Biotechnology in animal nutrition and feed utilization

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Abstract

The foremost role of biotechnology to the production of livestock is the use of different chemicals, such as feed additives to increase the nutrient value and content of animal feeds as well as the digestibility of low-quality feeds, including roughage. By safeguarding protein, amino acids, and fat, biotechnology can raise the nutritional value of animal feeds. Using different enzymes to increase nutrient availability from feed and reduce waste from feed and fodder, immune stimulants to stop harmful bacteria from infecting animals, plant biotechnology to produce feed and fodder with high nutritional values, adding antibodies to feeds to protect animals from disease, and genetic engineering of rumen microorganisms to improve animal gut health and performance are all examples of such techniques. Physical, chemical and biological treatments of poor quality feeds are also vital technology to improve digestibility and nutritional values in livestock feed sector.

Keywords: Biotechnology; nutritional value; feeds; digestibility

Introduction

Agriculture plays a significant role in the Ethiopia economy, accounting for 40% of the GDP and 80% of exports. In 2020, it employed 75% of the country's workforce (Muluye, 2021). Livestock is a crucial component of the agricultural sector, as it accounts for more than 26% of the value of annual crop production. The country has abundant livestock resources and is ranked first in Africa and fifth globally in terms of livestock population. The livestock population includes over 71 million cattle, 43 million sheep, 54 million goats, 57 million chickens, 13.33 million equines, and 7 million bee colonies (CSA, 2022). Livestock not only contributes to the agricultural GDP (45%) and the overall GDP (19%), but also plays a significant role in foreign exchange earnings, accounting for 16-19%. Livestock also provides food in the form of meat, milk, eggs, and honey, and owning livestock is associated with a 20% increase in potential caloric nutrition at the household level. A larger, increasingly affluent and urbanized population will demand more and more high-quality foods, including meat, milk and other livestock products (FAO, 2017).

Productivity of livestock sector in developing countries need to be considerably increased in order to satisfy increasing consumer demand, to more efficiently utilize scarce resources and to generate income for a growing agricultural population. Conventional methods of livestock productivity improvement have been used in the past many years and served the purpose of increasing livestock productivity for meeting the need of the world. But this method can no longer sustain production; consequently, new intensive techniques including biotechnology are now required to increase productivity of animals by using different alternatives (John and Maria, 2010). Due to the rapid population growth and economic expansion, there is a need to adjust to the growing demand for more food from livestock products, and biotechnology plays important roles in many ways in this regard. The feeding of livestock in many countries of the world is dependent on readily available low quality roughages or crop residues. In poorer countries that are densely populated, opportunities for supplementing these animals with products such as cereal grain, urea or molasses are limited (Rowe, 2009). Therefore, biotechnology in animal nutrition has role to play in improving nutritional quality and digestibility of poor quality feeds. According to Salem., *et al.* (2007), biotechnology plays a specific role in the production of livestock and may be divided into three categories: biological, chemical, and physical procedures that affect animal health, nutrition, breeding, and reproduction.

Feed availability and quality is among economically important factor that affect livestock sector in Ethiopia. As a generalisation, the forages consumed by animals of smallholder farmers in Ethiopia is almost always below 55% (usually 40–45%) digestibility and are often less than 8% crude protein and this protein level is more often around 3–5%, e.g. cereal straws. This problem calls for nutritional quality improvement strategies of the feed like crop residues. According to Leng (2011) biotechnology in animal nutrition has the potential to provide new opportunities for achieving enhanced livestock productivity in a way that alleviates poverty, improves food security and nutrition and promotes sustainable use of livestock products. Consequently, biotechnology can provide fresh and unexpected opportunities to boost animal productivity through improved nutrition and feed utilisation. Therefore, the aim of this article is to succinctly describe biotechnology for improved animal nutrition.

Role of biotechnology in animal nutrition

Biotechnology is the application of scientific and engineering principles that use living organisms to make or modify products, enhance plants or animals, or develop microorganisms for specific uses that are beneficial to humans (De, 2005 and Steinberg and Raso, 2008). It ranges from the conventional biotechnology also called traditional biotechnology process such as baking, making use of yeast to the complex, the recombinant DNA technology or the classical to include bio fertilizers, biological nitrogen fixation and fermentation to the modern biotechnology which ranges from plant tissue culture, cell culture, recombinant diagnostic and genetic engineering (Jindal and Sharma, 2010). Now day's biotechnology is mostly identified with applications in medicine and agriculture based on the knowledge of the genetic code of life. One of the benefits of biotechnology in animal husbandry is being able to provide increased livestock productivity. The main contribution of biotechnology to the production of livestock is the use of various chemicals, such as feed additives, to increase the nutrient value and content of animal feeds as well as the digestibility of low-quality feeds, including roughage (Pratik, 2023).

Improving fibrous roughage feeds

Fibrous feeds of low digestibility comprise the major proportion of feeds accessible to most ruminants under smallholder situations in developing countries. Fibrous feed utilization can be enhanced by improving metabolism and activity of gut microorganism, which is very important for animal health and growth. This can be done in three different ways. The first one is the introduction of biotechnical products to improve the gut ecosystem and promote the growth of beneficial bacteria/microbe. The second one is to genetically modify microorganisms naturally present in the gut to enhance their capacity of defined functions (Mc Sweeney et al.,

2019). Genetically modified microbes have the ability either to digest fibrous components and lignin of forages, to degrade toxins, to synthesize essential amino acids, to reduce methane formation, or to tolerate acids. The third way is to introduce new species or strains of microbes into the gut (Raeth et al., 2007). This application has a great potential than the first two methods to increase digestibility of feedstuffs and to improve animal health and growth. It is well known that some micro-organisms, including cellulose enzymes from anaerobic bacteria and white rot fungi (Pleurotus ostreatus) can degrade lignin in the cell walls. Several fungal strains have been used for lignocellulosic hydrolysis such as Asprigullus niger, A. terreus, Fusarium moniliforme and Chaetomium celluloyticum (Kim et al., 2005). However, among many species of fungi white rot fungi have been reported to be suitable for treatment of roughages so far. As white rot fungi have the capacity to attack lignin polymers, open aromatic rings and release low molecular weight fragment (Zadrazil, 2005). The other techniques for enhancing low quality forages, like cereal straws, include mechanical processes like grinding, physical processes like heating and cooling, temperature and pressure treatment, or a variety of chemical processes. Additionally, by breaking ligno-cellulosic linkages, these techniques enhance the rumen's ability to microbial break down roughage (Pratik, 2023).

Feed additives

Feed additives are an ingredient or combination of ingredients added to the basic feed mix or parts thereof to fulfil the specific need. Usually used in micro quantities and requires careful handling and mixing. They are used to improve rate of gain, feed efficiency, preventing and controlling disease, prevention against untoward environmental influences. Feed additives are helpful for the animal to enhance the effectiveness of nutrients and exert their effects in the gut (Fuller, 2019). The use of feed additives is a commonly adopted practice for enhancing swine and poultry production and is now gaining recognition for ruminant diets as well. Biotechnological advances have a fair share in adding convenience to the production and availability of these compounds, the following is an account of some major commercially available bio-engineered products manufactured through applications of modern biotechnology (Gohar et al., 2021).

Enzymes

The commercially produced exogenous enzymes, such as Cellulase, xylanase, protease, hemicellulase and phytase are added to feedstuff to improve its nutritive value which is otherwise hampered due to the presence of anti-nutritive and indigestible factors. Therefore, supplementation of these enzymes as a means of improving nutritive value is becoming usual activity. Their major purpose is to improve the nutritive value of available diets, especially when poor-quality like, roughages. Amino acid digestibility is improved with phytase enzyme supplementation. Cellulase enzymes can be used to break down cellulose, which is not degraded by endogenous mammalian enzymes. Enzymes are essential for the breakdown of cell-wall carbohydrates to release the sugars necessary for the growth of the lactic acid bacteria. Supplementation of a wheat by-product diet with cellulase increased the digestibility of non-starch polysaccharides from 0.192 to 0.359 and crude protein from 0.65 to 0.71 (McDoland, 2010).

Removing anti-nutritive factors

Protease inhibitors, tannin, and cyanogen in legumes, as well as glucosinolates, tannins, and saponin in rapeseed meal and other substances in feeds, are anti-nutritive elements found in plant tissues. The negative effects of these substances are more pronounced in non-ruminants than in ruminants, similar to deficits in amino acids. Such anti-nutritive elements have been lessened and, in some cases, eliminated from feed through different conventional methods (Pratik, 2023). Processing techniques and methods such as fermentation, germination, debranning, autoclaving, soaking etc. are used to reduce the anti-nutrient contents in foods. By using various methods alone or in combinations, it is possible to reduce the level of anti-nutrients in foods (Samtiya et al., 2020).

The alkali treatment

Tremendous amounts of fibrous crop residues such as wheat, barley and rice straws are underutilised throughout the world. During the 70s and 80s there was considerable interest in the chemical treatment of straws and other of low quality roughages to improve their quality for livestock feeding. The Beckmann method of alkali treatment consists of soaking crop residues, like straws in dilute alkali solutions for 24 hours and then washing it with clean water (Jackson, 2017). According to Jackson (2017), straw digestibility is increased from about 40 to about 70%. Other earlier researches also showed very exciting increases in the digestibility of roughages in response to treatment with sodium hydroxide. Sheep and cattle fed alkali-treated roughages showed benefits in terms of increased feed intake in addition to the expected improvements associated with higher digestibility of the roughage. Based on this early success, calcium and potassium hydroxide were investigated as alternative sources of alkali. There was also work on the use of ammonia to treat roughages, particularly from the point of view of treating straw with anhydrous ammonia, urea or, as an alternative source of ammonia, urine (Rowe, 2009). It has been noticed that ammonization (both for anhydrous ammonia and urea) has presented more efficient result in

animal's performance when compared with sodium hydroxide or calcium oxide. But, regarding nutritive values of roughage, both sodium hydroxide and calcium oxide have presented a higher efficiency in the decreasing of cell wall and in the increase of treated roughage' digestibility (Pires et al., 2010).

Physical treatment of roughages

Physical characteristics of roughages may be altered to improve digestibility and/or intake. Grinding, chopping, soaking, irradiation, pressure treatments using steam, and pelleting are common physical treatment method to improve digestibility of roughage feeds. Particle size, affects not only roughage, but can have a large effect on the rate of fermentation and intestinal digestion of cereal grains (Rowe, 2009). According to Kumar and Singh (2021) feeding of physically treated roughage (ground roughage) reduces rumination and rumen retention time and feed consumption is increased leading to better animal performance.

Table 1. Effect of alkali treatment on digestibility of straw in sheep

Treatment of barley straw	***in-vivo* digestibility %**
Untreated	50.8
Sodium hydroxide	75.2
Aqueous ammonia	65.7

Table 2. Intake and body weight gain of young cattle fed on urea-treated and untreated rice straw

Parameters	**untreated straw**	**treated straw**
Straw DM intake(kg/d)	1.81	2.69
Initial weight (kg)	152.8	152.2
Final weight (kg)	176.2	186.6
Weight gain (kg/d)	0.260	0.383

DM = Dry matter; d = day. As discussed by Rowe (2009).

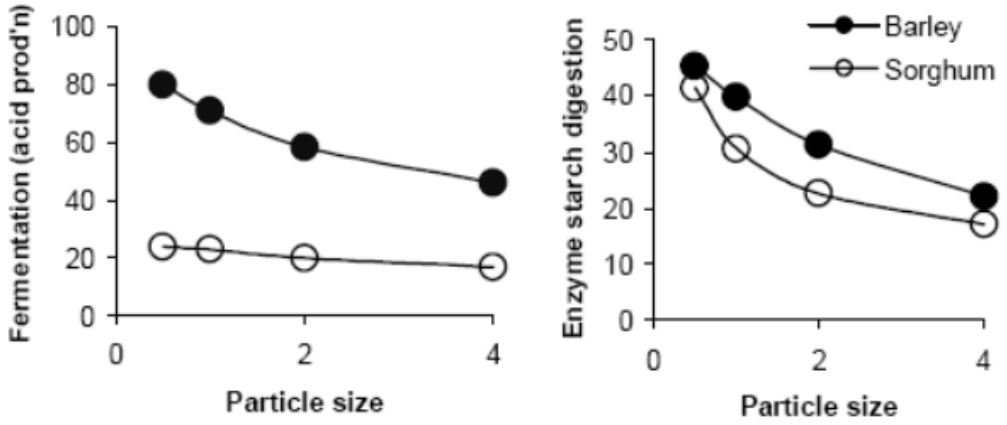

Fig 1. Effect of particle size on rumen fermentation and intestinal digestion of barley and sorghum as discussed by Bird *et al*. (2007).

Conclusion

There are numerous potential opportunities for improving the nutritional value and digestibility of feeds, roughages. Modification of rumen microbial population in ruminants is one such opportunity. Nevertheless, technical difficulties associated with making genetic modifications to individual species of rumen bacteria hamper progress in developing countries. Feed additives to animal nutrition, such as antibiotics, probiotics and prebiotics and enzymes in feed, are available technology to improve the nutrient availability and digestibility of feeds and the livestock productivity. Biological treatments, physical and chemical treatments are also important methods of poor quality feeds.

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