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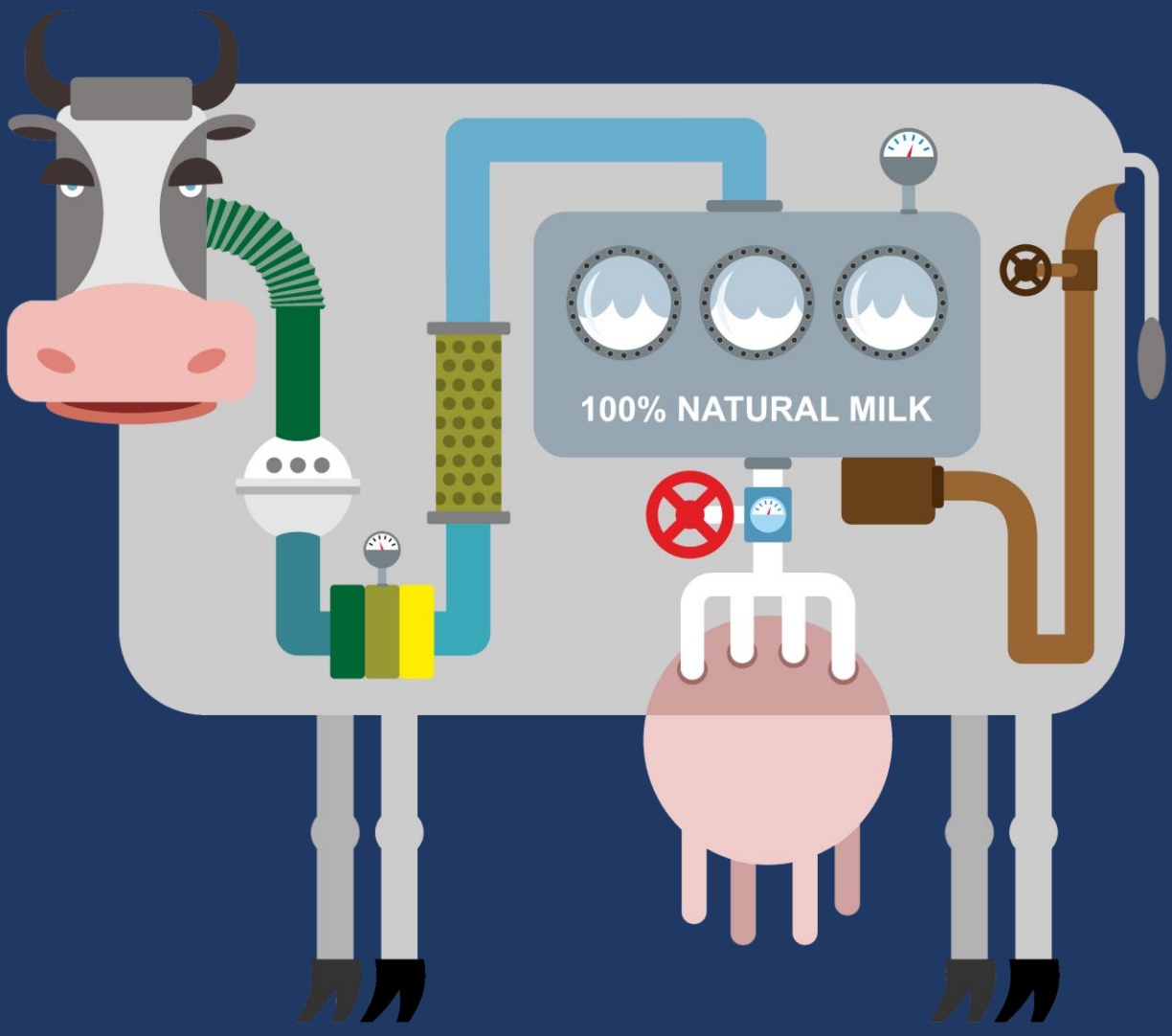

DAIRY KNOWLEDGE CENTER™

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With the main goal of following the DKC's motto, "evolving the dairy industry," the DKC Quarterly publishes ideas and insights from the DKC team and the world's leading experts in a thought-provoking way. The Quarterly provides emerging trends and research outputs that will impact the future of sustainable dairy production systems. It presents new developments in technology, business, people capital management, environmental issues, and cow care, among others

IN THIS ISSUE

Antimicrobial resistance continues being a global concern for the World Health Organization because threatens the effective prevention and treatment of an ever-increasing range of infections caused by bacteria, parasites, viruses and fungi. In this publication, Dr. Garcia- Fernandez discusses in depth the origin, evolution, and strategies to combat the problem of resistance in the animal industry. According to "Dairy 2014 Report 3: Health and Management Practices on U.S. Dairy Operations, 2014", the percentage of dairy cows treated with antibiotics for mastitis, respiratory diseases, diarrhea or other digestive problems, reproductive disorders, mastitis, lameness, or other disease was 22.0, 2.6, 1.1, 7.7, 3.6, and 0.5%, respectively. Since the highest percentage of cows are treated for mastitis, reducing the use of antibiotics to combat this disease may reduce the total usage on farms. Dr. Garcia- Fernandez explains how selective treatment of clinical mastitis based on on-farm culture results can potentially reduce total antimicrobial use on dairies.

Ruminants play a key role in society by converting fiber-rich plant resources into high-quality food that humans can eat. However, this conversion causes unavoidable losses of nitrogen in feces and urine that have the potential to become an environmental burden. Applying protective treatments against ruminal fermentation in high quality proteins is attractive to avoid their microbial degradation, which is usually associated with high ruminal ammonia losses and with reduced efficiency of microbial protein synthesis. This approach is discussed in my article "Reducing nitrogen contamination by feeding protected protein".

While unique at converting fiber into protein, the rumen degrades high-quality nutrients and active ingredients such as amino acids, vitamins, enzymes, drugs, and hormones. Microencapsulation is designed to increase the amount of a nutrient that passes through the rumen without degradation by the rumen microorganisms, thereby resulting in the delivery of a larger portion of that nutrient to the lower gastrointestinal tract. Dr. Sahraei-Belverdy describes how this technique protects nutrients from degradation in the rumen, making it possible to increase the bioavailability of the core ingredient in the small intestine.

The work in dairy farms is intensive with employees working every day of the year. This, coupled with the challenge of finding a qualified workforce, makes dairying one of the most difficult business in agriculture. In her publication "It's a match: How to win the talent war" the expert in Employer Branding "Carolina Borrachia describes a new paradigm for hiring talent based in building relationships.

Heat stress decreases the productive ability of lactating cows. Heat stress occurs when the cow is incapable of dissipating enough heat to maintain its core body temperature below 38.5 °C. Several key areas of nutritional management should be considered for complementing environmental cooling during hot weather. Jeff Kaufman, a Graduate Research Assistant at the University of Tennessee, publishes part of his doctorate work focused on providing strategies to improve milk production and protein metabolism in heat-stressed dairy cows.

Finally, Dr. Garcia discusses in a thought-provoking way about starch requirement in dairy cows. The optimum non-fibrous-carbohydrate (NFC) concentration for dairy cow diets is not well defined in the latest Nutrient Requirements of Dairy Cattle book. The concentration range suggested varies between 36 and 44 percent on a dry basis. Total NFC includes starch, sugars, soluble fiber and organic acids. Because of NFC differences in degradation rate and chemical composition, different NFC sources have a different potential to reduce ruminal pH. Starch can ferment to lactic acid, which has greater effect in decreasing ruminal pH than acetic, propionic or butyric acid.

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ARTICLES

The nitty-gritty of antimicrobial resistance

The nitty-gritty of antimicrobial resistance

Nuria García-Fernández

Introduction

According to their etymology, antimicrobials are substances against the life of microorganisms. (The word “antimicrobial” comes from the Greek “anti” [which means “against”], “mikros” [meaning “small”], and “bios” [which means “life”]). These compounds are used to treat infectious diseases in humans and animals. Doctors, veterinarians, and patients commonly refer to them as "antibiotics." However, the terms “antimicrobial” and “antibiotic” are not synonymous. The noun “antibiotic” was used for the first time in 1889 by the French biologist Paul Vuillemin to describe the destruction of one organism by another. However, the term was introduced in 1941 by the microbiologist Selman A. Waksman, later awarded the Novel Prize, who defined an antibiotic as a substance produced by microorganisms that has the ability, in solution, to selectively inhibit growth and even destroy other microorganisms[14,22,26]. Therefore, according to this definition, the term “antibiotic” refers only to substances of microbial origin that act on other microorganisms; it does not refer to synthetic compounds (such as sulfonamides or quinolones), semi-synthetic substances (amoxicillin or amikacin, among others), substances of plant origin (such as alkaloids), or substances of animal origin (lysozyme, among others). Nor does it refer to substances that are active against animal cells (such as anticancer drugs).

Antimicrobials that are routinely administered to humans and animals should show selective toxicity, i.e., affect only pathogenic microorganisms and not the host. In this selective toxicity, the mechanism of action of each substance is involved. The most selective antimicrobials are those that affect bacterial structures, for example, the bacterial cell wall or metabolic pathways, such as the synthesis of folic acid, that are not present in eukaryotic cells. In this way, antimicrobials that act on DNA, such as nitrofurans or nitroimidazoles, frequently also have toxic effects on humans and animals. On the other hand, biocides, disinfectants, and antiseptics such as quaternary ammonium compounds are applied to objects and surfaces because they are toxic to both prokaryotes and eukaryotes.

Before the development of antimicrobials, there was a high mortality rate due to bacterial infections caused by microorganisms such as Staphylococcus aureus,

Streptococcus pyogenes, and Mycobacterium tuberculosis. The introduction of antimicrobials drastically reduced deaths from these infections but did not completely solve the problem of the prevalence of these diseases[23]. The enthusiasm over the newly discovered antimicrobials and the disappointment resulting from the emergence of bacterial resistance to antimicrobials have alternated since the introduction of antibacterial chemotherapy around the year 1940. This concern is exacerbated by the frequent detection of multiresistant microorganisms among patients in critical condition.

During the last few years, many of the molecular mechanisms that produced bacterial resistance to antimicrobial agents have been elucidated, notably improving the understanding of the genetic basis of multidrug resistance[25].

Resistance to antimicrobials

Resistance can be defined in terms of multiple criteria (genetic, microbiological, biochemical, and clinical) that do not always overlap; the most common definitions are based on microbiological (*in vitro*) and clinical (*in vivo*) criteria[1]. According to the microbiological definition, a strain is resistant if it grows at high concentrations of the antimicrobial drug compared to phylogenetically related strains. Therefore, resistance is not a property that can be determined by studying a single strain; it can be taken into account only when one compares two or more strains of the same species under the same conditions.

According to the clinical definition, resistance occurs when the growth of a bacterial population is not inhibited at the concentration of the antimicrobial that is obtained at the site of infection after its administration in therapeutic doses[3,18]. In vivo, a strain can be sensitive or resistant depending on its location, dose, route of administration, and distribution in tissues as well as on the immune status of the individual being treated. Sometimes the antimicrobial cannot penetrate the site where the pathogen is found, for example, in the case of fibrotic abscesses, or it is not active under certain physicochemical conditions of the site of infection (e.g., alterations in pH or in oxygen concentration).

The resistance can be quantified under laboratory conditions by determining the MIC (Minimum Inhibitory Concentration) of a given substance, with the lowest concentration being able to completely inhibit the growth of a bacterial strain.

A strain is defined as resistant, moderate, or sensitive depending on the point of rupture or the breakpoint (microbiological or clinical). Breakpoints are used in research when the study's purpose is to monitor the resistance in bacterial populations and to identify the appearance of new resistance phenotypes. Clinical or pharmacological breakpoints are calculated considering in vivo parameters such as the distribution of bacteria in the host, the pharmacokinetic and pharmacodynamic criteria of the substance, and the correlation of the MIC with the final clinical result.

Appearance of resistance

In the early years of the twentieth century, when Paul Ehrlich announced the efficacy of salvarsan in the treatment of syphilis, many thought that the victory over infectious diseases was near[5]. Nothing is further from reality; the emergence of resistance has been a constant to this day and is a feature of microorganisms' ability to adapt, thus existing before the pharmacological use of antimicrobials[8]. The indiscriminate and inappropriate use of these compounds has accelerated the selection of resistant microorganisms. At this point, it should be noted that antimicrobials act as environmental modifiers, inhibiting or destroying sensitive bacteria but not affecting the few individuals who, by spontaneous mutation or gene transfer, have acquired a gene (or allele) that confers resistance. These individuals multiply and prevail. The resistance mechanisms thus selected will be retained by the cell and transmitted in turn vertically and/or horizontally, according to each case. The short time during which the bacteria are generated, along with the potential to mutate and exchange genetic material, lead to the rapid creation of resistant populations, which will be selected using specific antimicrobials.

To fight an infection, the administered dose of the antimicrobial must be appropriate; a concentration below the minimum inhibitory can exert a significant selective pressure that favors the appearance of resistance due to mutations or its acquisition by transfer between bacteria[15]. It was concluded that 40% of the antimicrobials prescribed for infections in primary care and 30% in hospitals are inadequate[16]. In this sense, it should be considered that a rational use of antimicrobials requires assessing the frequency of the emergence of resistance in bacterial species of clinical importance.

Resistance in bacteria of animal origin

The use of antimicrobials in animals can substantially reduce the effectiveness of the antimicrobial arsenal in treating human infections. In some cases, few or no effective substances are available to treat infections by resistant pathogens[7,12].

In veterinary medicine, in parallel with what happened in human medicine, antimicrobials began to be used in the 1950s to treat sick animals, and sometimes even to treat asymptomatic animals that lived with the sick animals (prophylactic group treatments). At that time, it was discovered that feeding pigs with tetracycline fermentation wastes accelerated their growth, improving the conversion rates. This is the historical beginning of the use of antimicrobials as growth promoters, which consists of adding subtherapeutic quantities of these substances to food. The groups of antimicrobials that were used for this purpose were penicillins and tetracyclines. Years later, concerns began to emerge about the emergence of strains resistant to these antimicrobials in isolated salmonellae from calves with the respiratory disease. Despite this, the positive results obtained have favored continued use to date, with important variations in the permissiveness of the laws of each country. This has generated an intense discussion over the last few years about the risks of these practices.

A wide variety of antimicrobials are used as growth promoters in different countries; information about the quantities and types of substances must be available to complete the one that comes from therapeutic treatments, always administered under medical or veterinary prescription and by both easily controllable, to be able to complete maps of the circulation of these substances that help prevent and combat the problem of resistance[6].

A good start was the European Union's prohibition of the non-therapeutic use of antimicrobials in human medicine, such as penicillins, tetracyclines, and streptogramins. In Denmark, it was possible to significantly reduce the use of antimicrobials for consumer animals, thereby achieving overall declines in resistance. Thus, in its report to the World Health Organization, Denmark stated that this fact drastically reduced the reservoirs of enterococci resistant to these growth promoters, consequently decreasing the circulating gene units that encode resistance to several of the clinically important antimicrobials in humans. In addition, there is some indication that the disuse of growth promoters is associated with the decline in streptogramin resistance in Enterococcus faecium isolates in humans. On the other hand, it seems that the resistance to erythromycin in E. faecium increased, which could reflect the increase

in the therapeutic use of tylosin (another macrolide), though this fact is considered less alarming because it is not the antimicrobial of choice in infections enterococcal in humans. In these cases, the substances of choice include ampicillin, amoxicillin, vancomycin, streptogramins, and linezolid[2].

Types of resistance of bacteria to antimicrobials

There are three types of resistance of bacteria to antimicrobials: intrinsic or constitutive, environmental, and acquired. The first refers to the fact that some bacteria are naturally resistant to antimicrobials because they lack the cellular mechanisms or targets that these require to exert their antibiotic action. This is the case with microorganisms belonging to the Enterobacteriaceae family and their intrinsic resistance to Vancomycin, that of mycoplasmas and their resistance to β-lactams, Gram-positive bacteria versus Polymyxin B, or many anaerobes against aminoglycosides. On the other hand, environmental resistance depends on the physical-chemical factors of the environment. Thus, under certain environmental conditions (for example, at high concentrations of some salts) a microorganism can better express its resistance to an antimicrobial. It is considered that the layer of mucopolysaccharide (slime) that some microorganisms create to protect themselves is a form of environmental resistance because it impedes contact of the antimicrobial with the bacterium.

Finally, acquired resistance is based on genetic variations and can occur by mutation (substitution, deletion, or insertion) or by transfer of genetic material. This resistance is very important in enterobacteria and is increasingly common in Gram-negative pathogens such as Bordetella, Haemophilus, Pasteurella, and Pseudomonas. This type of resistance has also been identified in the commensal microbial population in the digestive tracts of humans and animals. The severity of the problem increases if the resistance persists even when the selective pressure disappears, as the bacterial population then serves as a reservoir of resistance genes that maintain their potential over time. In the process of the horizontal transfer of genetic material, it is common to transmit joint resistance to several antimicrobials because the genes involved are associated with the same mobile genetic element, which facilitates their harvesting in the absence of selective pressure. The resistance acquired by genetic exchange can be transmitted vertically or horizontally, resulting in a large-scale health problem.

The main molecular mechanisms by which resistance to antimicrobials occurs are:

i) its enzymatic inactivation,

ii) the decrease in its intracellular concentration, and

iii) the existence of modifications of the antimicrobial target[3,18]. The hydrolysis and inactivation of β-lactam compounds by the action of β-lactamases is one of the paradigms of acquired resistance against antimicrobials.

The expression of these enzymes can be produced by activation of endogenous genes, or by gene transfer from other bacterial species. On the other hand, the structural modification of membrane proteins can hinder the entry or facilitate the exit of the antimicrobial, decreasing its effective concentration and producing resistance. Finally, modifications of the targets on which certain antimicrobial agents act (such as the proteins that synthesize the bacterial cell wall, certain ribosomal proteins, and DNA gyrase) will generate resistance against β-lactams, macrolides, or quinolones, respectively.

Transfer of antimicrobial resistance

Studies exist that prove the existence of a transfer of resistance genes by plasmids or conjugative transposons between bacteria of animal origin. The first evidence of the latter was obtained in 1982, when the transfer of resistance to clindamycin and tetracycline in a strain of B. fragilis was described, without any plasmid being involved[11]. Other studies have shown the transfer of plasmids conferring resistance to antimicrobials among microorganisms of the genus Lactococcus isolated from the microbial population of rodents[24]. The transfer of these genes from enterococci in the digestive systems of mice to humans has also been demonstrated[13]. In fact, until recently, studies of the mobilization and horizontal transfer of resistance genes focused on bacterial pathogens, though now this approach seems very limited because the microbial population of the colon could play a relevant clinical role acting as a reservoir of determinants of resistance to antimicrobials. It is usually considered that when two genes are virtually identical (percent identity > 95%) coming from bacteria that are not closely related (genera and different species), they must have been transferred horizontally[20,21].

Bacteria resistant to multiple antimicrobials are not restricted to clinical settings because they have also been easily isolated from environmental samples and foods[4,17].

The idea that the hospital environment is a closed compartment and that resistance to antimicrobials arises in patients inside the hospital seems to be incorrect. At least in a certain number of cases, the mobilization of resistance genes, as well as the resistant bacteria themselves, between different environments has been proven. To assess this problem, factors that contribute to resistance, which are the antimicrobials themselves, must be identified, along with the characteristics of the resistance. The genetic plasticity that bacteria possess has contributed to the efficiency with which resistance to antimicrobials has emerged; however, there would be no consequences if no selective pressure was derived from the massive use of antimicrobials[10].

The enormous capacity of the horizontal transfer of genetic material in bacteria is demonstrated by recent work, in which it has been possible to transfer, by means of polyethylene glycol transformation, the naked DNA containing the complete genome of a bacterial species (Mycoplasma mycoides) to another species (Micoplasma capricolum). Transformed cells, which were selected for resistance to tetracycline, contain the complete genome of the donor and totally lack detectable genomic sequences of the recipient strain; they are phenotypically identical to those of the donor according to several criteria[9].

Strategies to combat the problem of resistance

The problem of resistance to antimicrobials is so serious, particularly in nosocomially acquired infections, that strategies are being designed to prevent their emergence. The Centers for Disease Control and Prevention (CDC) of the United States has designed a strategy that includes four major axes: prevention of infections, diagnosis and effective treatment of infections, fair use of antimicrobials, and prevention of transmission and containment of resistant cases. The Society of Surgical Infections (SIS) has published, in collaboration with the CDC, a document detailing the points of each of these significant axes of prevention of antimicrobial resistance[19].

For many decades, the first line of defense against bacterial resistance has been the development of new antimicrobials. However, it is not likely that new substances will be available for many years that can be used against microorganisms resistant to previous therapies; any new antibiotic that emerges is destined for a short life if the guidelines are not respected. The misuse or abuse of new broad-spectrum antimicrobials has accelerated the problem. It is clear that antimicrobial employment must be improved to deal with multi-resistant micro-organisms, both nosocomial and community.

To reduce the problem of antimicrobial resistance, clinicians should concentrate their efforts not only on avoiding the misuse or overuse of antimicrobials but also on additional factors that contribute to resistance, such as hand washing and other measures of controlling infections. However, all people involved in the use of antimicrobials must participate. Regulatory commissions, infectious disease specialists, community doctors, and veterinarians must unite to promote the correct use of antimicrobials. Without aggressive action, we may face a public health crisis and return to the pre-antibiotic era.

Unfortunately, with the data currently available, it cannot be assured that the limitation in the use of antimicrobials will reverse the current trend toward resistance, or even stop the evolution of the bacteria into new types of resistance.

What is clear is that coordinated studies are needed in different parts of the world that use the same methodology, for better monitoring of the process of development or resistance reversal, depending on time, which will facilitate the making of correct decisions.

About the author

Nuria García-Fernández is the Research Manager at the Dairy Knowledge Center, LLC. She holds a DVM and a PhD in Biological Sciences (specialization in Dairy Manufacturing) and has extensive experience with veterinary diagnostics and antimicrobial susceptibility testing. She has conducted research studies on molecular diagnostics, antimicrobial resistance genes, and the use of enzymes in cleaning biofilms on dairy separation membranes. Nuria@dairykc.com

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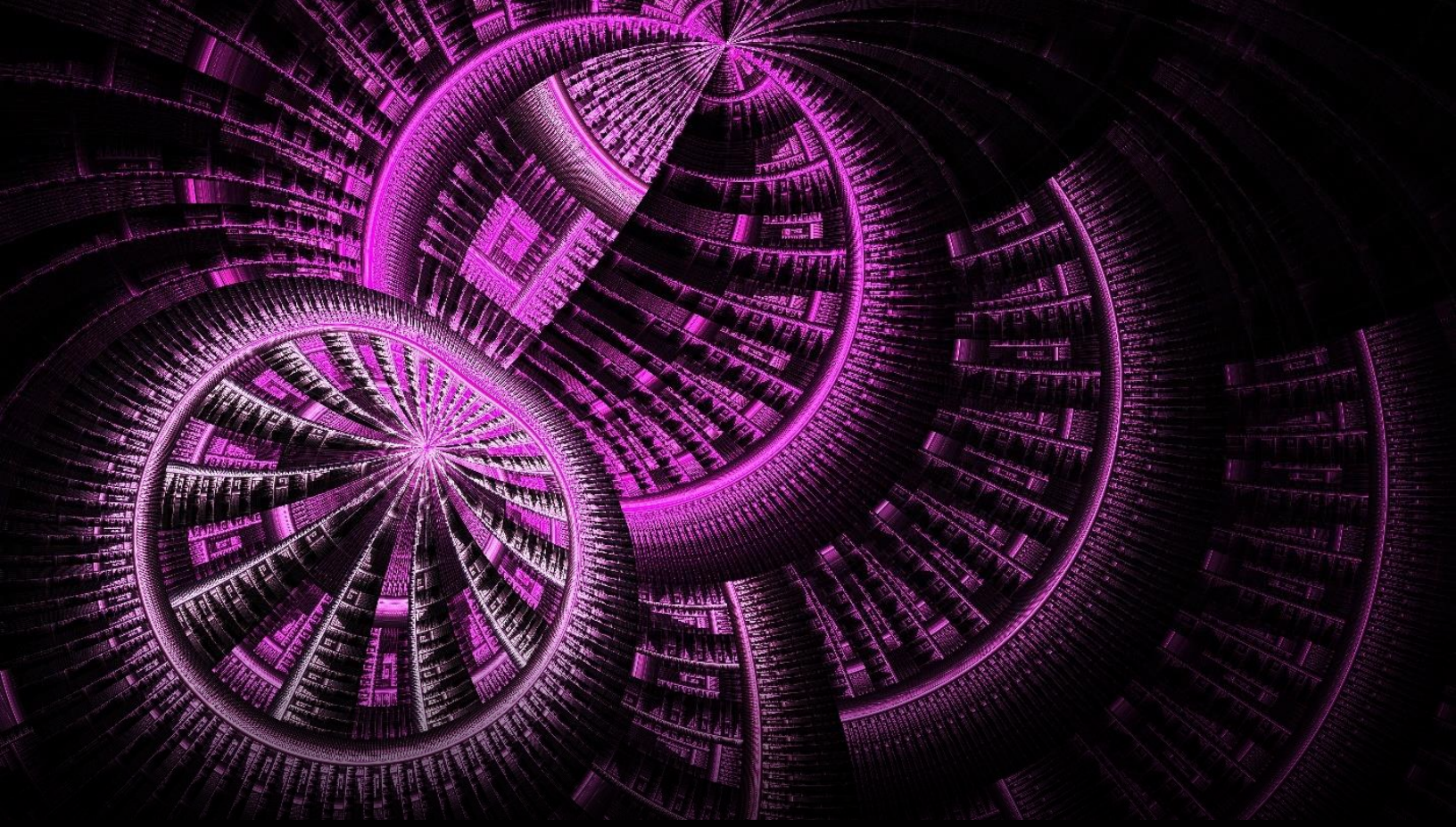

Reducing nitrogen contamination

by feeding protected proteins

Reducing nitrogen contamination by feeding protected proteins

Fernando Diaz

Introduction

The most recent nitrogenous formulation systems for dairy cows are based on the concepts of digestible protein in the intestine[11] and the contribution of amino acids to the small intestine of ruminants[19,23,17]. The interest in improving the precision of the protein formulation in these animals has depended not only on the need to continue improving production and reducing costs but also, in recent times, on the need to reduce the environmental impact of the excessive amount of nitrogen in diets[3,23,27].

The contributions of protein or amino acids to the small intestine of dairy cattle correspond in all systems to the sum of the microbial protein synthesized in the rumen, the feed protein not degraded in it, and the endogenous protein[6]. The complexity of the factors that affect the flow of each of these fractions makes it very difficult to predict the quantity and profile of the amino acids that flow into the small intestine of the ruminant[13], as unlike the monogastric, the amino acid composition of the protein available to the animal depends on the nature of the protein that leaves the rumen and not on that which the animal digests[10].

Environmental pollution from nitrogen in animal production systems

One of the main environmental problems is the emission of nitrogen (N) into the environment[8]. Nitrogen is a chemical element that cannot be produced or destroyed by animal metabolism and only molecules that contain it can be transformed[21]. Most of the N that animals consume is excreted, at which point it becomes a necessary nutrient for plant growth. However, the main problem during this N cycle is that high N losses contribute to the degradation of the environment[22]. The highest N losses that occur in intensive animal production systems are the result of the emission of gases into the atmosphere and the runoff of nitrates (NO_3^-) to surface water and groundwater. The main atmospheric pollutants that originate in animal production systems are detailed below[18]:

- ✓ **Ammonia (NH_3):** The urea present in animals' urine is hydrolyzed to NH_3 and carbon dioxide, facilitated by the urease enzymes found in feces. Once it has been emitted, NH_3 can be rapidly converted to the ammonium ion (NH_4^+). NH_4^+ contributes to the eutrophication, acidification, and fertilization of ecosystems. Forty-eight percent of NH_3 emissions into the environment comes from production animals.
- ✓ **Nitrous Oxide (N2O):** N2O is formed and emitted into the atmosphere through the microbial processes of nitrification and de-nitrification occurring in the soil. This gas warms the troposphere and results in the loss of ozone in the stratosphere. One-third of the amount of this pollutant comes from animal farms.
- ✓ **Nitric Oxide (NO):** NO and nitrogen dioxide (NO2) are rapidly released into the atmosphere and are therefore referred to as NOX. Emissions of this gas from animals and their excreta are very low, representing 1% of total emissions.

Degradation of the protein in the rumen

The degradation of dietary protein in the rumen is a complex process that involves many microorganisms, which provide the necessary enzymes to hydrolyze the peptide bonds that generate peptides and aminoacids[30]. These products of ruminal degradation are transported within the microbial cells and follow the following metabolic pathways[2]:

- ✓ Peptidases degrade the peptides into amino acids.
- ✓ According to the energy (in the form of carbohydrates) available in the microbial cell, the amino acids can be used in the synthesis of MP or can be deamidated, producing NH_3 and carbon skeletons, which are fermented into volatile fatty acids and CO_2.

Protein degradation in the stomach compartments of ruminants depends on several factors, some of which are related to diets, while others are connected to the animal[26]. The main factors that affect the amount of protein degraded in the rumen are: the proportional content of protein and non-protein nitrogen, the physical and chemical properties of the proteins, the retention time of the protein in the rumen, the microbial proteolytic activity, and the ruminal pH[24]. Among all these factors, differences in the three-dimensional structure of proteins constitute the most crucial factor determining the extent and degree of protein degradation because these differences affect microbial access to these proteins[17].

The rumen degradation of the protein normally causes a loss of net protein because the MP is composed of 15-20% nucleic acids, which are not available for livestock metabolism[27]. Moreover, the constitutive murein of the cell walls of bacteria contains a high proportion of amino-sugars (N-acetyl glucosamine and N-acetyl muramic acid) that also cannot be used in animal protein metabolism.

The RDP provides a mixture of peptides, free amino acids, and NH_3 for microbial growth and MP synthesis[17]. The microbial protein represents most of the protein that leaves the rumen (55-87% of the total amino acid nitrogen, according to Clark[6]), being, also, of outstanding quality. However, generally, this is not enough to provide the total amount of amino acids that high-production animals require. Thus, as production increases, the partial contribution of the microbial protein to the total amount of amino acids contributed to the intestine will decrease, which means the amount of feed protein that arrives without degrading the intestine must increase to cover the needs[17]. In high-producing dairy cows (45 kg milk/day), the maximum contribution of MP is limited to 63% of the total amino acid supply[6].

Protected protein

When RDP exceeds microbial needs, large amounts of ammonium are produced in the rumen, absorbed into the blood, converted to urea in the liver, and excreted in the urine. Rumen protected proteins are protein-containing feeds that have been treated or processed in ways that decrease ruminal protein degradability and increase the content of digestible rumen undegradable protein (RUP)[17]. Many methods have been investigated to decrease ruminal fermentation of protein concentrates; most of these methods are based on the application of heat, chemical agents, or a combination of both that alter the characteristics of the protein and increase its resistance to proteolytic enzymes[5].

Heat causes the denaturation of the proteins, consisting of the alteration of its three-dimensional structure, without rupture of peptide bonds. This entails a reduction of its solubility and accessibility with a consequent decrease in its degradation in the rumen[4]. The formation of bonds between the aldehyde groups of sugars and the free amino groups of the protein intervenes in this reduction. However, if the heating is excessive Maillard reactions or non-enzymatic browning that involve the degradation of sugars to phenolic compounds, the condensation of these with the amino acids and their subsequent polymerization[28], being the compounds resulting indigestible.

Therefore, the primary challenge is to identify treatment conditions that increase the digestible non-degradable protein to a degree that justifies the cost of the treatment and that result in a minimum loss in the availability of amino acids[17]. The conditions of time, humidity, and temperature that will provide optimum protection are variable depending on the supplement to be protected. However, the effect of moderate heat treatments on protein degradation has not been consistent. Thus, Tagari et al.[25], heating soybean meal to 140°C or more, reduced the release of ammonia *in vitro*, while heating to 120°C produced no effects. Similarly, Mir et al.[16] showed that heating at 110 or 120°C for 120 or 20 minutes, respectively, reduced *in situ* ruminal degradations of rapeseed meal but not soybean meal.

The combined treatments of vegetable protein concentrates have yielded positive results. Wright et al.[32] did not observe differences in the ruminal degradation of untreated or heat-treated rapeseed meal protein at a temperature of 100°C for 120 minutes. However, when 5% lignosulfonate was added the heating treatment, ruminal degradation was drastically reduced from 71.5% to 29.9%. Also, lactating cows that were fed heat-treated rapeseed and lignosulfonate excreted less N in their urine (as a proportion of N consumed) and had lower concentrations of ruminal NH_3 and blood urea in milk than cows fed the untreated rapeseed meal.

In the past, many chemical treatments have been used with the aim of decreasing the degradability of proteins. However, European Union directives have banned some products, such as formaldehyde. The primary objective of the treatment of proteins with chemical agents is to create a reversible modification in them depending on the pH, which allows for the inhibition of their degradation in the rumen-reticulum compartment (where the pH is close to neutral or moderately acidic) but not in the abomasum and the proximal duodenum where the pH is much lower[26].

The acid treatment denatures the proteins[31], being able to be the organic and inorganic acids. Initially, studies to reduce the degradability of protein concentrates were carried out with organic monocarboxylic acids (formic, acetic, propionic, etc.[29,12,15]), the protection obtained being limited and, in some cases, not permanent, given the volatile nature of some of these acids. However, in recent times, there has been a significant amount of interest in using di- or tricarboxylic acids as an alternative to growth-promoting antibiotics in ruminants, with malic acid being the most-used among them. The main advantage of the use of malic acid in the treatment of proteins is its high solubility in water, while its main drawbacks are its high cost and high corrosion power.

Within inorganic acids, only orthophosphoric acid is authorized for use in ruminant feed, as the use of hydrochloric and sulfuric acids is allowed only in silages. Orthophosphoric acid is pure liquid, corrosive, and palatable at a low dose; moreover, it produces little odor and is more economical than organic acids[14]. These characteristics make it a potential protective agent. A combination of heat treatment and the use of acids could enable the reaching of higher levels of protection than could the use of each method separately; it could also present economic advantages due to the decrease in the energy cost of the thermal treatment and the lower dose of acids needed, and present the least chance of generating irreversible Maillard reactions associated with protein overprotection[20].

Arroyo et al.[1] increased by 267% the RUP content of sunflower meal treated with a solution of malic acid or orthophosphoric acid combined with heating at 150°C for 6 h, regardless of the acid used. As a consequence of these changes, the effectiveness of intestinal digestibility of the protein of this concentrate increased by 11.8% (orthophosphoric acid) and by 20% (malic acid). Similarly, this author[7] increased the concentration of RUP by 150% in spring pea meal treated with malic acid or orthophosphoric acid and heat at 120°C for 1 h.

Applications

Applying protective treatments against ruminal fermentation in high-quality proteins is attractive as a means of avoiding their microbial degradation, which is usually associated with high ruminal ammonia losses and the reduced efficiency of microbial protein synthesis. The inefficiency associated with excessive ruminal protein degradation is important in high-producing cows, whose large amino acid requirements should be supplied mainly by protein concentrates. In particular, this inefficiency is significant for concentrates composed of highly degradable proteins such as soybean meal.

About the author

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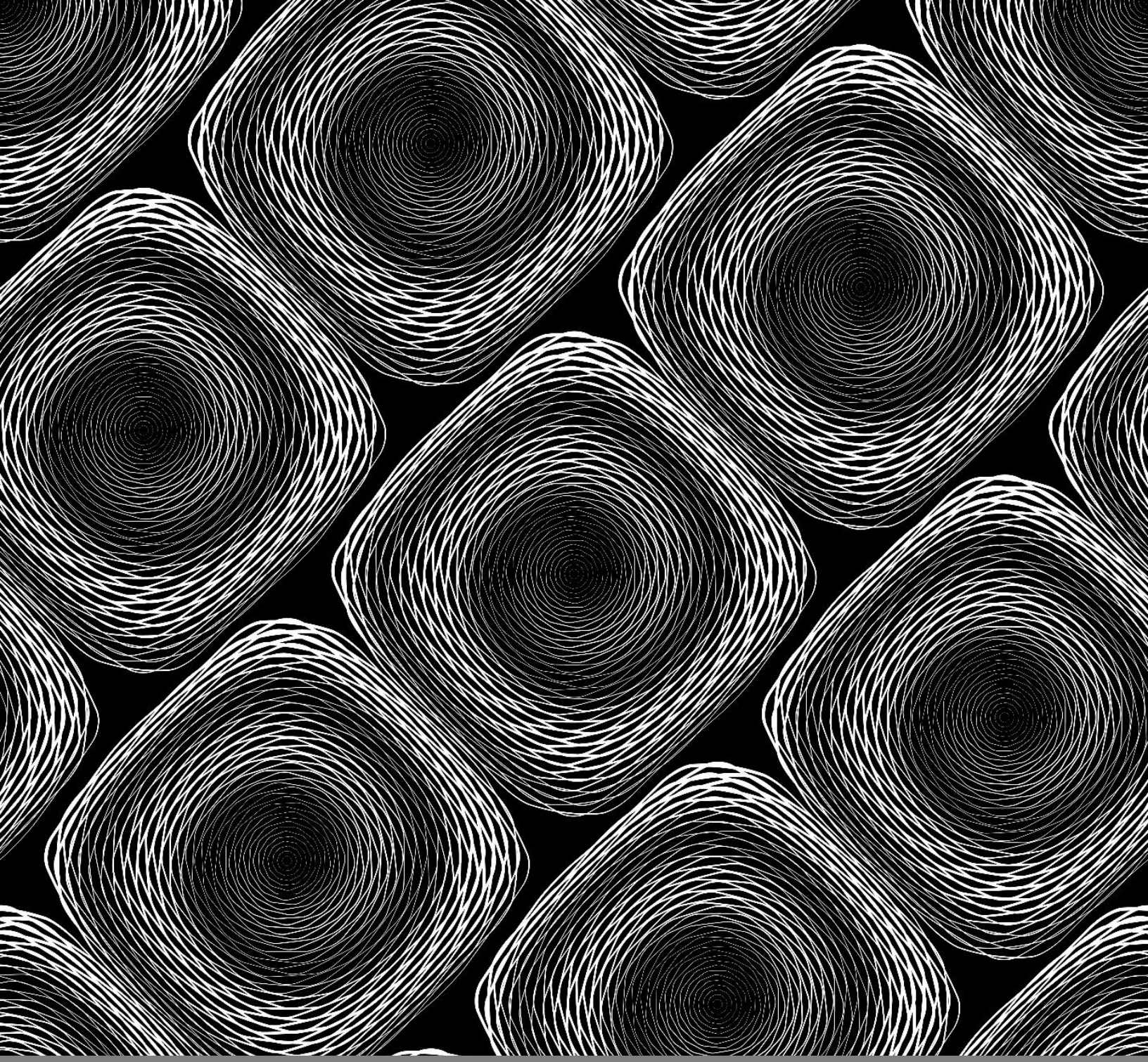

Feeding and balancing for dietary protein in heat-stressed dairy cows

Feeding and balancing for dietary protein in heat-stressed dairy cows

Jeff Kaufman

Introduction

Lactating cows at peak lactation can require up to 18% crude protein on a dry matter (DM) basis in their diet[8]. The protein portion of a diet accounts for the largest cost in a lactating cow's ration. Comparing plant-based protein ingredients (soybean or canola meal) to energy (corn) and forage (hay and silage) ingredients, protein costs can be from 2 to 10 times greater per ton. Rumen undegradable protein (RUP) can be even more expensive (e.g. blood meal can reach over $1,000/ton) but can be critical for providing adequate essential amino acids (lysine and methionine) to support lactation requirements.

High-protein diets and their costs

In a high-protein diet (18% on a DM basis) [typically 10% rumen degradable protein (RDP) and 8% RUP], the protein proportion can represent up to 20-30% of the total feed cost. Data derived from a previous study[5] indicates that the protein cost of a lactating cow's diet can be about $1.75/cow/day, which is 23.8% of the total diet cost (Table 1). When milk prices are low, high-protein diets are not cost-effective for dairy farmers, as they fail to provide significantly greater amounts of milk. For example, a 14.9% protein diet (DM basis) had sustained milk and milk component yields compared to a 17.5% crude protein diet (a yield of 38.4 versus 39.0 kg/day of milk, 3.68 versus 3.60% of milk fat, and 3.30 versus 3.28% of milk protein)[7]. Similarly, a 15% protein diet with a high-quality amino acid profile sustained milk and milk protein yields compared to an 18% crude protein diet with a low-quality amino acid profile[1]. A major problem with providing a high-crude-protein diet is when cows are experiencing high environmental temperatures and humidity. In these circumstances, high-producing dairy cows become less efficient at using dietary protein for production, which worsens the cost-effectiveness of high dietary protein.

Table 1. Economic evaluation of diet with different protein levels

	Diets			
	8% RUP		6% RUP	
	10% RDP	8% RDP	10% RDP	8% RDP
Milk Yield (lbs.)	82.7	76.9	69.4	76.1
Income ($/cow/day) @ $15/cwt	12.4	11.5	10.4	11.42
Total Feed Cost ($/cow/day)	7.35	6.94	6.86	6.70
Crude Protein Cost ($/cow/day)	1.75	1.48	1.46	1.21
Crude Protein Cost Over Total Cost (%)	23.8	21.3	21.3	18.1
Income Over Feed Cost ($/cow/day)	5.05	4.59	3.55	4.71
Milk Income Used for Feed Cost (%)	59.3	60.2	65.9	58.7

Source: Kaufman et al.[5]

Consideration for heat-stressed cows

Environmental impact from dairy cows is a major issue facing the dairy industry. Heat stress increases the loss of nitrogen through urine and feces coming from protein fed to dairy cows[4]. Urinary nitrogen excretion increased by 41% when lactating cows were exposed to 28°C and 60% humidity[3]. Nitrogen excretion contributes to groundwater and air pollution. Fecal nitrogen in manure is more stable, whereas urine nitrogen is present as urea that easily pollutes water sources and the air[2]. Therefore, lowering the increased urinary excretion of nitrogen resulting from heat stress will be important for ensuring sustainable dairy farming and improving public perceptions. To optimize protein and nitrogen efficiency in dairy cows, strategies for protein nutrition are necessary for heat-stressed dairy cows.

Focusing on milk production from heat-stressed cows

Heat stress decreases the productive ability of lactating cows, which may result from reduced protein nutrition. Milk yields decreased by up to 28% or 9.6 kg/day when temperatures increased from 29 to 39°C[11]. Similarly, milk components such as milk protein decreased ranging from 4.8 to 9.6% when cows did not have mitigation from heat stress[9,11]. When dietary protein is excreted as nitrogen in the urine and feces, less nitrogen is utilized for milk production. For example, in the previously mentioned

study, in which nitrogen excretion increased during heat stress[3], milk protein content fell by 9%. The goal would be to optimize protein utilization in heat-stressed cows to improve lactation performance. In fact, my research focused on providing strategies to improve milk production and protein metabolism in heat-stressed dairy cows.

Lowering dietary protein to improve components

A study was conducted at the East Tennessee AgResearch and Education Center at the University of Tennessee to observe the effects of comparing a mixture of 2 levels of RDP (10% and 8% on DM basis) and 2 levels of RUP (8% and 6%) on milk performance and nitrogen-use efficiency[5]. The trial evaluated mid-lactation cows (126 days in milk) housed in a free-stall barn experiencing up to 29.2°C and 58% humidity. Those combinations of RDP and RUP equaled 4 treatments of 10% RDP:8% RUP (18% protein), 8% RDP:8% RUP (16% protein), 10% RDP:6% RUP (16% protein), and 8% RDP:6% RUP (14% protein). A diet balanced with 8% RDP and 6% RUP, as a 14% crude protein diet, showed the most beneficial results in regard to milk production and nitrogen use combined (Table 2). Energy-corrected milk yield production was similar (34.8 vs. 35.0 kg/day) in the 14% and the 18% protein diet. However, milk fat and protein content increased from 2.75 to 3.17% and from 2.90 to 2.98%, respectively, when dietary RDP and RUP were reduced (18 vs. 14% protein diet). This study had low milk fat levels mainly due to the impact of heat stress on cows. Increased milk components and sustained milk production may be attributed to an increment in nitrogen-use efficiency and a reduction in urinary nitrogen excretion. Nitrogen use efficiency increased from 31.6 to 37.8% and urinary nitrogen excretion decreased by 54% when both RDP and RUP were reduced. This data demonstrates that not only can milk production be sustained and components improved but that this will decrease feed costs during heat stress. Table 1 shows the income over feed costs (IOFC) ratio from this study, providing the lowered RDP and RUP diets. The 14% crude protein diet had the highest income over feed cost (IOFC), the lowest percentage of milk income going to feed costs, and a marginal difference in milk yield compared to the high crude protein diet. In summary, the 14% crude protein diet had a greater IOFC ratio, improved milk components, and decreased nitrogen excretion from urine.

Table 2. Diet composition and performance of heat stressed cows

	Diets			
	8% RUP		6% RUP	
	10% RDP	8% RDP	10% RDP	8% RDP
Ingredients (%)				
Corn Silage	45.0	45.0	45.0	45.0
Wheat Silage	1.50	1.50	1.50	1.50
Clover Hay	3.50	3.50	3.50	3.50
Concentrate	50.0	50.0	50.0	50.0
Composition (%)				
Crude Protein	17.6	15.9	15.6	13.8
Rumen Degradable Protein	9.80	7.80	9.70	7.80
Rumen Undegradable Protein	7.80	8.10	5.90	6.00
Production				
ECM (kg/day)	35.0	33.8	32.0	34.8
True Protein (%)	2.90	2.88	3.17	2.98
Fat (%)	2.75	2.95	3.14	3.17
MUN (mg/dL)	11.7	7.98	9.17	5.46
Nitrogen				
Use Efficiency (%)	31.6	32.8	32.4	37.8
Urinary Excretion (g/day)	214	143	162	98.2

Source: Kaufman et al.[5]

Lowering dietary protein to improve utilization of amino acids

Heat-stressed cows have a negative energy balance that changes the animal's normal state of maintenance, especially during lactation. Cows increase the breakdown of muscle tissue to provide protein and amino acids for energy purposes. For example, cows exposed to 28°C and 60% humidity showed a 96% increase in a blood marker for muscle breakdown (3-methylhistidine)[4]. As a result, fewer amino acids and less nitrogen are available for milk protein production. My research, explained in the previous section, confirmed that lowering RDP and RUP to a 14% crude protein diet increased the use of fat instead of protein for energy needs in heat-stressed cows[6]. This allows the body's natural energy stores to be used for energy instead of protein and amino acids, which are used for productive reasons (muscle growth and milk production). This work showed that lowering RDP and RUP (18% to 14% protein diet) increased blood levels of fatty acids, which demonstrates a nutritional drive that supports increased energy needs by breaking down fat (Table 3).

Likewise, more protein and amino acids were being used to support milk protein as demonstrated by the 27% increase in milk protein yield efficiency (the amount of absorbed amino acids from the diet making milk protein). This is evident from the existence of greater blood concentrations of essential amino acids used for milk protein synthesis (lysine and methionine) from low RDP and RUP diets compared to the 10% RDP and 8% RUP diet. For cows experiencing hot temperatures and high humidity, a lower crude protein diet with an equal or greater RDP and RUP ratio of 50:50 that equals between 14 and 16% crude protein should not only benefit milk component production and efficient use of dietary protein but also lead to a reduction in feed cost.

Table 3. Energy and protein metabolism of cows fed diets with different protein levels.

	Diets			
	8% RUP		6% RUP	
	10% RDP	8% RDP	10% RDP	8% RDP
Item				
Energy Balance (Mcal/day)	-2.08	-5.12	-2.23	-4.29
Milk Protein Yield Efficiency* (%)	45.3	44.2	50.8	57.3
Insulin (μU/mL)	22.8	19.8	19.7	12.0
Fatty Acids (μEq/L)	123	199	206	175
Essential Amino Acids (μM)	907	1,296	1,245	1,110

*Milk protein yield efficiency = milk protein yield / metabolizable protein supply.
Source: Kaufman et al.[6]

Applications:

- ✓ Provide sufficient dietary energy: Energy is needed to support the healthy microbial breakdown of RDP, especially for heat-stressed cows.
- ✓ Quality and degradability of protein matters: Determining the digestibility and the amino acid profile present in the feed ingredients will dictate availability and use in the animal. A high-quality ingredient will make a big difference. In addition, sources of RDP can provide RUP in sufficient amounts (canola meal).
- ✓ Optimize RDP use: This protein fraction must be provided to optimize the production of microbial protein from the rumen without oversupplying nitrogen that will be excreted as urea through urine and feces.

- ✓ Evaluate and balance RUP: Knowing the amino acid profile of the feed ingredient is important so that specific amino acid requirements other than protein requirements can be met. Research has been summarized to suggest the ideal essential amino acid requirements[10].
- ✓ Balance with mixture of protein ingredients: To better meet amino acid requirements, mixing various protein ingredients will better supply limiting amino acids throughout the diet.
- ✓ Stage of lactation, parity, and production: Lactation requirements from late to early lactation, multi- to primiparous, and low to high producer cows in heat stress may affect the need to increase protein closer to 16% crude protein.
    - Component focus during heat stress: Heat stress makes it difficult to increase milk yield without causing other health effects. However, increased components are manageable with proper dietary protein management.
    - Think about the future: Dietary protein is an easily managed nutrient in the diet that can largely reduce environmental pollution and help improve public perception.

About the author

Jeff Kaufman is a Graduate Research Assistant at the University of Tennessee pursuing a Ph.D. in Dairy Cow Nutrition. His research focuses on protein and amino acid metabolism, production efficiency, and heat stress. He has published four articles from previous research and is currently working on his Ph.D. dissertation titled "Nutritional Strategies to Improve Production and Nitrogen Efficiency in Lactating Dairy Cows". He has presented most of his research at international meetings. kaufma8@vols.utk.edu

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Mastitis treatment in dairy farms

Mastitis treatment in dairy farms

Nuria García-Fernández

Introduction

According to "Dairy 2014 Report 3: Health and Management Practices on U.S. Dairy Operations, 2014"[9], the percentage of cows treated with antibiotics for mastitis, respiratory diseases, diarrhea or other digestive problems, reproductive disorders, mastitis, lameness, or other disease was 22.0, 2.6, 1.1, 7.7, 3.6, and 0.5%, respectively. The Dairy 2014 study was conducted in 17 of the nation's major dairy states, representing 80.5% of U.S. dairy operations and 81.3% of U.S. dairy cows. Data from this report were collected during 2014 by state and federal veterinary medical officers and animal health technicians from 265 operations with 30 or more dairy cows. Mastitis was the disease that affected the highest percentage of cows (25.7%). Not surprisingly, the highest percentage of cows were treated for mastitis (22.0%).

The percentage of cows treated with antibiotics for mastitis increased significantly from the two previous surveys. In 2002[6], the percentage of cows treated with antibiotics for mastitis, respiratory diseases, diarrhea or other digestive problems, reproductive disorders, mastitis, lameness, or other disease was 15.0, 2.2, 2.0, 4.9, 7.0, and 0.2%, respectively. Similarly, in 2007[7], 2.8% of cows were treated with antibiotics for respiratory diseases, 16.4% for mastitis, 1.9% for diarrhea or other digestive problems, 7.4% for reproductive disorders, 7.1% for lameness, and 0.5% for other diseases.

Antibiotics approved for mastitis treatments

In the United States, no antimicrobials are approved for systemic treatment of mastitis, and only a few antimicrobial drugs are labeled for intramammary treatment of mastitis[11]. Table 1 shows the antibiotics that the FDA has approved for treatment of mastitis in lactating dairy cows. While several products have been withdrawn from the U.S. market, no new antimicrobials have been approved for mastitis therapy since 2006[12]. Various types of drug use are permitted on dairy farms:

- Over-the-counter (OTC) drugs may be used only under the exact label specifications and doses.

- Prescription products (Rx) cannot be purchased without a veterinary prescription. This type of use requires that the product be used exactly as the label specifies. If the product is used outside the label specification, a veterinary label for extralabel use is required. Extralabel use refers to any use of a drug that is not specifically listed on the drug label and that is legal only under the guidance of a local veterinarian who meets the criteria defined for a valid veterinary-client-patient relationship.

Table 1. Antibiotics approved by the FDA for treatment of mastitis in lactating dairy cows

Trade Name	Active Ingredient	Antibiotic Class	Species	Route	Spectrum	Withhold	RX
Albacillin suspension special formula 17900-Forte Suspension	Novobiocin sodium, penicillin G (procaine)	Penicillin G-related penicillins (B-lactams)	Dairy, all classes	IMM	S. aureus, S. agalactiae, S. dysgalactiae, and S. uberis	72h/15d	OTC
Albamast Suspension	Novobiocin sodium	Penicillin G-related penicillins (B-lactams)	Dairy, all classes	IMM	S. aureus	72h/15d	RX
Amoxi-mast	Amoxicillin trihydrate	Penicillins (B-Lactams), amino derivatives	Dairy, all classes	IMM	Penicillin sensitive S. aureus,	60h/12d	RX
Cefa-Lak, Today	Cephapirin sodium	Cephalosporin, 1st generation	Dairy, all classes	IMM	S. agalactiae and S. aureus including strains resistant to penicillin	96h/4d	OTC
Dariclox	Cloxacillin sodium	Penicillinase-resistant penicillins (B-lactams)	Dairy, all classes	IMM	S. agalactiae and S. aureus	48h/10d	RX
Erythromast 36	Erythromycin	Macrolides	Dairy, all classes	IMM	S. aureus, S. agalactiae, S. dysgalactiae, and S. uberis	36h/0d	OTC
Formula A-34 Uni-biotic 4 dose	Penicillin G procaine	Penicillin G-related penicillins (B-lactams)	Dairy, all classes	IMM	S. agalactiae,S. dysgalactiae, S. uberis	60h/3d	OTC
Gallimycin-36 sterile	Erythromycin	Macrolides	Dairy, all classes	IMM	S. aureus, S. agalactiae, S. dysgalactiae, and S. uberis	36h/14d	OTC
Hetacin K	Hetacillin Potassium	Penicillins (B-Lactams), amino derivatives	Dairy, all classes	IMM	S. agalactiae, S. dysgalactiae, S. aureus, and E. coli	72h/10d	RX
Masti-clear	Penicillin G procaine	Penicillin G-related penicillins (B-lactams)	Dairy, all classes	IMM	S. agalactiae,	Dependent on dose/4d	OTC
Pirsue Sterile Solution	Pirlimycin hydrochloride	Macrolides	Dairy, all classes	IMM	Staph spp. and Strep spp.	36h/9d/21d	RX
Spectramast LC	Ceftiofur hydrochloride	Cephalosporin, 3rd generation	Dairy, all classes	IMM	CNS Staph, S. dysgalactiae, E.coli	72h/2d	RX

Abbreviations: IMM: intramammary, OTC: over the counter, RX: prescription drug.
Source: Food Animal Residue Avoidance Databank (2018)

According to the results of the Dairy 2014 Report 3[9], the primary antibiotics used to treat mastitis were third-generation cephalosporins, lincosamide, and first-generation cephalosporins (50.5, 24.6, and 15.1% of treated cows, respectively; Table 2).

Table 2. Percentage of cows by primary antibiotic used for mastitis treatment

Primary Antibiotic Used	% Treated Cows
Third-Generation Cephalosporins	50.5
Lincosamide	24.6
First-Generation Cephalosporins	15.1
Penicilins	8.7
Tetracycline	0.2
Sulfonamide	0.2
Other	0.7

Source: National Animal Health Monitoring System, 2018. Dairy 2014 Report 3: "Health and Management Practices on U.S. Dairy Operations, 2014".

The treatment of clinical mastitis occurring in 51 large dairy herds in Wisconsin was recently evaluated[12]. The distributed clinical mastitis treatments in 589 cows were:

- **Ceftiofur** (Intramammary, 74.9%)
- **Hetacillin** (Intramammary, 19.7%)
- **Cephapirin** (Intramammary, 13.7%)
- **Amoxicillin** (Intramammary, 4.8%)
- **Sulfadimethoxine** (Systemic, 3.7%)
- **Pirlimycin** (Intramammary, 2.7%)

The use of intramammary antibiotics at dry-off is common in U.S. dairy herds. Administering intramammary antibiotics at the time of dry-off cures many existing infections and reduces the incidence of new infections. Table 3 shows the antibiotics that the FDA has approved for the treatment of dry cows. "Dairy 2014 Report 2: Milk Quality, Milking Procedures, and Mastitis on U.S. Dairies, 2014"[8] indicated that almost 1 of 10 operations (9.2%) did not use a dry-cow treatment; a percentage of these were organic operations in which the use of antibiotics is not allowed. These results align with those of another study conducted in 51 large dairy herds in Wisconsin, in which only 8% of farms did not use any form of dry cow therapy[17].

Table 3. Antibiotics approved by the FDA for treatment of mastitis in dry cows

Trade Name	Active Ingredient	Antibiotic Class	Species	Route	Spectrum	Withhold	RX
Quartermaster	Dihydrostreptomycin sulfate/ penicillin G procaine	Aminoglycosides/ Penicillin G-related	Dairy, dry	IMM	S. aureus	96h postcalving/ 60 days	RX
Dry Clox	Cloxacillin benzathiene	Penicillinase-resistant penicillins (B-lactams)	Dairy, dry	IMM	S. aureus and Strep agalactiae	30 days	RX
Boviclox	Cloxacillin benzathiene	Penicillinase-resistant penicillins (B-lactams)	Dairy, dry	IMM	S. aureus and S. agalactiae	72h post calving, 30d	RX
Orbenin DC	Cloxacillin benzathine	Penicillinase-resistant penicillins (B-lactams)	Dairy, dry	IMM	S. agalactiae and S. aureus	28d	RX
Dry-mast	Dihydrostreptomycin sulfate, penicillin G (procaine)	Aminoglycosides/ Penicillin G-related	Dairy, dry	IMM	S. aureus and S. agalactiae	24h postcalving/	OTC
Albadry Plus	Novobiocin sodium, penicillin G procaine	Antibacterial (other)/penicillin G-related	Dairy, dry	IMM	S. aureus and S. agalactiae	72h postcalving/ 30d	OTC
Go-dry	Penicillin G procaine	Penicillin G-related penicillins (B-lactams)	Dairy, dry	IMM	S. agalactiae, S. dysgalactiae, S. uberis	72h post-calving/14d	OTC
Formula A-34 Uni-biotic 4 dose	Penicillin G procaine	Penicillin G-related penicillins (B-lactams)	Dairy, dry	IMM	S. agalactiae, S. dysgalactiae, S. uberis	72h/14d	OTC
Biodry Suspension, Drygard suspension	Novobiocin sodium	Penicillin G-related penicillins (B-lactams)	Dairy, dry	IMM	S. aureus and S. agalactiae	30 days	OTC
Cefa-dri, Tomorrow	Cephapirin benzathine	Cephalosporin, 1st generation	Dairy, dry	IMM	S. agalactiae and S. aureus including penicillin-resistant strains	72h postcalving/ 42D	OTC
Spectramast DC	Ceftiofur hydrochloride	Cephalosporin, 3rd generation	Dairy, dry	IMM	S. aureus, S. dysgalactiae, and S. uberis	16d	RX
Erythro-36 Dry, Gallimycin-36 Dry	Erythromycin	Macrolides	Dairy, dry	IMM	S. aureus, S. agalactiae, S. dysgalactiae, and S. uberis	36h/14d	OTC

Abbreviations: IMM: intramammary, OTC: over the counter, RX: prescription drug.
Source: Food Animal Residue Avoidance Databank (2016)

"Dairy 2014 Report 2"[8] indicated that almost all cows (93.0%) were treated with dry-cow intramammary antimicrobials at dry-off. A higher percentage of cows in large operations (96.4%) were treated at dry-off compared to the percentage of cows in small or medium operations (81.9 and 82.6%, respectively). The most commonly used dry-cow antibiotics were penicillin G (procaine)/dihydrostreptomycin (36.9% of cows) and cephapirin (31.0% of cows; Table 4).

Table 4. For cows treated with dry-cow intramammary antibiotics, percentage of cows treated, by type of antibiotic

Antibiotic	Percent of cows*
Cephapirin benzathine	31.5
Penicillin G procaine/Dihydrostreptomycin	23.8
Ceftiofur hydrochloride	22.3
Penicillin G (procaine)/Novobiocin	11.6
Doxacillin benzathine	9.1
Penicillin G procaine	0.7
Other	0.9

* As a percentage of cows dry treated. Some cows were treated with more than one antibiotic.
- Source: NAHMS 2014

On-farm culture

On-farm culture can help reduce the administration of antibiotics, which may have several benefits, including preventing the unnecessary discarding of milk while waiting for laboratory results, decreasing the potential for drug residue in milk, and improving treatment outcomes as a result of targeted treatments[10]. It has been stated that, in between 10 and 40% of cases, cultures from clinical mastitis yield no bacterial growth and therefore do not require antimicrobial therapy[16]. In a recent study of 20 dairies in Wisconsin, 80% of all antimicrobials used were for the treatment or prevention of mastitis, and 50% for clinical mastitis[15]. Taking into account the mentioned study, with 50% of all antimicrobial drugs used in dairy farms dedicated to clinical mastitis treatment, the selective treatment of clinical mastitis based on on-farm culture results can potentially reduce the total antimicrobial use on dairy farms by 25%. Lago et al.[4] conducted a multi-state, multi-herd clinical trial on 422 cows from Minnesota,

Wisconsin, and Ontario, Canada, and observed that the treatment of clinical mastitis with intramammary antibiotics could be reduced by half without significant differences in days to clinical cure by using on-farm culture systems to guide strategic treatment decisions in cows with clinical mastitis. In addition, a recent study conducted by University of Minnesota researchers reduced antibiotic use in dry cows by 48% through the use of a selective dry cow therapy at the quarter level based on culture results[13].

There is increased awareness of treatment-related costs and the economic costs of extensive antibacterial therapy for mastitis. Treatment of only Gram-positive infections after the use of on-farm culture can result in significant cost reductions. A study that enrolled 189 cases of mild to moderate mastitis estimated that a net income of about $3,342 per month or about $18 per case can be obtained[15]. Lago et al.[4] published a review of antibiotic usage on dairy farms that included a collection of studies on the economic consequences of mastitis treatments, including milk production losses due to clinical and subclinical mastitis, mastitis-related infertility, the culling of costs, and the transmission of infection to other cows. This review presented a collection of recent studies conducted in the United States showing that the average treatment cost of a case of clinical mastitis ranges from between $50 to $212[1,14,17]. The direct costs associated with antibiotic treatment include extra labor (19%), the cost of antibiotics or other therapeutics (21%), and discarded milk (60%)[17]. Bar et al.[1] estimated that the average treatment cost of a case was $50, distributed as follows: discarded milk (40%), drugs (40%), and labor (20%). The number of days during which milk is discarded depends mainly on the treatment protocol and the withhold time of the product used for treatment. Pinzón-Sánchez et al.[14] estimated that the expected monetary value per case of mild or moderate clinical mastitis ranged from $25 (no intramammary antimicrobial) to $212 (eight-day extended treatment) per case, depending on the treatment strategy implemented. By using an on-farm culture system to strategically identify and treat clinical mastitis, Iowa State University researchers reduced the direct cost of clinical mastitis by 65%.

Furthermore, the typical milk discard period after a case of clinical mastitis (including treatment and withdrawal time) is about six days. If a 1,000-cow dairy herd experienced a 6% mastitis treatment rate per month, that herd would discard approximately 360 cow-days' worth of milk every month (60 cases at six days milk discard). At a 36/cow/day milk yield and $330/tn milk, the discarded milk would be valued at $4,320 per month or about $52,000 per year. In this scenario, each additional day of milk discard will create another $8,500 per year in discarded milk costs[18].

Application

The successful treatment of mastitis depends on early detection and proper diagnosis. On-farm culture methods are generally used to attain rapid access to results in situ that allow for an early mastitis diagnosis and facilitate the decision-making process with respect to mastitis treatment. On-farm culturing enables producers to obtain bacteriological results in just 24 hours. Because antibiotics do not cure many mastitis cases, withholding antibiotic treatment for 24 hours does not really affect treatment success rates. Cows that need treatment (those with Gram-positive infections) can be treated once the results are obtained. Cows with cases that will not respond to antibiotics (those with Gram-negative infections) may be monitored to ensure that they are systemically treated if the immune system is unable to fight the infection and the mastitis becomes toxic. However, cows that successfully fight off Gram-negative infections will not have been treated with antibiotics, meaning no treatment costs and no milk discard. In conclusion, selective treatment of clinical mastitis based on on-farm culture results can potentially reduce total antimicrobial use on dairy farms.

About the author

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It’s a match:

How to win the talent war

It's a match: How to win the talent war

Carolina Borrachia

Between love and rejection

"Unfortunately, you're not the one we're looking for but ... your CV will be saved for future searches!" To the candidate, this phrase means only one thing: rejection. The end of the opportunity. Empty hands. Rejection is the quintessential experience that an employer brand provides today. We have all been rejected by an employer brand. Therefore, the more interest a company shows in a candidate, the more it puts their ability to attract at risk. That's because today it's "all or nothing." You work with me or I reject you. Employer brands think about only talent, about the "talent war," about how to fill vacancies. They ask themselves: Is he/she the one? Yes or no? The opportunity stems from the way we connect with candidates. We must create win-win experiences that can resignify the rejection.

However, there are a lot of things between acceptance and rejection. The world isn't always black or white. It changes forms, experiences, circumstances. If, on a romantic date, a man makes me feel beautiful and intelligent, but for whatever reason we don't see each other again, at least I took away something good from that situation. The experience was not only about rejection.

With how many people do we experience attraction? The answer is, many more than we get to fall in love with. In most of those cases, one feels "we wouldn't work for X reason." Think of these people: most likely, despite the obvious attraction, there's no mutual choice, for a definite or shared reason, ranging from "he/she is gay" to "she/he is too structured." I am very aware of how complex it is to fall in love; more significant yet is the statistical improbability of this happening between two people. However, the only path to love is to try to get to know someone and to allow them to get to know me. If we won't work well together, it's better to know this as soon as possible. All the time that I invest in a person who isn't "it" for me is time that I'm not spending with someone who is.

I believe that the love of our life is a Match: a mutual choice. The problem with employer brands is that they don't show the candidate that the rejection is taking place on both sides. For example, the candidate couldn't survive the company's culture or handle the pace of work. A person who works in the selection process is always seeking compatibility. In the old paradigm, rejection is not mutual because the candidate isn't given the ability to realize why we aren't the company for him. Companies don't usually provide honest feedback when they don't hire a person. The closest thing to feedback is "we chose another candidate." And not only do companies not explain why someone wasn't chosen, they don't explain to the person who *was* chosen what led to that decision.

In the same way, those who are already employees suffer from a lack of communication. They don't necessarily know how they are seen. In many companies, people with high potential don't know that they maintain this status. Above all, we must break with the unidirectionality of communication. This is because companies, by engaging in one-way communication, are missing very interesting feedback – feedback that would improve the selection process, employees' relationships with their bosses, the employee value proposal and the benefits program.

In the old paradigm, the company acts unilaterally in the selection process. It alone decides. This paradigm is based on the notion that each CV is the equivalent of a Tinder profile; if I like a CV, I get a match. And then what happens? The candidate is invited to meet the company! Think about it! It's crazy! And so you lose a lot of time and money. It's a lose-lose because a candidate who doesn't choose me is a candidate I don't want. We must know each other first. We must choose each other.

It's a match! Why Tinder?

It's a Match! is the phrase that typifies Tinder, the app for finding a partner. Most likely, you already knew that. As I write this, Tinder has millions of active daily users and more than one billion profiles. Each day, 15 million matches are produced. What is Tinder doing in this book? Why is it so important? Because Tinder is a perfect example of the new paradigm. Tinder facilitates a connection between people in the shortest possible time. It allows us to very quickly dismiss those who, at first sight, don't interest us. It clears the panorama so that we can dedicate more energy to those who have some kind of mutual interest with us.

Tinder doesn't replace human contact; it increases your chances. It allows you to filter profiles of interest. It provides opportunities. You can engage in several conversations at the same time. Tinder generates contact between people who otherwise wouldn't cross paths and it avoids the feeling of rejection: Contact occurs only between those who like each other. Tinder's paradigm has changed the way we meet people either for a night of sex or to establish a lifelong love. In the old paradigm, dating portals embodied the promise of connecting with "the love of your life," requires those interested to invest a lot of time and to enter all kinds of information, "ensuring" a certain compatibility that could collapse upon the first in-person visual contact. By contrast, the Tinder paradigm is revolutionizing human relationships. Yet beyond any app, the mindset it represents hasn't yet affected the way companies and candidates are chosen. It's time to open ourselves up to that opportunity.

Would you fight a war with weapons from 1482?

I'm the one who writes now, but I'm also the one who paints pictures. I'm Ringo's mother, an activist who promotes awareness of the spread of Generalized Anxiety Disorder, a lover of flowers and much more. I am many and I am one. No one from my generation feels like "the engineer," nor does he/she want to be cut off from the rest of his/her life. That's water under the bridge. There are no more consumers, neither clients, nor candidates, nor graduates. There are people: Juanes, Cecilias, Lucios…

That's why we don't think about cutting ourselves off in a CV. We aren't a chronological compendium of work experiences predefined in a formula invented in 1482 (yes, yes, I don't want to bore you, but you know that the CV is the invention of another era; that's why it has a Latin name). The CV can never be a compendium of everything I am. No one from my generation is capable of being summarized on a single page. The CV is a technical description of oneself. It's a hard, dry, structured document. It's devoid of soft aspects. No one includes emoticons; no one shows feelings or mentions the other elements of his/her life.

A CV is simply a tool tailored to organizations that – logically – must continue fitting everyone into a single matrix so that they can compare and select. Note: I'm not questioning the CV itself. A round of applause for the CV. Few things have remained valid since 1482. The CV has been fantastic so far. It's perfect for that paradigm in which companies choose talent with omnipotence and discard the majority. However, it just so happens that those times have passed and the so-called "talent war" needs new solutions to new problems. Will we continue making our choices using only a CV?

Fear doesn't fight: it paralyzes!

In the war of talent, companies are paralyzed by fear. They think they lack a budget, but I think what they lack is courage. The formulas they find are within the old paradigm, and they aren't satisfactory. They don't mix the hard and soft elements. It's necessary to recognize and forget about fear. When someone has panic attacks, if they don't recognize them, they can't fight them. The same happens in this case. In companies, there is more fear than budget. Such companies are used to a certain way of seeing things. However, to win the talent war, it's crucial to think outside the box. The problem isn't so much understanding the new generations but how to use that information differently. It's like when you go to therapy for the first time and discover your story from another place. It can be very revealing.

As in therapy, clarifying our motivations, what makes us who we are, our fears and our history, allows us to understand. However, changing and growing requires much more than knowing and learning. It requires courage. Broadly and generally speaking, all companies are standing in this place. They feel that they are amid "a war" because they haven't yet managed to connect to the new generations, who experience another dynamic, another way of thinking. Opportunities appear when we pass without victimizing ourselves to be protagonists, when we take charge of our lives. In this case, for those who dare try new methods, the opportunities are significant. There will be perfect recipes in this book. I don't believe in them. Those who realize this and learn to manage themselves in the new world are those who not only stay with the best people but who attain the admiration of others. They are the ones who win the talent war.

The spermatozoid’s road

In the classic view, a company that seeks someone appeals to one-to-many communication. Put a notice in the newspaper or on an employment portal, and I, as the candidate, must find the notice in the correct medium and answer it. My CV thus starts a journey of improbable success. It must compete with dozens, hundreds or maybe thousands of other CVs. And, among those, surely one or two people will get the position. The CV takes the path of the sperm, running a blind marathon to reach the ovule.

Because the chances of my CV standing out are so remote, the temptation exists to increase my chances of success by any means possible. I want to improve my CV, ensure it makes an impact, change it so that it reflects what I think every company demands.

This requires an investment of time and energy that is rarely fruitful. Some job portals even charge (!!!) their candidates for this service. Another possibility is to use a photocopier to create a bunch of CVs and send them out indiscriminately. The reasoning is that sooner or later, if I persist, my document will reach the hands of someone with enough power to consider (my) merits and call me. There are all sorts of stratagems. There is an expectation of a game of appearances, which requires one to "make up" a CV so that it can compete with other (also made-up) CVs.

After all that, if my CV is chosen, the next step is to enter the selection process. I must overcome a series of barriers that each company has. These barriers can include several interviews with different people, psychological tests and aptitude tests. Many of these steps are standardized in different companies, and you can tell which kinds of things are useful to say (or not say). I'm aware that if I know this, those who are competing with me will probably know it too. Also, the chances are high that I would win over someone who was a better candidate than I was, but who wouldn't have been better at the work itself (!!!).

This is still valid. Although the market is highly segmented, the selection process remains as though each position is highly desirable and coveted by crowds of people. Everywhere, they suppose that I'm very interested in the company and that I must feel lucky that they are giving me a chance. If you go to the HR section of any bookstore, you will find many books that seem to be self-help in nature but whose objective is to act in complicity to disassociate the candidates to overcome the selection processes: how to answer typical interview questions, what body language to use to simulate authenticity, and even why Comic Sans is not the best choice for designing a CV. Do we really want to meet the candidates, or are we inciting them to manipulation? What's the point? Large numbers of companies make candidates feel like small people, not especially different from those next to them. They show faces like machines, filled with indifference, and they reduce the desire to enter for many of those who try. Those who enter may be satisfied but those who don't – who are the vast majority – have had a rejection experience.

Deaf dialogue

There is still no real communication between companies and candidates. Each party has different expectations of the other. Many companies present themselves as the "number one" at something. They are Lionel Messi or George Clooney.

It's common for companies that want to sell to show presence data in different countries or global billing. They emphasize how well the company works and what a privilege it would be to become part of it. However, often that information is more relevant to a shareholder than to a candidate. Many companies sell something that candidates aren't interested in buying.

More than seducing, this generates a conflict of scales. Because, to be short, when something is so successful and large, it is also distant and "suspicious." We must build close relationships through which we can admire and discover each other. It's a Match! It's about mutual choices. When the base relationship is so uneven, the mutual factor is difficult to uncover. The idea is for companies to stop looking at their navels, to remove their makeup and, in the most natural way possible, show themselves as they are, to discover the people beyond the profiles. That is why I find, in Tinder, a reflection of all this. If you start reviewing Tinder profiles, you will understand that people who have several appointments to their credit have managed to develop a capacity for discernment about what they are looking for so that they are not deceived. That's because it's very frustrating to get to a date and find that the person's appearance is unfavorably quite different from what appeared in those sexy photos I had selected. This is why many users add "the photos are updated" to their profiles: They look for transparency because, without it, there is no chance of a match in real life.

Humility? Why?

In the old paradigm, companies look at their navels and talk with hard data. Soft communication is missing. They don't know what candidates find interesting. What makes the company attractive, so that candidates want to work there? A company starts from the position that everyone dreams of becoming part of it. One of the trends among men on Tinder is that they are sculpted and that they practice extreme sports. However, a woman is most likely looking for something else: a man to hold her, someone to hug her like in the movies, someone to share an ice cream with. A person. Many companies portray themselves as the bodybuilder. They expect everyone to admire them. However, a man who lends you a hand is much more seductive than a bodybuilder. Companies don't realize this. What is "shaking hands" in this case? It may simply be the ability to use sneakers. Go to the soft. The soft involves the near, the palpable, the human. It involves sharing codes and understanding the other. Hard is not irrelevant; for example, physical attraction is still important. Yet conquest takes place on the side of the soft. That's where a connection is generated. It's where a match is made.

A candidate probably isn't thinking about the next three decades of his/her career. Instead, the candidate is thinking about the coming years and his/her day-to-day experience. The candidate is thinking about enjoying life, which is taking place all around us. What seduces is the soft. The war for talent has wiped out all the perfect recipes. It's a vacuum that generates the opportunity. And the tip of the ball to win it involves understanding hard and soft – understanding that the message sent by the richest, most attractive one isn't necessarily the most successful.

Selection 2.0: The Tinder paradigm

Something happens when a company realizes that this experience of rejection is harmful to the company itself. It's hurtful because not only do those who managed to enter have that image of the company but also many valuable people can be lost if they don't feel welcome. Companies select people, but people also select companies. People want to be valued as people, and when we can choose, we will go to those who do just that. Companies that understand this are dedicated to building relationships with those who may be interested in working with them. They want to make themselves known, show the work environment, highlight employees' achievements.

Social networks are ideal for this kind of thing. Through them, we can build a presence and develop our employer brand. We can offer different opportunities, which don't have to be work-related but must aim to achieve an experience of mutual benefit. Consumer brands have long understood this. The "continue participating" (or, in HR language, "we will keep you in our database for future searches") is harmful. Not only does the candidate experience the frustration of not having won the prize but he/she has the flavor of the generic, the letter. I'm that anonymous person who continues to participate.

In the new paradigm, all the caps have a prize. Not everyone can earn a brand-new car. However, there are many kinds of benefits. The one who didn't get a job but who managed to obtain coaching, an internship, a university program, a course, or career counseling is not only happy but also empowered. They come out better.

Building relationships

One of Tinder's benefits is that it saves time. In addition to providing an extensive sampling, it allows users to generate connections with other people before they get to know each other more personally. Each relationship is managed on its own time. However, with a little practice, a Tinder user can much more quickly filter out those who aren't a good match. In the same way, we can determine which of our characteristics are better or worse. That is to say, although we aren't achieving our ultimate goal, we aren't wasting time. On Tinder, there is no rejection experience. When a match is not produced, it's painless. We are building relationships, or at least learning how to build them. We are developing ourselves as candidates.

In the old paradigm, I select the best talents. In the new paradigm, I believe (or co-create) the best candidates. I think the key lies in generating learn-learn experiences (in which everyone learns). The people who haven't been selected will value those who made an effort to get to know them. They will achieve a positive experience, which will be reflected in beneficial word of mouth. They will recognize those who treated them as people and who gave them tools to improve their lives. This kind of experience creates enthusiasm and excitement. The company not only gains a better reputation but also better candidates for its searches. You will achieve one of the most important goals: desire. Through desire, you will find better candidates.

Employees are people, candidates are CVs

It's a Match! is much more present inward than outward. It's amazing how companies have evolved in dealing with employees. Benefit programs are a great example of this. Companies, in general, already realize that it is necessary to balance work with the rest of one's life, and they offer different ways to do this. The possibility of setting up a home office, and not as a favor but as a mutual benefit, is a win-win. Companies are loosening up their dress codes and providing unique diversity practices. The idea is to make the employee feel good as a person. This is of mutual benefit. Inside, companies' methods show that an employee is more than his/her CV. Outside, myopia continues to reign.

Differences in brief:

- It's no longer about selection, but about mutual choice.
  - ✓ In the old paradigm, talents competed for positions.
  - ✓ In the new paradigm, companies also compete for candidates.

- Self-centered companies should stop looking at their navels.
  - ✓ In the old paradigm, companies spoke in a hard tone.
  - ✓ In the new paradigm, companies speak softly.

- We don't detect profiles, we discover people.
  - ✓ In the old paradigm, a candidate was liable to cut himself in a CV.
  - ✓ In the new paradigm, the candidate wants to be valued beyond his/her CV, as a whole person, with work being only part of his/her life.

- All caps have a prize.
  - ✓ In the old paradigm, everyone competed for a bigger prize (the car, the trip) and "continue participating" was the norm.
  - ✓ In the new paradigm, everyone has a positive experience.

- Transparency distributes power.
  - ✓ In the old paradigm, the candidates didn't know with whom they competed, or what the process was like. Sometimes they didn't even know the name of the company.
  - ✓ In the new paradigm, adequate information helps with decision-making on both sides.

- We take advantage of communications.
  - ✓ In the old paradigm, the development of communications was a challenge to regular procedures.
  - ✓ In the new paradigm, it's a huge opportunity.

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Microencapsulation in the ruminant feed industry

Microencapsulation in the ruminant feed industry

Mohsen Sahraei Belverdy, Ali A. Alamouti, and Mohammad Hossein Azizi

Introduction

Numerous methodologies have been designed to increase the amount of a nutrient that passes through the rumen without degradation by the rumen microorganisms, thereby resulting in the delivery of a larger portion of that nutrient to the lower gastrointestinal tract. Some of these methods include heat and chemical treatment and polymeric compounds of amino acids[4]. The microencapsulation technique has widespread application in the agricultural, food, and pharmaceutical industries[3]. This technique is also applicable to the ruminant feed industry, as it protects nutrients from degradation in the rumen, making it possible to increase the bioavailability of the core ingredient in the small intestine. Microencapsulation is defined as a process in which particles of solids or droplets of liquids or gases at micron sizes are surrounded by a coating material or embedded in a homogeneous or heterogeneous matrix to create small capsules with many useful properties[12]. The product obtained from this process is called microencapsulate, and it includes both microspheres and microcapsules. Microcapsules are particles consisting of an inner core containing the active substance, which is covered with a polymer layer constituting the capsule membrane. Microspheres are matrix systems in which the core is uniformly dispersed and/or dissolved in a polymer network. Microspheres may be homogeneous or heterogeneous depending, respectively, on whether the core is in the molecular state (dissolved) or in the form of particles (suspended)[9].

This review will briefly discuss some aspects of microencapsulation, such as the wall material, core ingredients, encapsulation techniques, and some of their uses in ruminants' feed technology.

Coating materials

Originally, most methods related to encapsulation dealt with the protection of hydrophilic compounds such as choline, amino acids, proteins, vitamins, enzymes,

carbohydrates, drugs, and hormones. Various material including proteins, polysaccharides, lipids, and synthetic polymers can be used for the encapsulation of ingredients in the food industry[3]. However, as the enzymatic activity of ruminal microorganisms vigorously destroys many of these coating agents, only a limited number of these techniques has been applied to the ruminants' feed industry. Materials to be chosen as a coating matrix should have these specific properties to protect the core nutrient/feed from ruminal degradation: 1) be insoluble in the rumen of the animal where the pH is greater than 6; 2) be soluble in the more acidic juice (pH 1.5 – 2) of the abomasum; 3) be resistant to microbial attack; and 4) possess mechanical properties to withstand breakage (e.g. flexibility and strength). The encapsulated product should also contain a high amount of the core/active ingredient, have a smooth surface and appropriate specific gravity (1.2 – 1.7 g/cm^3)[11]. The capsules must be sufficiently dense to ensure that they do not remain floating at the top layer of the rumen contents for an unlimited time. The capsule density can be conveniently adjusted by varying the ingredients forming the core of the capsule, e.g. through the addition of a high-density weighing agent such as kaolin, chromium sesquioxide, or barium sulfate[10].

Recently, encapsulation with lipid materials has gained much attention. Lipid-protected products rely on their resistance to enzymatic attack, which maintains the integrity of the protective coat in the rumen, while it is digested by intestinal enzymes where the active core components are released. In designing a fat-coated product, an active ingredient is either embedded in a lipid matrix or prepared in small spheres, then coated with lipid material. In general, coating fats consist of fatty acids with a melting point of ≥40 ºC and having at least 14 carbon atoms.

Lipid coating for bypassing the nutrients of interest to the ruminant intestine has the advantage of using relatively low-cost food-grade materials compared to formulated polymeric coatings[5]. In addition, fats and fatty acids are used almost globally in dairy rations, which further justifies the idea of using the same ingredient as a coating material. Contrastingly, the disadvantages of this protection method include low payloads of the active material and its limited post-ruminal release and absorption. The latter is generally inversely related to the degree of rumen protection[2]. Nevertheless, several lipid-based, rumen-protected products are commercially available. For instance, lipid encapsulation technology has been used to produce rumen-protected conjugated linoleic acid[6].

Currently, a new method has been introduced that protects polyunsaturated fatty acid oils from ruminal degradation using a polymeric coating[2].

In this method, the active ingredient is coated with multiple layers including an inner coating such as zein or caseinate and an outer layer consisting of a delayed-release material such as gum arabic, gelatin, ethylcellulose, or hydroxypropyl methylcellulose.

Techniques

Some of the major encapsulation techniques using fats are fluidized bed coating, spray cooling/chilling, and centrifugal suspension separation.

1. **Fluidized bed coating**

   This type of coating leads to forming of capsules called a reservoir structure, where the particles are coated by a layer. Using this technique, the lipid material is sprayed at temperatures above its melting points onto a template to constitute the shell. As it is cooled, the fat mass solidifies around the template and forms a protective coat. Fluidized bed is applied to various products for encapsulation; some of which include vitamins B and C and minerals such as potassium chloride[1,13].

2. **Spray cooling/chilling**

   Spray cooling and spray chilling are two commercially available encapsulation processes that both involve dispersing the core material within a melted lipid through homogenization process. Here, the mixture of core and lipid wall is atomized in the low-temperature air causing the fat to solidify around the core, thereby forming a crude encapsulated product[7]. These techniques have been used for encapsulation of water-soluble core materials such as minerals, water-soluble vitamins, enzymes, and some flavors[7].

3. **Centrifugal suspension**

   Centrifugal suspension separation is extensively used for coating of particles with a thin shell of fat or wax. In this technique, the particles are suspended in a melted shell material and poured onto a spinning disk. As the particles spread on the disk, a thin film of shell material is applied. When they move toward the edge of the rotating disk through centrifugal force, the particles leave apart from the fat film and microcapsules of core-shell are formed[13].

Application

Various techniques are now available to protect single nutrients from ruminal degradation, some of which were briefly discussed above. As modern dairy cows continue to reach higher milk production records, the application of these technologies seems to extend to many other feed additives to precisely meet cows' nutrient requirements.

About the author

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Do cows have starch requirements?

Do cows have starch requirements?

Alvaro D. Garcia

Introduction

Much research has concentrated on the effects of starch on the rumen microbial population (both positive and negative). Recent research[3] however, showed that the fiber to starch ratio in the diet, also affected the growth of the rumen papillae in lactating dairy cows. This is significant since these tiny structures determine how much energy the cow obtains from feed fermentation. This study found that as the fiber to starch ratio increased, the expression of the gene regulating the growth of papillae decreased. We oftentimes state there are no requirements for starch, a seemingly accurate assertion based on our present body of knowledge. Too little starch in the diet however, and the papillae growth will be inadequate to maximize the absorption of volatile fatty acids (and thus energy). The right amount of starch thus determines the cow's absorption precursors for energy (for which there are requirements!). On the other hand, too much starch in the diet reduces forage digestibility, and increases the incidence of digestive upsets. The fact that science has not yet been able to determine starch requirements in high lactating cows, does not mean they do not exist! It is safe to assume however that cows fed high amounts of well-eared corn silage have their starch needs met. Not only because of the corn grain in the silage, but also because it is more degradable than dry-shelled corn.

Starch supply

Let us assume the main starch sources in a given dairy cow diet are 8 kg of corn silage and 7 kg of shelled corn dry basis. Using the equation proposed by Lauer and Undersander[2], we can calculate the corn grain per ton of silage. Assuming a yield of 25 tons of silage (as is) per acre or 8.75 tons of dry matter (DM), the grain yield will be:

Corn grain yield (bushels/acre) = (42.3*tons of silage DM) – (1.53*(tons of silage DM^2) – 72.7.

180.28 bushels or 4589 kg of corn grain/acre = (42.3 x 8.75) – (1.53 x $(8.75)^2$) – 72.7.

Each kg of corn silage will contain 0.57 kg of corn, 8 kg of corn silage fed, will supply nearly 4.5 kg of grain, which added to the 7 kg of shelled corn, totals 11.5 kg of corn grain. In the not so distant past, corn for grain varieties had approximately 60 percent starch. This particular diet would have supplied then approximately 7 kg of starch. Today's corn hybrids however, contain approximately 70-74 percent starch, driven particularly by the needs of the US ethanol industry. That very same diet could easily contain nowadays 8.5 kg of starch or nearly 20 percent more. The conclusion is that modern corn hybrids are "hotter" than in the past, and there needs to be more precision and care when fed at higher concentrations.

Dairy cows however can digest relatively large amounts of starch particularly if the sole source is not just dried shelled corn. Work of Firkins et al.[1] suggested cow's digestion of corn starch in the rumen ranges from a low of roughly 45 percent for dry cracked shelled corn, to a high of approximately 87% for high moisture rolled corn (HMC). As mentioned above this can be also highly variable depending on how fast the feed transits through the rumen (particle size and level of intake). Other factors that affect the degree of degradability are prolamin (zein) content, degree of processing, and rate of passage. In the work of Firkins[1] the starch digestibility in the total tract was 85 and 94 percent for cracked and HMC, respectively.

Starch digestibility

The total tract digestibility of the starch in corn silage is very similar to that of HMC, and even slightly higher, at 99 percent[1]. For the sake of simplicity, let us assume they are both 94 percent. Based on these figures and the dietary starch estimations above, modern cows fed dry corn and corn silage could degrade in the rumen 5.7 kg of starch. Cows fed corn silage and HMC could degrade 7.7 kg of starch in the rumen, or roughly 35 percent more.

When the source of starch in dairy cow diets was exclusively dry ground corn, partially switching it with HMC (degradable rumen energy), we could predict almost with absolute certainty an increase in milk protein in just a few days! This resulted from increased microbial production, consequence of the higher rumen fermentable energy, which ended in more microbial protein supply to the intestines. The results of Ma et al.[3] suggest that given a little more time this would also result in the development of more area of absorption (papillae). This matches increased energy available in the rumen with greater intestinal protein availability, promoting greater milk production.

We have come full-circle to conclude that ideal starch concentrations (requirements) will also increase protein/energy availability and will sustain higher milk production.

Once in the intestines, the work of Firkins et al. showed a degree of compensation between the total tract starch digestibility of dry corn and HMC corn. The total tract digestibility of dry cracked corn was 85 percent, which means that of the 8 kg in the diet approximately 1.2 kg ended in the feces. The question is if this relatively high fecal loss is unavoidable, and is the result of insufficient intestinal amylases incapable of digesting the starch mostly from cracked dry corn. In this circumstance, the content of prolamin, which encapsulates starch granules in the endosperm, certainly plays a significant role.

When applied to the HMC diet the results seem to confirm this. The total starch tract digestibility of the HMC (including corn silage) was 94 percent, which means that of 8 kg of starch in the diet, 0.48 kg ends in the feces. Since there was also 0.5 kg left after rumen degradation, it is clear that what ends in the feces was what neither rumen microbes nor intestine enzymes can degrade any further. Feeding HMC is without a doubt the most efficient utilization of starch by the high production dairy cow.

Applications

From the iterations above it is obvious that many things affect starch requirements, but it seems grain maturity and moisture content are likely the most important. In today's world, everything is about environment, optimization, and rational use of land resources. It might be possible that starch requirements for dairy cows need determinations based on certain "standard", which rather than dry shelled corn could very well be the starch dry matter in corn silage kernels or in high moisture corn. We do know today that dairy cow's pancreatic α-amylase exhibits fluctuations in secretion depending on the diet. It seems that energy intake is important resulting in increased microbial flow, which stimulates α-amylase and enhances the morphological papillae development, necessary to enhance VFA absorption. From the discussion above, the balance between fermentable energy (and subsequent rumen microbial protein) plays a major role. It leads to increased α-amylase production, and starch (glucose) availability, which in turn decreases α-amylase production and secretion. One way or the other there are challenges ahead that need holistic approaches involving the cows and their environment if we are to determine their starch requirements.

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