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FEED ADDITIVES AND LACTATING ANIMALS: RESEARCH AND APPLICATIONS

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SUMMARY

Feed additives are defined as products used in animal nutrition for improving the quality of feed or the animals' performance and health. Feed additives are "Non_ nutritive substances added to feed to improve its efficiency of utilization and acceptance, metabolism and health of the animal". Feed additives are the substances that are added to the feed and don't have any nutritional value. Before the addition of additives to the diet, their adverse effects are checked by continuous experimentation. They are added to ruminant feed to enhance digestion, promote growth, increase palatability, and maintain rumen environment etc. Additives have their biological and economic benefits. According to the increasing human population in the world which reached about seven billion people and it continuously increases. In this background, the food source of both animal and plant origin must be accordingly increased. Therefore, we must use and add some feed additives such as antibiotic, probiotic, prebiotic, postbiotic and synbiotic for the animal feeds to increase production (meat, egg, milk and fish) and improve health.

Feed additives and their use in livestock feed:

Feed additives can be classified as (Faraz, 2018):

1) Additives that influence feed stability, feed manufacturing, and non-nutritive properties of feeds: mold inhibitors, antioxidants, pellet binders.
2) Additives that modify feed intake, digestion, growth, feed efficiency, metabolism and performance: feed flavors digestion modifiers, metabolic modifiers and growth promoters.
3) Additives that modify animal health: drugs, environmentally active substances.

Additives that influence stability and non-nutritive properties of feed:

Peroxides are formed that react to produce aldehydes and ketones, reduce palatability and performance and destroy vitamins. Adding antioxidants in diet inactivates peroxides. Rancid oils can be toxic. Natural antioxidants include vitamin C, vitamin E and selenium. Preservatives may reduce risk of CHD and cancer and increase longevity. Pellet binders (bentonite, a clay mineraletc.) are added to increase palatability of feed (Faraz, 2018).

Additives that modify feed intake or digestion:

Feed flavors are added to increase feed intake. Enzymes and buffers maintain pH and acidosis is prevented. Anti bloat agents break the bloat into bubbles and gas is released. Defaunating agents are added to kill undesired protozoa examples include bovatec and saponins. Ionophores are added to inhibit growth of gram-positive bacteria e.g. rumensin. Additives that affect metabolism include melengestrol acetate which is a heifer heat-suppressant. Metabolism can also be affected by doping (Faraz, 2018).

Additives that modify animal health:

Antibiotics are added commonly to the feed. Alternatives are probiotics e.g. copper sulphate, arsenical nitro furans and sulphonamides. Repartitioning agents convert the body fats into proteins and are thus used to remove excess body fats. They cause a change in nutrient profile of body tissue e.g. rectopamine and clenbuterol (Faraz, 2018).

Role of minerals, vitamins and feed additives in reproductive performance of dairy animals:

Minerals:

Minerals play important roles in production and reproduction performance of dairy animals (Table 1). Therefore, mineral deficiencies and imbalances are often responsible for poor reproductive performance. Accordingly, balancing of minerals in adequate amount is important. So, exploration of mineral profile in soil, plant and animal for a particular region is desirable to develop suitable area specific mineral mixture to achieve optimum reproductive performance. Minerals are involved in body functioning starting from digestion to maintain homeostasis through balancing various function of body. Mineral supplementation in the ration should be balanced otherwise utilization of different mineral may hamper. Therefore, mineral supplementation of appropriate quantity is more desirable to achieve optimum reproductive performance (Chandra el al., 2015).

Vitamins:

In general, the vitamins requirement of dairy cows are met by green fodder, rumen and tissue synthesis as well as feed supplementation (Table 1). Most commercial concentrates contain vitamins supplements so, the probability of infertility due to a vitamin deficiency is less. When commercial concentrates are not fed, vitamin supplements should be provided. Proper vitamin and mineral balance must be provided in dry cow rations when feed intake is restricted and/or low quality forage is fed to achieve optimum body condition for better reproductive performance during next lactation. To ensure adequate intake, vitamins and minerals should be fed in small amounts along with ration (Chandra el al., 2015).

Table 1. Role of minerals, vitamins and feed additive supplementation of dairy animals

	Role in animals reproduction	
Minerals		
Chromium	Play in the secretion of pregnancy specific proteins from the uterine endometrium which is helpful in preventing early embryonic mortality. It exerts a significant influence on follicular maturation and LH release.	Tuormaa, 2000
Iron	The reproductive performance of Iron deficient animals may be badly affected due to anaemia, reduced appetite and lower body condition. A deficient animal becomes repeat breeders and require increased number of inseminations per conception and occasionally may abort.	Kumar *et al*., 2011
Molybdenum	In case of molybdenum deficiency there is decrease libido as well as spermatogenesis and causes sterility in males and is responsible for delayed puberty, reduced conception rate and anoestrus in females.	Satish Kumar, 2003
Cobalt	Infertility is likely to arise as a secondary consequence of debilitating condition due to severe cobalt deprivation.	Judson *et al*., 1997
	Cobalt deficiency is associated with delayed uterine involution, irregular estrous cycle and decreased conception rate.	Pulls, 1994; Satish Kumar, 2003
Vitamins		
B12	In case of B12 deficiency appetite and feed intake decrease which further leads to delayed sexual maturity and atrophy of the ovaries and uterus in cows. Cobalt is essential for B12 synthesis.	Hedges *et al*., 2002
Biotin	Feeding of 200 mg/day biotin reduces service period from 169 to 108 day and reduces service per conception from 2.96 Vs 1.5.	Hedges *et al*., 2002
Feed additives		
Beta-Carotene	Restoration of reproductive function and improve reproductive performance.	Hutjens, 1991

Supplementation of feed additive during transition period:

Reproduction is important for dairy animals; therefore, it should not be taken lightly, by giving emphasis on production performance only. Among the factors influencing reproductive performance are minerals which have the most crucial role. Therefore, area of specific minerals mixture development by analyzing mineral level in soil, animal and plant is most pragmatic way to reduce the reproductive problems and improve productive performance which ultimately leads to economic benefit to the farmers. Time to time, vitamin and feed additive supplementation are helpful in better reproductive and productive performance. During summer months mineral blocks can be provided to the dairy animals to overcome any kind of mineral deficiency and for better reproductive performance.

1) Niacin supplementation is effective in case of high producing cows (mature cows producing over 35 kg and heifers over 25 kg milk per day), ketotic-prone cows and cows that lose excessive weight. To prevent ketosis and to maintain dry matter intake, 6 to 12 grams per day niacin supplementation until 10 to 12 weeks postpartum is effective.
2) Buffers are additives that maintain rumen pH between 6 to 6.3. Sodium bicarbonate and sodium sesquicarbonate are the most common commercial products fed @ 120 to 250 grams per cow per day. Magnesium oxide is not a buffer, but is an alkalinizer (raises pH). A combination of 2 to 3-part bicarb to 1-part magnesium oxide is recommended. Supplementation of propylene glycol is converted in the liver to glucose which can prevent ketosis and fatty liver problem. Drenching 0.5 kg per day to cows with elevated blood ketones (based on milk or urine color tests) has been successfully used in the field. Propylene glycol 0.1 to 0.25 kg in a grain mix or TMR (Total Mixed Ration) can also be used to prevent ketosis, it is normally converted in liver to glucose to prevent ketosis and fatty liver syndrome.
3) Yeast culture and yeast products are very effective probiotic that help in better fiber digestibility by stimulating favorable bacterial population, maintaining rumen pit and improves VFA production. Probiotic supplementation is cost

effective and level at supplementation varies from 10 to 115g per cow per day.

Methane inhibition

Condensed tannins can reduce enteric methane emissions from ruminants (Puchala *et al.*, 2005). The reduction in methane was confounded with changes in forage quality. Carulla *et al*. (2005) reported that feeding *Acacia mearnsii* (black wattle tree) extract (2.5% of DMI) to sheep decreased methane/kg of DM intake by approximately 12%. The affinity of condensed tannins for protozoa and methanogens may be particularly important due to the symbiotic role these populations have on methane production (McAllister et a1, 1996).

Patra *et al*. (2006) reported the effect of spices on *in vitro* gas production and found that ethanol and methanol extracts of clove and garlic and methanol extract of fennel inhibited methane production. However, water extracts of these products and all extracts of onion and ginger had no effect on methane production. Total VFA's were higher on inclusion of extracts of garlic and onion. All extracts of garlic and methanol extract of fennel decreased molar proportion of acetate and A:P ratio. Methanol and ethanol extracts of clove decreased DM degradability

InduChaturved *et al*. (2015) studied the effect of herbal feed additives on methane and total gas production during the rumen fermentation for environment and animal health concern. Different parts of the five medicinal plants were selected such as leaf and small stems of *Ocimum sanctum* (Tulsi), roots of *Curcuma longa* (Haldi), fruits of *Emblica officinalis* (Amla), leaves of Azadirachtaindica (Neem) and leaves and small stem of Clerodendrumphlomidis (Arni) for our study. Addition of different herbal additive combinations did not influence IVDMD and total gas production, however methane production (mg/g of substrate DM) was significantly ($P<0.05$) reduced in Amla: Neem and Neem: Arni combinations. Total nitrogen significantly ($P<0.01$) increased in the combinations of Tulsi: Haldi and Amla: Neem. TCA–ppt-N is significantly ($P<0.01$) increased in Tulsi: Haldi, Haldi: Amla, Amla: Neem and Neem: Arni however NH3-N (mg/dl) significantly decreased in all treatments. We conclude that the screening of plant combinations, Amla: Neem and Neem: Arni have potential to decrease methane production and our herbal feed supplements have no side-effects on the ruminant in small amount.

Total gas (ml) production/g of DM ranged from 114.32 in T7 (Tulsi: Amla) to 130.08 in T10 (Haldi:Arni). Methane production (mg/g of substrate DM) was significantly ($P<0.05$) reduced in T4 (Amla: Neem), T5 (Neem: Arni) than control T1(substrate without herbs).

Some critical issues should be considered:

- As herbs, PSM possess different chemical and physical properties, they have different fermentation characteristics and hence, affect animal health.
- Optimal levels of inclusion in diets yet to be established for most animal species.
- The optimum level may vary depending on the physiological status of the animal.
- Interactions between the active components need to be elucidated.
- Prebiotic oligosaccharides may antagonize the effects of antibiotics.
- Type of feedstuff offered, roughage to concentrate ratio in the diet and production potential (milk, meat and wool) of the animal may affect the response to PSM.
- Most of the studies are based on *in vitro* fermentation; similar results may not be obtained in *in-vivo* studies, under field conditions.
- The possible adaptation of rumen microbes to the herbal feed additive may limit the utility of an herb (PSM) on the performance of animals.
- The duration of supplementation of herbs and specific withdrawal periods needs to be investigated.
- Due to the growing focus on food safety, it is imperative to explore alternatives to antimicrobial compounds to address the acidosis problem.
- Practical formulations and economics are yet to be worked out.
- Mode of supplementation (powdered herb or crude extract or active component extract or pure active component) needs to be worked out.

Encapsulating potassium carbonate to reduce its chemical reactivity:

Potassium carbonate is a feed additive used as a source of potassium in dairy diets; however, in the presence of moisture, this reacts to cause the heating of the total mixed ration and palatability issues (Diaz and García, 2019). Researchers from South Dakota State University evaluated whether feeding a free fatty acid (FFA) encapsulated potassium carbonate would create palatability issues in lactating dairy cows when compared with to feeding potassium carbonate sesquihydrate, a less reactive source of potassium carbonate (Diaz and García, 2019). Cows were fed either 68 g/day of potassium carbonate sesquihydrate plus 204 g/day of bypass fat as individual ingredients or 272 g/d of FFA-encapsulated potassium carbonate. The findings, published in The Professional Animal Scientist, showed no differences in dry matter intake between diets for either consumption within the first 10 minutes after feeding or the daily *ad libitum* intake. In conclusion, the authors suggested that there was no palatability issue with the FFA-encapsulated potassium when fed to lactating dairy cows.

Added fat and fiber digestibility:

Diaz and García (2019) reported that dietary fat significantly affects total-tract fiber (NDF) digestibility in lactating dairy cows. A meta-analysis published in the Journal of Dairy Science showed the effects of supplemental fat on fiber digestibility. The data set included 108 fat-supplemented lactating cow diets from 38 publications in which fiber digestibility averaged 49.4 percent (± 9.3 standard deviation). The authors, from the University of Wisconsin-Madison, classified the fat sources in eight categories: medium-chain fatty acids (12- and 14-carbons), unsaturated vegetable oil, palmitic acid, tallow, animal vegetable fat, calcium salts of palm oil, calcium salts of long-chain fatty acids, and saturated fat. In summary, while medium-chain fatty acid (12- and 14-carbons) and unsaturated vegetable oil both significantly decreased fiber digestibility (2.7 and 0.6 percentage units/1 percent fatty acids, respectively), calcium salts of long-chain fatty acids and saturated fats increased fiber digestibility (1.1 and 0.4 percentage units/1 percent FA, respectively). The other fat supplements did not affect fiber digestibility.

Innovations in feed additive research enhance animal performance:

Two multiparous and one primiparous cows were used to compare current diets (approximately 17.6 percent protein) with reformulated diets intended to reduce feed cost and dietary protein concentration (15.9 to 17.6 percent) containing a high-quality rumen undegradable protein source and rumen-protected amino acids (lysine and methionine). The prices ($/lb) of milk fluid, protein, fat and solids of the grade A milk in Washington state were 0.009, 2.889, 1.624 and 0.443 in 2013, respectively, and 0.017, 3.22, 2.36 and 0.479 in 2014. When cows were fed the balanced amino acid diets, income over feed cost was consistently greater than the control diets in first lactation cows (US$0.15 to US$0.18 cow/day) but consistently lower in multiparous cows (US$0.08 to US$1.01 cow/day (Diaz and García, 2019).

Synbiotic as Feed Additives Relating to Animal Health and Performance:

Probiotic:

A new description by the American Academy of Pediatric Committee on Nutrition states that probiotic is "microorganisms that generate small molecular metabolic by-products that exert beneficial regulatory effect on host biological functions and may function as immunomodulators" (Hickey *et al*., 2012; Hamasalim, 2016).

these bacteria affect the gut microflora positively and reduction the microbial toxic activity in intestine(Gismondo*et al*., 1999)

Probiotic is mainly lactic acid creating bacilli, mostly Lactobacilli (L. acidophilus DDS-1, Lactobacillus casei (L. casei), L. lactis, L. rhamnosus, L. salviarius) and Bifidobacteria (B. longum, B. infantis, B. bifidum), and the yeasts *Sacharomyces boulardii* (Brewer's yeast) and *Sacharomyces cervisiae* (Baker's yeast) (Kumar, 2013).

Probiotic may play a beneficial role in several health conditions and performance, including Intestinal microbial composition, therapeutic effects, metabolic effects and immunomodulation (Brown and Valiere, 2004; Hamasalim, 2015; Anandharaj *et al*., 2015).

Prebiotic

Prebiotic is "indigestible fermented diet substrate that selectively stimulates the composition, growth, and activity of microflora in gastrointestinal tract and thus improves hosts' health".

Prebiotic carbohydrates are naturally found in such fruit and vegetables tomatoes, Jerusalem artichoke, as oatmeal, bananas, flaxseed, asparagus, barley, berries, garlic, wheat, onions and chicory, greens and legumes. Crittenden, R. and Payne, M.J. (2008)

Prebiotics are not broken down by gastric enzymes, but pass unaltered into the large intestine, where they are then selectively fermented, creating beneficial effects (Hamasalim, 2009)

A study has shown that administration of prebiotic also results in increased numbers of beneficial intestinal flora (especially Bifidobacteria) (Vulevic *et al*., 2008; Schiffrin *et al*., 2007). Prebiotic have been demonstrated to increase mineral absorption, chiefly that of magnesium and calcium (De Preter *et al*., 2011; Demigné *et al*., 2008).

3) Synbiotic

Synbiotic refers to nutritional supplements combining prebiotic and probiotic and in a form of synergism. The main aim for using a synbiotic is that a true probiotic, without its prebiotic food, does not survive well in the digestive system. Synbiotic refers to nutritional supplements combining Probiotic and Prebiotic that are thought to act together; i.e. synergism. It has been suggested that a combination of a probiotic and a prebiotic, i.e. Synbiotics, might be more effect than either a probiotic or prebiotic alone Bengmark, 2005; De Vrese and Schrezenmeir, 2008). Furthermore, synbiotic is a mixture of probiotic and prebiotic which beneficially affects the host by improving the survival and the implantation of live microorganisms dietary supplements in the gastrointestinal tract, and thus improving host health (Harish and Varghese, 2006). Synbiotic is designed not only to present beneficial microorganisms populations, but also to promote proliferation of autochthonous-specific strains in the intestinal tract (Gourbeyre *et al*., 2011). Studies on the effects of synbiotic on metabolic health still are limited. It is worth mentioning that the health effect will likely depend on the synbiotic combination. Therefore, synbiotics seem promising for the modulation of the gut microbiota composition (Scavuzzi *et al*., 2014).

In early cases, probiotic as mono or mixed beneficial live microorganism was used as feed additive that plays a significant role in several health conditions and performances. In another way, the scientists use some indigestible ingredients with carbohydrates origin, especially oligosaccharides as a source of energy for beneficial microorganisms in the body which were called prebiotic and they are indigestible fermented food substrates that stimulate the growth, composition and activity of microorganisms in gastrointestinal and improve host. Most of the scientists urged to use all the above in such way that have more benefits in animal health and performance which were therefore called synbiotic, that was a combination between probiotic and prebiotic which beneficially had significant effects on the host by improving the survival and implantation of live microbial dietary supplements in the gastrointestinal tract, and thus improving animal health and performance. So, it was proposed that the synbiotic in this research increased beneficial microorganisms in the gastrointestinal tract and improved intestinal architect, and then promoted intestine environment. Consequently, it can improve blood indices, and especially decrease bad cholesterol (Low-density lipoprotein), decrease harmful microorganisms and toxins. However, it can also improve ingredient product, increase mineral absorption and nutrient. In conclusion, it can improve animal health and performance (Hamasalim, 2016).

CONCLUSION AND FUTURE PERSPECTIVE

Unlike probiotic, prebiotic do not add to an existing colony of bacteria, rather they provide nourishment for existing flora, allowing the colony to grow naturally and flourish. As probiotic is principally active in the small intestine and prebiotic is only effective in the large intestine, the combination of the two may give a synergistic influence. Probiotic is a live microbial food ingredient which is beneficial to host, while prebiotic is a non-digestible food ingredient which beneficially affects the host by selectively stimulating the growth and activity of one or a limited number of microorganisms in the colon having the potential to improve host well-being nevertheless, synbiotic is a mixture of probiotic and prebiotic which beneficially affect the host and thus improving host health and well-being .

From the research, it could be conclude that the intestine was a variable niche of beneficial and harmful microorganisms. The gastrointestinal tract has a compound community of microbiota that provides benefits to its host in many different methods, including nutrient production, protection against pathogens, detoxification, drug metabolism and regulation of the immune system. Animal studies have demonstrated changes in these gut microbial communities, and there are documents funding the use of probiotic, prebiotic and synbiotic. Though, the practice of synbiotic may possibly produce greater benefits rather than the application of individual portions. In recent years, synbiotic has become an integral part of the animal practices for improving the growth, enhancing blood picture, stimulating intestinal architecture, improving performance and competing against the pathogenic microbes. But limited information is available regarding the application of synbiotic in animal science. Experts recommend further research to substantiate preventive and therapeutic health benefits, mechanism of action, optimal intake, duration of treatment and selection of the best synbiotic (specific probiotic strains and type of prebiotic) for a targeted outcome in agriculture's animals.

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