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Review

Factors Affecting Rumen Microbial Protein Synthesis: A Review

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ABSTRACT

There is a diversified microbial ecosystem in the rumen for efficient utilization of diet by providing essential nutrient to their host. But there are different factors affecting rumen microbial protein synthesis which are physical factors, chemical factors, dietary factors, biological factors and endogenous factors. Among the details of factors, dietary factors and ruminal pH are the dominant factors influencing rumen microbial protein production. The effects of some dietary factors, on the amount and efficiency of microbial protein synthesis, are discussed in this review. Specifically, these factors include forage quality diets, level of feed and types of feed. It seemed that diets containing a mixture of forages and concentrates increase the efficiency of microbial protein synthesis because of an improved rumen environment for the growth of more diverse bacterial species. This review describes physical and chemical factors which include: pH and buffer system, oxygen concentration, rumen outflow rate and synchronized release of nitrogen and energy from the diet, a nitrogen compound, energy spilling, vitamins and minerals and antimicrobials chemicals, respectively. Age, species, physiological status, sex, and stress are among endogenous factors that mostly affect microbial protein synthesis of a ruminant. Bacteriophages, protozoa predation and bacterial lysis are biological factors affecting the efficiency of microbial protein synthesis. All these factors have a direct effect on the synthesis of microbial protein in the rumen. Therefore, the cumulative effects of the above factors are resulted in the depopulation of rumen microflora and finally reduction of animal product. So, improvement in quantitative aspect of microbial protein synthesis solves many problems from simple to complex so that, the quantitative aspect of rumen microbial biomass are invaluable for health and productivity of ruminants than qualitative aspect hence, maintain health rumen ecosystem means having healthy ruminant.

Keywords

Rumen; pouvoir hydrogène (pH); Microbial protein; Rumen ecosystem; Ruminant; Rumen microflora; Nutrient; Haematological parameters reference ranges; Healthy status.

Abbreviations

MBP: Microbial protein; MCP: Microbial crude protein; NDF: Neutral detergent fiber; NPN: Non-protein pitrogen; NSC: Non-structural carbohydrate; OM: Organic matter; OMTDR: Organic matter truly digested in rumen; RDP: Rumen degradable protein; RUP: Rumen undegradable protein; SCFA: Short chain fatty acid; TDN: Total digestible nutrient; VFA: Volatile fatty acid; ATP: Adenosine Tri-phosphate; CP: Crude protein; CS: Concentrate supplementation; DM: Dry matter; DOMI: Dry organic matter intake; EMPS: Efficiency of microbial protein synthesis; FOM: Fermented organic matter.

INTRODUCTION

Ruminants have diversified microbial ecosystem consisting of bacteria (10^{10}-10^{11} cells/mL), ciliate protozoa (10^4-10^6/ mL), anaerobic fungi (10^3-10^5 zoospores/mL) and bacteriophages (10^8-10^9/ mL). The synergism and antagonism among the different groups of microbes and even among different genera of the same group is so diverse and complicated that it is difficult to

quantify the role played by any particular group of microbes present in the rumen. The net result of these reactions in the rumen is responsible for the bioconversion of feed into a form that is utilizable by the animal as a source of energy (short-chain volatile fatty acids) and microbial protein (as single-cell protein).[1]

Ruminants are distinguished from the rest of the animals by the morpho-physiological adaptation of the upper part of their stomach. This peculiarity allows them to turn roughages and low quality protein, even non-protein nitrogen (NPN) into quality nutrients for themselves such as microbial protein and volatile fatty acid.[2] Microbial protein synthesis is important in ruminants because microbial protein synthesized in the rumen provides 50% of amino acids required for ruminants. Synthesis of microbial protein and growth of ruminal microbes largely depend on adequate energy (ATP), resulting from the fermentation of organic matter in the rumen, and N resulting from degradation of non-protein and protein nitrogen sources and this can be affected by either natural or diet-related factors.[3] Ruminants' foregut microbial community structure could be expected to be constrained by, physical, chemical, physiological, and even biological characteristics that evolved along with the varied feeding strategies in the various ruminant lineages.[4]

Adaptation has resulted in a diversity of rumen sizes and passage rates of rumen contents, allowing ruminant species to exploit a range of feed types. In addition, feed composition effects, and the host adaptations might also play a role in regulating rumen microbial community structure. Host and diet effects on rumen microbial community structure could be separated. Microbial communities could clearly be discriminated by both host and diet, with bacteria being the main drivers behind the observed differences. This probably reflects their more diverse metabolic capabilities compared with the less versatile archaea and protozoa.[4]

Among the factors that affect the synthesis of microbial protein, the availability and synchronization between energy and nitrogen compounds (N) in the rumen have been recognized as the most important factor. Although the other most important factors such as dietary factors, animal factors, biological and chemical factors can influence the efficiency of microbial protein synthesis in the rumen.[5]

Therefore, this paper is to highlight major factors affecting the rumen microbial protein synthesis.

FACTORS AFFECTING MICROBIAL PROTEIN SYNTHESIS IN THE RUMEN

Due to the complexity of microbial protein synthesis, there are many factors affecting the performance of the same.[2] The contributions of energy and nitrogen in the rations, as the most limiting factors for microbial protein synthesis in the rumen,[6] although other nutrients such as sulfur, volatile fatty acids, fatty acids of branched-chain, minerals and vitamins, are also very important for microbial growth, which is in a lesser extent.[7]

Physical Factors

pH and buffer system: One of the important factors affecting on the level of synthesis of microbial protein in the rumen is the acidity of the forage pouvoir hydrogène (pH).[8] Functional performance of rumen will be greater when rumen pH is above 6.0 and pH above 5.7 is necessary for protein synthesis. When rumen pH fell below 6, microbial enzymes in rumen do not function effectively and bacterial growth decline markedly.[9]

Cerrato-Sánches et al[10] reported that the negative effect on rumen fermentation started as soon as pH decreased to 5.50. However, fiber digestion rates decrease when ruminal pH declines below 6.00-6.20 which reduces access of bacteria and enzymes to the protein thus decreasing crude protein degradability.[11] A low pH value is also expected to reduce the digestibility of fibrous plant tissues and due to low pH value, the energy within the rumen is diverted to non-growth functions, i.e. maintaining neutral pH in bacterial cells.[12] Apart from affecting congenital prosopagnosia (CP) degradation, rumen pH could also affect membrane co-factor protein (MCP) synthesis, the efficiency of MCP synthesis and yield of MCP which are affected by rumen pH and outflow rate of solid particles and liquid from the rumen.[13] Different bacterial species grow in different pH range; for instance, cellulolytic bacteria are sensitive to acid pH; whereas, amylolytic species are more acid tolerant.[12]

Rumen pH is largely a function of the volatile fatty acid (VFA) concentration,[14,15] and pH will drop if there is a reduced rate of VFA absorption.[16] In a diet with high neural stem cell (NSC) and rumen degradable protein (RDP), VFA concentrations are high and ruminal pH is low.[17] Feed intake and salivary secretion affect pH in the rumen.[18] At a higher level of feed or dry matter (DM) intake, the pH of the rumen is lower.[17]

Rumen under normal conditions has Na^+, K^+, bicarbonate and short-chain fatty acids as the main buffering component. Forages encourage buffering through increased salivation and cation exchange of fiber.[9] The rumen is usually well buffered, due to the presence of bicarbonates and phosphates founded in the continuous flow of saliva.[19] Rumen, although well buffered by bicarbonate, phosphate, protein and VFA can vary in pH from approximately 7.0 to less than 5 under different dietary condition.[20] Rumen buffering could avert the reduction in pH and could enhance rumen microbial growth, diversity and activity, fermentation end product and microbial protein synthesis.[21] Ammonia from degraded protein or NPN would also act as a buffer in the regulation of the ruminal pH.[16] The rumen is well buffered by salivary secretion; however, if the amount of dietary non-deliverable forward (NDF) is restricted and the rate of carbohydrate fermentation is fast, the pH may decline.[12]

Oxygen concentration: The rumen is a suitable environment for the development of a large number of anaerobic microorganisms, having unique characteristics such as temperature around 38 to 42 °C.[22] But normally, the temperature was more commonly found to

be 39 °C.[23,24] Rumen environment is anaerobic, and hence most of the bacteria are obligate anaerobes. Some of them are so sensitive to oxygen that these are killed on exposure to oxygen.[1] Oxygen sequestration up to 16 L of O_2 can enter the rumen daily through water intake, rumination, and salivation, and inhibit the growth of obligate cellulolytic anaerobes like *Fibrobacter succinogenes*. So, yeasts can make the rumen environment more conducive for anaerobic, autochthonous microbes by scavenging O_2.[25] About 10 to 20 liters/day of O_2 could enter from capillaries through the mucosal lining. Strictly anaerobic species, e.g. methanogens, survive in the rumen under O_2 tensions previously found to be inhibitory to these organisms. Therefore, the ruminal microbial population must be able to rapidly utilize O_2 and remove it from the environment of highly O_2 sensitive organisms.[26]

Rumen outflow rate: It is one of the important factors which influencing the level of synthesis of microbial protein in the rumen is the rate of passage of food masses through the rumen. Passage of food masses through the rumen at high-speed increases the number of microorganisms without high energy consumption. Faster outflow rate is visualized to reduce the maintenance expenses of microorganisms (microbes) since they contribute less time inside the rumen.[27] According to the Agricultural and Food Research Council (AFRC)[28] data increasing the rate from 0.02 to 0.08-hours increases the level of synthesis of microbial protein in the rumen to 20%. The presence of dry matter in the forage increases the rate of passage of food passes through the rumen and the level of synthesis of microbial protein in the rumen. Rumen outflow rate is a function of dry matter intake and therefore it can be assumed that the efficiency of microbial protein synthesis in the rumen can be increased as dry matter intake increases (5 and 13). Level of DM intake, the residence time in the rumen and fractional outflow rate has an effect on degradability and extent of cerebral palsy (CP) degradation in the rumen.[29]

The rate of passage of ingested feed depends on the feed intake by the animal,[30] and the improvement of growth and microbial efficiency is due to a reduction in the maintenance requirements of the microorganisms.[31] Therefore, ensuring an adequate intake of dry matter is a way of increasing the production of MCP and reducing the need of rumen undegradable protein (RUP) in the diets.[32] The increased passage of microbial protein to the small intestine occurred as a result of the increased passage of both fluids and solids with increased intake.[33]

Chemical Factors

Synchronized release of nitrogen and energy from diet: Synchronization means both energies in the form of carbohydrates or organic matter (OM) and protein in the form of N or peptides are available in the rumen throughout the day, and neither OM nor N is exceeded or limited for maximal microbial synthesis at any point of time. Synchronization of rumen available protein and energy is one of the conceptual methods to increase the efficiency of utilization of nutrients by the ruminants. Formulation of diets that are synchronous for energy and nitrogen release in the rumen has been shown to increase the efficiency of maltose-binding protein (MBP) synthesis in the rumen.[34] Matching the release of ammonia-N from dietary protein with the release of usable energy may improve N utilization.[5]

Synchronizing energy and N availabilities in the rumen seems to have the potential to enhance the output of microbial protein from the rumen and efficiency of ruminal fermentation, thereby improving feed utilization and animal performance.[35] The optimal RDP balance of a diet is close to zero and corresponds to rumen degradable N to fermented OM ratio equal to 25 g of N/kg of fermented organic matter (FOM), which reflects a well-balanced availability of energy and N to rumen microbes. When the RDP balance is positive for a diet, N losses from the rumen occur. Negative RDP balance indicates a shortage of nitrogen and consequently, the microbial activity may be impaired. Matching degradation of carbohydrate and protein rates of degradation in rumen allows efficient MBP yield and overall dietary protein incorporation.[36]

Nitrogen compound: Rumen microorganisms act normally if the level of raw protein in the feed is more than 11%. To ensure the growth and progression of rumen microorganisms it is important to use feed with nitrogenous compounds in the feed. Nitrogenous compounds and degradability of feed proteins in the rumens are important for meeting the needs protein in ruminants in protein. And modern protein systems indicate that microorganisms' requirement for nitrogen is satisfied by a degrading protein in the rumen, yielding oxidized amino acids and nitrogen,[5,8] Showed that nitrogen compounds, which are released during the protein degradation, are crucial for microbial growth in the rumen. It seems that proteins which have lower rates of ruminal degradation tend to improve the efficiency of microbial protein synthesis, probably because of the better capture of released N by rumen microbes.

Microbial protein is largely dependent upon the availability of energy generated by the fermentation of carbohydrates. On average, 20 grams of bacterial protein is synthesized per 100 grams of organic matter fermented in the rumen. The percentage of protein in bacteria ranges from 38 to 55%. Non-protein nitrogen from the feed and urea recycled into the rumen through saliva or the rumen wall also contribute to the pool of ammonia in the rumen. In addition, ruminants possess a mechanism to spare nitrogen. When feeding a low nitrogen diet, large amounts of urea (typically excreted in the urine) recycles into the rumen, where it can be used again by the microbes. If ammonia levels in the rumen are too low, there will be a shortage of nitrogen available to bacteria and feed digestibility will be reduced.[5]

Energy spilling: Energy spilling is energy dissipated as heat when the amount of ATP available from the fermentation of feedstuff exceeds the amount used for growth and maintenance.[37] Energy spilling can be a major detraction from efficient growth in bacteria. Those bacteria that spill energy fermented glucose 10-fold faster than those that did not.[38] Energy spilling diverts energy away from growth, decreasing the efficiency of the microbial growth and thus the amount of microbial protein available for digestion. Energy spilling has been measured in rumen bacteria but could

not be in rumen protozoa (which make-up 10-50% of the microbe biomass.[39]

Vitamins and minerals: In addition to N and carbohydrate supply, the microbial yield is affected by the concentrations of trace minerals and vitamins. Dietary sulfur concentration has been found to affect microbial growth.[7] The amount of sulfur required by rumen microorganisms for the synthesis of methionine and cysteine ranges from 11 to 20% of the total diet based on the status of the cattle.[29] Limited intake of sulfur may restrict microbial protein synthesis when large amounts of non-protein nitrogen are fed to ruminant animals, such as urea.[7] Sodium sulphate and methionine have been shown to stimulate riboflavin and B12 vitamin synthesis by rumen microorganisms to a greater extent than cysteine or elemental sulphur. It is essential in the synthesis of sulphur containing amino acids that are needed in the elaboration of the MBP.[40] Phosphorus (P) is another mineral required for the synthesis of ATP and protein by rumen microbes. Microbial protein synthesis can be limited by an insufficient supply of P for microbial growth.[5]

Magnesium activates many bacterial enzymes including phosphohydrolases, phosphor transferases and pathways involving ATP and thiamine pyrophosphate reactions. Its concentration in the ribosomes makes it essential for the protein synthesis process but it can be partly replaced by manganese.[9] Vitamin B2 is required only 0.38 mg/d but pantothenic acid (B5) is required about 360 mg/d to dairy cows for the optimum rumen fermentation. MBP production in control, water and fat-soluble vitamins were 163 and 140 g/d, respectively thus, indicating B-complex vitamin supplementation improves rumen MBP production.[41]

Antimicrobial chemicals: Effect of plant extracts like garlic and ginger extracts were found to have decreased the protozoa population resulting in a reduction of methane emission in the rumen and thus inhibiting methanogenesis and decrease rumen protein production. The other one is essential oils in the rumen which resulted in the reduction of protein and starch degradation, due to selective action on certain rumen microorganisms like Gram-positive bacteria due to the barrier of the cell wall structure not tolerating the inflow of the secondary metabolites.[42] Ionophores (such as monensin, lasalocid, laidlomycin, salinomycin and narasin) are antimicrobial compounds that are commonly fed to ruminant animals to improve feed efficiency. These antimicrobials specifically target the ruminal bacterial population. They are lipophilic compounds that exert their effects at the membrane level, and are most effective against gram-positive bacteria and alter the microbial ecology of the intestinal microbial consortium. Ionophores transport ions across cell membranes of susceptible bacteria, dissipating ion and uncoupling energy expenditures from growth, killing these bacteria.[43] The efficiency of microbial protein synthesis was greater in forages containing saponin and tannins, which reduce ruminal N degradability.[5] The readily degradable fraction of protein is higher in forages than in grains. Approximately 40% of the protein in fresh alfalfa is soluble in the rumen environment.[44]

Dietary Factors

Forage quality: The yield and efficiency of synthesis of microbial protein have frequently been recorded as high (30-45 g microbial-N per kg OM apparently digested in the rumen), when high-quality grass is grazed.[45,46] Much lower microbial efficiencies (<20%) have been noted with lower-quality autumn-grass, though in these experiments season was confounded with the physiological state of the animals.[46] MPS is often increased by supplementing silage-based diets with moderate levels of readily-fermented carbohydrates.[47,48]

Level of feed: Increasing the level of feeding in ruminants is expected to reduce maintenance costs of microbes because they spend less time within the rumen.[2] Experimental evidence is available which suggest that the frequency of feeding improve the efficiency of microbial protein synthesis and was certainly observed through stimulation models of rumen function. Also, frequent feeding increases the rate of passage of liquid and solids from rumen and influence in microbial protein synthesis so, increasing the feeding frequency of dried grass meal from 2 to 8 times increased MBP synthesis from 36 to 46 g/kg of dry organic matter intake (DOMI).[27] The level of feeding effect appears to hold true for maximum electronic music plotting system (EMPS) since there are no occurrences of high EMPS at low intakes.[28] However, no significant effect was found in the diets containing rolled barley which indicated that the frequency of feeding leads to increase in MBP production mainly due to the impact on the roughage diet. Feeds associated with lower outflow rates, for example, processed-grain rations, have a higher total energy production but lower efficiency of MBP production.[9] Therefore increased feeding frequency should lessen variation in ruminal ammonia N concentration and improve microbial protein yield.[49]

Types of feed: The efficiency of microbial protein synthesis greatly differs in animals fed different diets, even within similar diets. The average efficiency of microbial protein synthesis was 13.0 g membrane cofactor protein (MCP)/l00 g organic matter truly digested in the rumen (OMTDR), ranging from 7.5 to 24.3 for forage-based diets. For mixed forage-concentrate diets, the average efficiency of microbial protein synthesis was 17.6 g MCP/100 g OMTD in the rumen, ranging from 9.1 to 27.9 g.[3] Efficiency of microbial protein synthesis for high concentrate diets was 13.2 g MCP/100 g OMTD in the rumen, ranging from 7.0 to 23.7. Overall, the average efficiency of microbial protein synthesis is 14.8 g MCP/100 g OMTD in the rumen, ranging from 7.0 to 27.9 g MCP/100 g of OM truly digested in the rumen.[29]

The efficiency of microbial protein synthesis was predicted to be around 13 g MCP/100 g of total digestible nutrient (TDN) for beef cows. Sources of carbohydrates, such as different ratios of structural to nonstructural carbohydrates, would have little effects on the efficiency of microbial protein synthesis. It is well known that the rapid digestion of nonstructural carbohydrate results in reduced ruminal pH. The efficiency of microbial protein synthesis is reported to be low in animals fed high-concentrate diets because of reduced ruminal PH.[36] Also, the efficiency of MBP production varied widely between forages. MBP production in grass and maize silages was from 115 to 158 and 165 to 217, respectively while with green forage and hay was 145 to 199 and 126 g/kg of fermentable OM.[3]

Biological Factors

Bacteriophages: Bacteriophages are the viruses of bacteria and are reported to be present in the rumen in large numbers.[1] The phage densities ranging from 109 to 1010 particles per milliliter of rumen fluid and considerable morphological diversity has been observed, with 26-40 morphologically distinct types from three viral families (Myoviridae, Siphoviridae, and Podoviridae) being reported.[50] Viruses of prokaryotes (phages) are ubiquitous to the gastrointestinal tracts of all animals, and particularly dense and diverse populations occur in the rumen of herbivores these viruses have characteristics that can be both detrimental (reduce feed efficiency, transfer toxin genes) and advantageous (bacterial population balance, lateral gene transfer, phage therapy, novel enzymes), very little is known about their biological properties or genetic make-up.[51] One cause of reduced efficiency is the non-specific lysis of bacteria within the rumen and subsequent fermentation of the bacterial protoplasm. This phenomenon has not been explained but at times a large proportion of the bacterial pool can be affected.[52] Bacteriophages (bacterial viruses) are implicated in this lysis. Bacteriophages are obligate pathogens of bacteria and occur in dense populations in the rumen.[53] Because, they lyse their bacterial hosts within the rumen and, the process is identified as reducing the efficiency of feed.[50]

Protozoa predation: Protozoa engulf bacteria and digest them to cover their nutritional needs. Bacterial proteins are degraded into peptides and amino acids inside the protozoa. Nearly half of the ingested amino acids are used by ciliates. The other half reappears in the medium where they are deaminated by bacteria as it was calculated that as much as 90 g of bacterial dry matter can be engulfed by protozoa each day in a sheep rumen, which corresponds to a loss of 27 g of bacterial protein. As a consequence of the predation, the turnover of bacterial protein is increased by the presence of protozoa.[40] Protozoa predate on bacteria as their main protein source and as a result, defaunation makes the rumen more efficient in terms of proteosynthesis increasing the duodenal flow of microbial protein (+30%, $p<0.001$) and total non-ammonia N flow (+31%, $p<0.001$). Defaunation also increased the efficiency of microbial protein synthesis (+27%, $p=0.008$) as a result of both better microbial proteosynthesis and a lower OM digestion. Protozoal generation time is far higher than that of bacteria, thus the energetic requirements for maintenance are higher when expressed as a ratio of protein leaving the rumen.[54] As a result, the presence of protozoa has a negative impact on the overall energetic efficiency of the rumen ecosystem. In addition, defaunation can also modify the composition of rumen bacteria.[55] The ability of protozoa to engulf exogenous fatty acids[56] may divert more carbon toward VFA production in preference to fatty acid synthesis and ultimately increase VFA production. On the basis of stoichiometry, such a shift in rumen VFA production should result in a decrease in methane production as less metabolic H_2 will be available as a substrate for methanogenesis.[57]

The effect of the presence of rumen protozoa on pathogen's survival in the rumen and pathogen shedding is another area of interest. As noted above rumen protozoa engulf and digest a wide range of bacteria[54] and can reduce the shedding of potential pathogens from the animal, although the effect is highly dependent on the composition of the protozoal population present.[58] However, it has also been shown that rumen protozoa enhance the pathogenicity of certain pathogens leaving the rumen[59] suggesting that more work is needed in this area.

Bacterial Lysis: The microbial turnover is estimated in defaunated sheep using N and autolysis of bacteria in the rumen environment. In gram-positive rods first deposited peptidoglycan at the inner surface while their outer layers were cut by autolytic enzymes and stress is gradually transferred to more recently synthesized portions of the peptidoglycan. The low pH, in turn, would inhibit autolysis. Conversely, starvation could dissipate the membrane potential, increase pH, and activate the autolysins. Compounds those decreases the membrane potential accelerates the lysis of rumen bacterium. However, bacterium e.g., *Fibrobacter succinogenes*, appeared to be regulating its autolysis *via* a mechanism involving the proteolytic degradation of autolysins.[9,54]

Endogenous Factors

Age: DM and CP degradability in calves differs from that of mature cows up to the age of 10-12-weeks after which the calves ability to degrade feed CP approaches that of mature cows This is to be expected due to the young calf's rumen still being in development.[60] MBP reaching the duodenum is increasing with age. However, studies based on excretion of purine derivatives (PD) in the urine showed that their excretion was lesser in adult sheep than in the lambs or yearlings because of reduced efficiency of MBP production and increase in proteolytic activity.[9]

Species: Microbial protein production rate estimated by Sodium sulfate in cattle fed straw alone or supplemented with CS or urea-molasses-mineral block (UMMB) licks was 80, 269 and 251 g/d, respectively.[9] MBP production in sheep varies from 15 to 35 g/kg of fermented OM (FOM). Such large variation within species was due to feeding regime, pattern and feed intake. Although the extent of MBP production varies between species, its efficiency is diet dependent.[9] If sheep and cattle were fed the same diet, microbial populations would be expected to be similar. However, there are differences because of different outflow rates.[61]

Physiological states: The rumen microorganism appears to provide sufficient protein for maintenance, slow growth and early pregnancy.[9] In the early lactation, the dry matter intake of high-producing dairy cows is increasing but the energy intake is not sufficient to support milking outputs, therefore the body weight is dropping dramatically. Following peak lactation, the consumption of high-quality diet peaks and milk production drops. During this stage, dairy cows tend to maintain body weight. In the mid and late lactation, energy required for milking is less demanding because of milk production is declining. Dairy cows still need more energy because of pregnancy and energy reserve for the next lactation. Maintaining body condition during the dry period is important for ensuring dairy cows have adequate body reserve for the next lactation. The transition period, defined as three weeks before to three

weeks after parturition, is characterized by dramatic changes in physiology and nutrient metabolism and imposes great challenges to the dairy cow.[62] Shifts in the rumen microbial composition of the cows in this period and in general, may alter the rumen fermentation characteristics, influencing parameters like short-chain fatty acid (SCFA) and methane production and thereby affecting feed efficiency of the cow.[63] Lesser MBP production during pregnancy may relate to poor energetic efficiency of just 20% for fetal growth.[64]

Multiparous cows tend to have a lower pH in the rumen than primiparous cows because higher feed intake leads to more fermentation acids produced in the rumen, which is not compensated by increased salivary secretions associated with increased chewing.[18]

Sex: Microbial protein synthesis is not affected by sex being male or female, bull *vs* heifer and ox *vs* cows. No suggested evidence that microbial protein synthesis since sex does not affect the intake of DM and digestibility of OM but the intake of digestible OM (DOM) tended to be greater for bulls than for heifers.[65]

Stress: Stress factors is a condition that affects the welfare of the animal. Animal welfare implies that the animals will develop physically and mentally in good conditions, and that nutritional, social, management, health and comfort factors do not adversely affect production.[66]

Health disorders which result from diet stress specially acidogenic diets, in acute acidosis are based on the degree of pH ruminal decrease which causes great challenge from decreasing the buffering capacity of the ruminal intake, change the population of microorganisms, rumen motility and the systemic fluid balance.[67]

Under heat stress conditions, lactating dairy cows exhibit several physiological responses including a voluntary reduction of feed intake, an increase in maintenance requirements, a decrease in milk yield, and a decline in the quality of milk for manufacturing. Milk protein composition is subject to significant detrimental changes under the effects of heat stress. It is clear that heat stress has an effect on milk protein and casein production and composition that is greater than the indirect effect of reduced intake.[68]

CONCLUSION AND RECCOMMENDATIONS

Conclusion

Ruminants have diversified microbial ecosystem consisting of bacteria, ciliate protozoa, anaerobic fungi and bacteriophages. Microbial organism in the rumen plays a key role for the production of single-cell protein and volatile fatty acid for ruminants and they solve issues with nutrition to methanogens. If one factor is not properly managed it causes other factors to worsen the problem on microflora and resulted in affection on the host. Microbial protein synthesis can be affected by many factors that reduce efficiency of MPS in rumen. Factors influencing them are microbial factor, chemical factors and dietary factors even physical factors together with endogenous factor and there is enormous information on how they affect rumen microbial protein synthesis.

If each factor is properly maintained and quantitatively improved microbial protein production they improve the nutrition, health condition, immunity, production, environmental stress as well as methanogens. Quantitative improvement of microbial protein synthesis has improved feed conversion efficiency also increased the synthesis of B-complex vitamins in the rumen by rumen microflora and available to host animal for stress tolerance and metabolism of energy in dairy cattle than qualitative improvement. Since ruminants rely on around 75% of microbial proteins so they obtain these proteins from them and build their body mass and improve milk yield. So, if we improve factors affecting them we will also get improved milk yield and meat. Therefore, understanding the effect of each factor on microbial protein production is a key for resolution of an animal problem.

Recommendation

Recommendation is based on:

- Understanding the effect of each factors on microbial protein synthesis and the way to solve those problems should be imposed upon them.
- Use accurate feed nutrient composition value in formulating ration
- Avoid access the ruminants to highly fermentable carbohydrate
- Diet containing a mixture of forages and concentrates should be provided to increases microbial protein synthesis.

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