2020), however, no literature on α-amylose hydrolysis by ß-chitinase, nor the link between α-amylose hydrolysis and the subsequent effects on gelatinisation and WS could be found.

Furthermore, the mode of action of glycoside hydrolases remains complex, with several carbohydrate-hydrolysing enzymes displaying high activity towards several substrates. It is evident that chitinase significantly influences WS of extruded feeds, likely due to the hydrolysis of the glycosidic bonds, however, the exact mode of action remains to be confirmed through further analysis.

Conclusion

The use of functional ingredients remains an attractive venture for high-value aquafeeds. The WS of extruded abalone feeds was significantly influenced by dietary chitinase inclusion. The WS of feeds was shown to be impaired and severe WS deterioration observed at the lowest inclusion following six hours of water exposure. The utilisation of dietary ß-chitinase can, therefore, not be used in this regard.

References available on request. For more information, send an email to Mighael van Schalkwyk at 19967985@sun.ac.za.

1st

The team from EW Nutrition took first place. From the left are Jaco Truter, Tertius Harmse, Dewaal Grobler and Klasie Hodgson.

Liesl Breytenbach was announced as the new CEO of AFMA shortly after the event. Here she is with Anina Hunter, chairperson of AFMA.

2nd

Second place went to the Automill team. From left to right are Liesl Breytenbach (AFMA), Wicus Hattingh, Gerhard Neethling, Francois Gey van Pittius and John Gush.

Alex Jenkins and Frans Hagg from Allied Nutrition.

Automill's Suné Britz and Chrisna van Rooyen.

Perfect score for the 2023 AFMA Golf Day

3rd

RCL Food's Epol team took third spot. The team members, from the left, are Andrew Wilkinson, Wouter de Wet, David Wilkinson and Marthinus Stander.

The AFMA organising committee are, from the left, Lucius Phaleng, Bee Oelofsen, Mandy Joubert, Liesl Breytenbach, Bonita Cilliers, Olivia Botha and Wimpie Groenewald.

The Animal Feed Manufacturers' Association (AFMA) held their annual golf day in August last year at Centurion Golf Estate. This was the 17th golf day of its kind hosted by AFMA. The event was established in 2006 in collaboration with Afri Compliance, after which AFMA took over as the sole organiser of the event in 2017. The day provided an excellent networking opportunity for all involved in the animal feed industry.

The team from EW Nutrition took top honours when they came in first, with team Automill in second place and RCL Foods Epol in third place. Nearest to the pin went to Kabelo Nadebe, the 'longest day' to Andries van Schalkwyk, and the *gees* (spirit) trophy went to team Chemuniqué. George Muller won the lucky draw.

Gerlan Boonzaaier and Wald van Zyl from BiTEK Industries.

Cargill's Nicole Scholtz, Marjorie Potgieter and Isabel Erlank.

The Chemuniqué team: In the back, from the left, are Zanele Mdleko and Anneleen Swanepoel. In the front, from the left, are Stenelle van Marle and Louma Mostert.

Chantelle Botha, Michelle Kruger, Yourisha Govender, Bernice Schoeman, Jano Williams and Adam Smith from CJP Chemicals.

Kyle Westergaard, André Kilian and Iwan Smit from RCL Foods' Epol.

JVD Consulting's Pieter Delport and Christiaan Aspeling.

The Elanco team, from the left, are Wimpie Voges, Ruon Strydom, Ronel Wolmarans, Holly van Gerve, Johan Linde and Francois Smit.

Zee Botes, Ashleigh Reynolds and Danél Vermaak from Manuchar.

Nutri Feeds' Santa Ferreira and Sergio de Lima.

André Pienaar, Shaé de Kock, Claire Pugh and Cara Nel from Trouw Nutrition.

More than 40 exhibitors were present in the exhibition hall at Sun City.

Industry dissects the Fourth Agricultural Revolution at AFMA Forum 2023

By Elmarie Helberg, Plaas Media

The 2023 AFMA Forum, themed "Feed and Food – The Fourth Agricultural Revolution", took place at the beginning of September at Sun City. Automill was the main sponsor of the event.

The First Agricultural Revolution occurred around 10 000 BC, marking the change from nomadic hunter-gatherer cultures to more fixed settlements. This necessitated the use of cultivated fields to provide a steady supply of food.

The Second Agricultural Revolution happened much later and lasted from the mid-17th to late 19th century. Irrespective of increased human labour, innovations during this period primarily led to tremendous productivity improvements such as advanced ploughing techniques, crop rotation, selective animal breeding, improved transportation and land drainage, which enabled geographic expansion.

In the 1950s and 1960s, significant advances in agricultural mechanisation, chemical fertilisers, and new high-yielding crop development led to the Third Agricultural Revolution. These changes were considerably more pronounced in developing countries where the introduction of high-yield rice, wheat and maize led to enormous improvements in the standard of living.

Technology drives Agriculture 4.0

We are now entering the Fourth Agricultural Revolution (Agriculture 4.0). In the coming years, Agriculture 4.0 will undergo significant structural changes which will mostly be sparked by technological developments and digital advances.

Among many other innovations, some advancements may include automation (robotics), artificial intelligence, gene editing, nutrigenics, traceability, precision livestock farming, waste reduction, improved logistics, and the like. At the same time, never-ending economic 'crises' are also now commonplace. In the modern world, there is no 'normal' and animal agriculture must be able to evolve and mitigate the effects of sudden change.

According to Liesl Breytenbach, executive director of the Animal Feed Manufacturers' Association (AFMA), the more than 40 exhibitors went above and beyond to present a world-class exhibition during 2023's forum.

"Animal feed is an integral part of the food chain, and it is important for us to convey this message. The era we are in presents numerous challenges and the

Anina Hunter, chairperson of AFMA, addressing attendees. Chantelle Fryer (left), chairperson of the AFMA Forum Programme Committee, was the moderator of the first plenary session.

Laurentia van Rensburg of Alltech North America touched on the question of whether carbon negative beef production on pasture is at all possible, based on a Buck Island case study.

Nico Groenewald, head of Agribusiness at Standard Bank Group South Africa, discussed the issue of whether the combination of technology, a revolution, and (financial) success is in fact achievable.

topics discussed at this forum addressed, among other things, sustainability issues and the technology at our disposal – how to use it and incorporate it into our businesses, and how to move forward and grow as an industry.

"This year's forum hosted 30 international and local speakers who addressed precision nutrition issues and new technology local feed millers can employ in their operations," she said.

Is Africa ready for Agriculture 4.0?

Topics such as sustainable production and health, and new developments in gut health and immunity in both monogastrics and ruminants were put in the spotlight during the three-day event. Given the current state of the economy and future predictions, how feasible is the Fourth Agricultural Revolution in South Africa?

This theme was highlighted during the first sessions at the forum. Nico Groenewald, head of Agribusiness at the Standard Bank Group South Africa, gave delegates some food for thought regarding technology and whether Agriculture 4.0 is a silver bullet for success.

According to Groenewald, the realities of agriculture in Africa that might affect the adoption of this movement include an increasing population, pest and disease outbreaks, inefficient production systems, deteriorating infrastructure, climate change and food waste. The challenge is that South Africa is still in the early phase of the Fourth Agricultural Revolution, hence the country's lag behind first world countries.

He added that adopting technology can lead to decreased labour demand in the sector, and warned producers that they must make certain the technology they invest in will fit into their strategies and business plans.

Nitrogen efficiency

Mike Shearing, global ruminant amino acid formulation manager at Adisseo North America, kicked off the ruminant session on the second day, focussing on the issue of improving nitrogen efficiency in lactating dairy cows for sustainability and profit.

Three studies have been conducted on this topic, with the conclusion that nitrogen efficiency can be improved by feeding lower crude protein levels. According to Shearing, with improved efficiency in a cow herd, less nitrogen is released into the environment which reduces the amount of nitrous oxide (N_2O) produced.

The productivity-success interplay

Laurentia van Rensburg, technical mineral manager at Alltech North America,

Dr Mohammed el Amine Benarbia from Nor-Feed SAS in France discussed coccidiosis management in broilers.

touched on the question of whether carbon negative beef production on pasture is at all possible, based on a Buck Island case study.

Buck Island Ranch is a 10 500-acre working cattle ranch in the headwaters of the Everglades in America. According to Van Rensburg, only 2% of America's carbon emissions come directly from cattle,

Automill was the main event partner of the 2023 AFMA Forum.

The AFMA Forum has become synonymous with networking at the highest level during and between sessions.

The AFMA Forum 2023 concluded with a customary beach party with Dr Victor who entertained guests.

with the total direct emissions from all agriculture at 8%. She claims it is possible to increase beef production, reduce the carbon footprint, improve genetics and management practices, as well as optimise nutritional status and vaccination and health programmes – all at the same time.

She demonstrated this with data taken over the past couple of years at Buck Island, showing that they were able to improve production while decreasing the carbon intensity.

"Productivity is a powerful tool for improving the sustainability of food production, including beef, in the face of a growing population and increasing food demands. We need to find practical solutions to maximise on-farm efficiency, productivity and profitability for producers."

Predicting net energy

During the monogastric session on the last day of the forum, Dr Yves Mercier, scientific and technical support manager, Adisseo France SAS, discussed the recent developments in energy systems for poultry. According to him, feed energy management should follow lighting evolution and adapt to new standards. He discussed the potential of a net energy system in poultry production. Development of such a system has been a topic of research for many decades, following its successful implementation in pig production.

"Comparing the different energy systems available, the net energy system appears better at predicting retained energy. This system better valorises enzymes, allowing further feed price reduction and more accurate usage," he said.

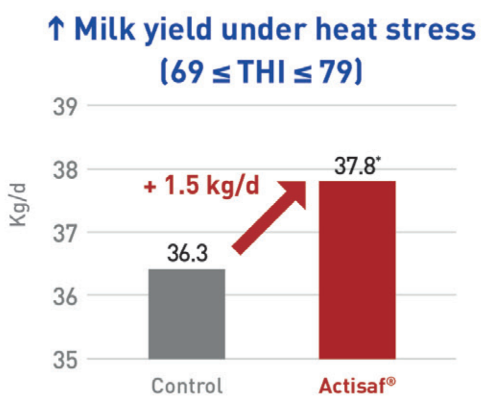
He added that there are numerous energy systems in poultry nutrition that coexist, but a net energy system is more promising for sustainable animal nutrition. Switching to such a system offers the opportunity to better predict animal response and possibly adapting energy supply in challenging conditions.

Coccidiosis management

Dr Mohammed el Amine Benarbia, research and development manager at Nor-Feed SAS in France, discussed coccidiosis management in broilers. We need to rethink coccidiosis management for several reasons, he said.

He did a comparative study between 100% botanical-based active compounds and conventional coccidiostats. This blend, called YTS, contains fenugreek among other products and has shown no resistance in the poultry used in the trails yet. Numerous trials have been done to support the efficacy of YTS, showing that it is as efficient as ionophores and synthetic coccidiostats. It also decreases mortality while being a cost-effective solution.

Visit *www.afmaforum.co.za* for more information



Moallem et al., 2009. J. Dairy Sci. 92:343-351.
*p < 0.007

Program
Heat stress

phileo-lesaffre.com/heat-stress/dairycows

Phileo by Lesaffre


nu-pro
Est. 2004
GROUP
nu-soy
nu-pro COMMODITIES
nuTOPIA AGRI DEVELOPMENTS (PTY) LTD
A JOINT COMPANY BETWEEN BKB AND NU-PRO GROUP
nu-soy
NPC logistics
OXFORD STREET
Niel Ungerer Cell: 082 333 3150
nungerer@nupro.co.za | www.nupro.co.za