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REVIEW ARTICLE

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Nutritional Limitation and Opportunities of Biotechnology in Solving Livestock Feed Shortage: Review

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ABSTRACT

As a result of a growing population, national economies and urbanization the consumption of animal products has risen sharply and will also rise substantially in the future, leading to a huge demand for animal feed. This paper illustrates that feed impacts almost all sectors and services of the livestock sector and its sustainability hinges on how feed is produced and fed. However, there are beginnings of using biotechnology in animal production particularly animal nutrition these days. On this parts, the linkages between animal nutrition and biotechnology in sustainably solve the nutritional limitation are highly vital in the present situation. The review mainly focus on common nutritional limitation in livestock production; Seasonal variation of feed resource, variable livestock feed cost, feed quality and Product Interaction, impact of nutritional limitation, increased food-feed competition and contributions of biotechnology in animal feed utilization; biotechnology in nutrient recycle, biotechnology in nutrition and feed utilization, biotechnology in fibrous feeds improvement, improving nutritive value of cereals, removing anti-nutritive factors from feeds, biotechnology in forage breeding, Improving nutritive value of conserved feed and defaunation in ruminants. The ultimate goal of using biotechnology in animal nutrition is to improve the plane of nutrition through increasing availability of nutrients from feed and to reduce the wastage of the feed.

Keywords: Biotechnology, Livestock feed and Nutritional limitation.

INTRODUCTION

Many developing countries may have to double their food production to nourish their alarmingly growing population (Royal Society, 2009; Alexandratos *et al.*, *2012;* Bimrew, 2014). It is likely that the demand growth for cereals will be less than demand growth for food in the aggregate, but one can also imagine a scenario in which both cereal and livestock production may have to double within that period if meat consumption and livestock feed accelerate (Bimrew, 2014). Demand for livestock products is increasing because of the increasing human population, growth in income and urbanization (Thornton, 2010) in different parts of the globe. Most food of animal origin consumed in developing countries is currently supplied by small-scale, often mixed crop-livestock family farms or by pastoral livestock keepers (John, 2001).

Productivity of animals in developing countries will need to be substantially increased in order to satisfy increasing consumer demand, to more efficiently utilize scarce resources and to generate income for a growing agricultural population (Leng, 2010). On the other hand, conventional methods of livestock improvement have been used in the past served the purpose of increasing livestock productivity (Bimrew, 2014). Under the present scenario, it will be difficult to meet simultaneously the goal on eradicating poverty and hunger while also satisfying livestock feed demand in food-feed competition situation (Royal Society, 2009; Alexandratos *et al., 2012*). However, these options can no longer sustain production; consequently new intensive techniques including biotechnology are now required to augment productivity (Soetan and Abatan, 2008). Modern biotechnology 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 natural resources (Leng, 2010; Bimrew, 2014). This paper reviewed the common application of biotechnology in animal nutrition to solve the livestock feed limitation and future implications.

COMMON NUTRITIONAL LIMITATION IN LIVESTOCK PRODUCTION

1. Seasonal variation of feed resource

Both wet and dry season are feed shortage time in most parts of the country especially on April, May, June and Jully is the most focusing area (Amare, 2012). Lack of rainfall, over grazing, scarcity of land and drought are major causes for shortage feed in dry and wet seasons. Purchasing extra grazing land and purchase extra hay is reducing the number of sheep per house hold (Zinash *etal.*, 2011). During wet season due to small grazing land, sheep are predisposed to feed shortage and the farmer purchase extra grazing land and crop residues (Zinash *etal.*, 2011). Hay and crop residue are also a good source of feed provision measurement during dry season. Management with respect to feeding or grazing was different for dry and rainy or cropping season (Tesfaye, 2008). Livestock largely depend on range land grazing or crop residues that are poor nutritive value and fed is not uniformly supplied and the quality is also poor (Tesfaye, 2008).

2. Variable Livestock feed cost

Feed is financially the single most important element of animal production in most production system, irrespective of species. Feed costs can account for up to 70% of the total cost of production of an animal product (Makkar and Beever, 2013). High feed costs and/or high volatility in feed costs can wipe out a livestock rearing operation. As a result of global financial and economic crisis in 2008 high cost of feeds decreased supply of animal products and increased prices. Optimization of feed-use efficiency (i.e. producing more with less feed) decreases feed in costs and increases economic viability of the livestock operation (Makkar and Beever, 2013).

3. Feed Quality and Product Interaction

Feed type, ingredient in the feed and amount of nutrient contained in daily ration of animal has profound effect on the product harvested (Butler, 2014). Several studies (e.g. Butler, 2014; Vazirigohar *et al*., 2014) present opportunities to improve final product quality including increases in conjugated linoleic acid, omega-3 fatty acids, minerals in animal products, and product shelf life through manipulation of animal feeding. Many of these changes elicit positive effects on human health (Ip *et al*., 1991; Belury, 2002; Bauman *et al*., 2006). Recently, there has been interest in the use of dietary polyunsaturated fatty acids, specifically the omega-3(n-3) fatty acids a-linolenic acid, eicosapentaenoic acid, and docosahexaenoic acid, to improve sow and piglet performance. Feeding specific n-6 and n-3 fatty acids from either fish (Mateo *et al*., 2009; Leonard *et al*., 2010) orflax (Farmer and Petit, 2009) to sows also transfer these fatty acids to their offspring via milk. Feeding cattle with flax-based feeds can increase concentrations of n-3 fatty acids in beef, which is considered to have human health benefits (Drouillard *et al*., 2004). Likewise, meat from pasture-finished lambs had higher n-3 polyunsaturated fatty acids than from those finished indoors on commercial pellets (Kitessa *et al*., 2010). Addition of tannins and saponins in the diet has been shown to change colour and increase shelf life of meat. Increase in antioxidation potential in milk has also been shown by phenolicrich diets (Vasta *et al*., 2011).

4. Impact of Nutritional Limitation

Improper nutrition (unbalanced diet: under- or overfeeding) can impact adversely health, both directly as well as indirectly by making animals more prone to diseases (Berthon and Wood, 2015). Furthermore, in case of disease, corrective measures in the form of medicines may be less or not effective. Vaccination done during the period of improper nutrition might also not properly protect the animals (Saker, 2006). Correct nutrition can reduce infectious diseases by enhancing cell-tissue integrity and optimizing defence mechanisms of the immune system (FAO, 2012*b*). Feeding of a balanced ration has been shown to increase immune-globulin levels in blood, suggesting higher immunity (FAO, 2012*a*). Supplements such as minerals, antioxidants and amino acids such as methionine also play a role in immune stimulation (Celi *et al*., 2014; Jankowski *et al*., 2014). Influence of nutrition on the aging process and ultimately lifespan in pet animals has recently been highlighted (Butterwick, 2015). Even, maternal nutrition during pregnancy has an impact on animal health of offspring later in life (Bell and Greenwood, 2013; Mossa *et al*., 2015). Better nutrition could also be a bio-security measure to control zoonotic and infectious diseases.

5. Increased Food-Feed Competition

In 2012–2013, 795 million tonnes of cereals (one-third of total cereal production) were used globally in animal feed and by 2050 an additional 520 million tonnes would be required for feeding livestock to meet the anticipated increase in demand of animal products. In 2000, 78% of feed grains were fed to pigs and poultry in regions where industrial intensive systems dominate (FAO, 2013). According to an estimate, taking the energy value of the meat produced from all livestock into consideration, the loss of calories by feeding the cereals to animals instead of using the cereals directly as human food represents the annual calorie need for more than 3.5 billion people (Nellemann *et al*., 2009). In the past 20 years, there has been an increased interest in forage-fed beef for multiple reasons (health related, environmental concerns, and welfare issues; Scaglia *et al*., 2014). Use of smart feeding options such as a decrease in the level of grains in the concentrate by using agro-industrial by-products, an increase in green fodder use, use of chopped forages, and increase in digestibility of crop residues could contribute to decrease in grain in ruminant diet. About 10% (~120 million tonnes) of global production of coarse grains are used for bioethanol production (FAO, 2012). The International Food Policy Research Institute estimates that under a scenario of drastic biofuel expansion up to 2050 would lead to the number of undernourished pre-school children in Africa and South Asia being 3 and 1.7 million higher than would have been otherwise the case (FAO, 2009).

CONTRIBUTIONS OF BIOTECHNOLOGY IN ANIMAL FEED UTILIZATION

Nutrition is one of the most serious limitations to livestock production in developing countries, especially in the tropics (Rege, 1996). Plants generally contain anti-nutrients acquired from fertilizers, pesticides and several naturally-occuring chemicals (Igile, 1996). Some of these chemicals are known as secondary metabolites and they have been shown to be highly biologically active (Zenk, 1991). Examples of these secondary plant metabolites are saponins, tannins, flavonoids, alkaloids, oxalates, phytates, trypsin (protease) inhibitors, cyanogenic glycosides etc. Some of these chemicals have been shown to be deleterious to health or evidently advantageous to human and animal health if consumed at appropriate amounts (Kersten *et al.,* 1991; Sugano et al., 1993). These anti-nutritional factors affect the overall nutritional value of human foods and animal feeds (Osagie, 1998). Some of these plant components have the potential to precipitate adverse effects on the productivity of farm livestock (D'Mello, 2000).

Conventional plant breeding methods has been used to reduce and in some cases, eliminate such anti-nutritive factors (ANF) (Rege, 1996). An example is the introduction of cultivars of oilseed rape which are low in or free from erucic acid and glucosinolates.

A combination of genetic engineering and conventional plant breeding methods could lead to substantial reduction or removal of the major anti-nutritive factors in plant species of importance in animal feeds (Rege, 1996). Transgenic rumen microbes could also play a role in the detoxification of plant poisons or inactivation of anti-nutritional factors (Rege, 1996). Successful introduction of a caprine rumen inoculum obtained in Hawaii into the bovine rumen in Australia to detoxify 3 hydroxy4 (IH) pyridine (3,4 DHP), a breakdown product of the non-protein amino acid mimosine found in Leucaena forage. Jones and Megarrity (1986) demonstrate the possibilities. However, the pharmacological and other beneficial effects of these anti-nutritional factors in plants have been reviewed by Soetan (2008).

1. Biotechnology in nutrient recycle

Livestock recycle nutrients on the farm, produce valuable output from land that is not suitable for sustained crop production and provide energy and capital for successful farm operations (Delgado *et al.,* 1999). Livestock can also help maintain soil fertility in soils lacking adequate organic content or nutrients (Ehui *et al.,* 1998). Adding animal manure to the soil increases the nutrient retention capacity (or cation-exchange capacity), improves the soil's physical condition by increasing its water-holding capacity and improves soil structure (Delgado *et al.,* 1999). Animal manure also helps maintain or create a better climate for micro- flora and fauna in soils. Grazing animals improve soil cover by dispersing seeds, controlling shrub growth, breaking up soil crusts and removing biomass that otherwise might be fuel for bush fires (Delgado *et al.,* 1999). These activities stimulate grass tilling and improve seed germination and thus improve land quality and vegetation growth. Livestock production also enables farmers to allocate plant nutrients across time and space by way of grazing to produce manure, land that cannot sustain crop production. This makes other land more productive (Delgado *et al.,* 1999). Grazing livestock can also accelerate transformation of nutrients in crop by-products to fertilizer, thus speeding up the process of land recovery between crops. As disease constraints are also removed, large breeds of livestock can be integrated into crop operations for providing farm power and manure (Delgado *et al.,* 1999). Biotechnology has enhanced increased animal production Through Artificial Insemination (AI) and also improved animal health and disease control through the production of DNA recombinant vaccines (Soetan and Abatan, 2008).

2. Biotechnology in nutrition and feed utilization

The shortage of feed in most developing countries and the increasing cost of feed ingredients mean that there is a need to improve feed utilization (Akinfemi *etal.,* 2009). Aids to animal nutrition, such as enzymes, pro-biotics, single-cell proteins and antibiotics in feed, are already widely used in intensive production systems worldwide to improve the nutrient availability of feeds and the productivity of livestock (Ehui *et al.,* 1998).

Gene-based technologies are being increasingly used to improve animal nutrition, either through modifying the feeds to make them more digestible or through modifying the digestive and metabolic systems of the animals to enable them to make better use of the available feeds (Bedford, 2000). Feeds derived from GM plants (a quarter of which are now grown in developing countries), such as grain, silage and hay, have contributed to increases in growth rates and milk yield (Butler, 2014). Genetically modified crops with improved amino acid profiles can be used to decrease nitrogen excretion in pigs and poultry (Ehui *et al.,* 1998). Increasing the levels of amino acids in grain means that the essential amino acid requirements of pigs and poultry can be met by diets that are lower in protein (Ehui *et al.,* 1998).

Metabolic modifiers have also been used to increase production efficiency (weight gain or milk yield per feed unit), improve carcass composition (meat-fat ratio), increase milk yield and decrease animal fat. The use of recombinant bovine somatotropin (rBST) in dairy cows increases both milk yield and production efficiency and decreases animal fat. In the USA, the use of rBST typically increases milk yield by 10% to 15% (Ehui *et al.,* 1998). Although trials conducted in developing countries have reported a similar percentage increase, this increase is not significant because of the low milk yields and the high cost-benefit ratio (Butler, 2014). However, rBST is being used commercially in 19 countries where the economic returns make its use worthwhile. A porcine somatotropin has been developed that increases muscle growth and reduces body-fat deposition, resulting in pigs that are leaner and of greater market value (Akinfemi *etal.,* 2009). livestock feeds and nutrition, improving animal health, managing natural resources relating to the livestock sector, assessing the impact of technological interventions, and strengthening the capacity of the national agricultural research systems of developing countries (Ehui *et al.,* 1998). Furthermore, the potential production capacity and contribution of livestock to the economy are still not being achieved in developing countries because the transfer, adaptation and adoption of technology is hampered by the lack of a clear policy for livestock development that is conducive to the introduction of new proven technology and by the lack of information flow from and to decision makers (Akinfemi *et al.,* 2009).

3. Biotechnology in fibrous feeds improvement

Fibrous feeds of low digestibility comprise the major proportion of feeds accessible to most ruminants under smallholder situations in developing countries (Lebbie and Kagwini, 1996; Vasta *et al*., 2011). 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.,*1985). However, among many species of fungi white rot fungi have been reported to be suitable for treatment of roughages so far. As in (Zadrazil *etal.,*1995), the white rot fungi have the capacity to attack lignin polymers, open aromatic rings and release low molecular weight fragments. Significant results were reported in (Akinfemi *etal.,* 2009) for CP of maize cob treated with fungi species (*Pleurotus pulmonarius and Pleurotus sajor-caju)*.

It must be remembered, however, that whatever organism is grown on the roughage must obtain its energy from the roughage itself (Leng, 1991). In general, the organisms that suit for this purpose must have a number of special properties (Butler, 2014). They must be capable to grow on a wide range of carbon sources, have high growth rates to minimize the size of the fermentation system and have a high efficiency in converting of substrate to biomass with high protein content (Vasta *et al*., 2011).

Another indirect approach to the enhancement of fiber digestion in ruminants is through modification of silageinoculants. In silages containing low carbohydrate contents, inclusion of amylase, cellulase or hemicellulase enzymes has been shown to increase lactic acid production by releasing sugars for growth of lactobacilli (Vasta *et al*., 2011). Thus, inoculation of silage bacteria genetically modified to produce such enzymes has been proposed to obtain better ensiling and/or pre-digest the plant material in order to lead to better digestibility in the rumen (Vasta *et al*., 2011). As in (Scheirlinck *etal.,*1990), recombinant *Lactobacillus plantarum*, a species used as silage starter, were constructed to express alphaamylase, and cellulase or xylanase genes. The competitive growth and survival of such modified lactobacilli in silage has been reported by other workers (Sharp *etal.,*1992), although the impact on silage digestibility has not been studied.

4. Improving nutritive value of cereals

Moderate protein content and low amounts of specific amino acids limit the nutritive value of cereals and cereal by-products (e.g. barley is low in Iysine and threonine). This is a major limitation in the ration formulation for non-ruminant livestock which necessitates addition of expensive protein supplements (Butler, 2014). There are different studies to enhance the low level of Iysine in barley by genetically engineering the grain genome (Miflin *et al.,* 2003; Shewry and Kreis 2001). Genetic modification through insertion of genes into rice protoplasts and generation of transformed plants has already been achieved (Akinfemi *etal.,* 2009).

5. Removing anti-nutritive factors from feeds

Anti-nutritive factors in plant tissues include protease inhibitors, tannins, phytohaemagglutinins and cyanogens in legumes, and glucosinolates, tannins and sanapine in oilseed rape (*Brassica napus*) and other compounds in feeds belonging to the *Brassica* group (Butler, 2014). As with amino acid deficiencies, the adverse effects of these compounds are more marked in non-ruminants than in ruminants (Chubb, 1983). Conventional plant breeding has been used to reduce and, in some cases, eliminate such anti-nutritive factors (Butler, 2014). An example is the introduction of cultivars of oilseed rape which are low in, or free from erucic acid and glucosinolates. A combination of genetic engineering and conventional plant breeding should lead to substantial reduction or removal of the major anti-nutritive factors in plant species of importance as animal feeds (Butler, 2014). Transgenic rumen microbes could also play a role in the detoxification of plant poisons (Gregg, 1989) or inactivation of antinutritional factors. Successful introduction of a caprine rumen inoculum obtained in Hawaii into the bovine rumen in Australia to detoxify 3-hydroxy 4(IH) pyridine (3,4 DHP), a breakdown product of the non-protein amino acid mimosine found in *Leucaena* forage (Jones and Megarrity, 1986) demonstrates the possibilities.

6. Biotechnology in forage breeding

Improving and utilization of food and forage crops through bioengineering technique has variety of potential benefits for production, the environment and human health, are at present being developed (Edwards, *etal.,*2000). The modification of crops can be done by modifying recombinant DNA technology with the objective of introducing or enhancing a desirable characteristic in the plant or seed. These genetically engineered crops are aimed at offering a range of benefits to consumers, as well as developers and producers. Products to be consumed by humans, derived from animals fed on transgenic forage crops, are not themselves transgenic. Thus, food products derived from animals fed on transgenic forage crops offering human health benefits may receive different levels of support from the public than the currently obtainable set of transgenic food crops (Dschaak, 2012).

High lignin content reduces the efficiency of feed utilization and thereby reduces animal growth. Conventionally Bred forage varieties with reduced lignin are available, but they tend to have weaker stems and poor standability in the field. Researchers have developed engineered alfalfa with 20 percent less lignin and 10 percent more cellulose, a combination that makes it more digestible. The ability to modify specific components of fiber biosynthesis may allow scientists to develop reduced-lignin forage that is more digestible and still has the stem strength needed for good field performance. Protein content and feeding quality are being targeted for improvement in biotech crops (Etherton *etal.,* 2003). Several fungal strains have been used for lignocellulosic hydrolysis such as *Asperigillus niger*, *A. terreus*, *Fusarium moniliforme* and *Chaetomium celluloyticum* (Akinfemi *etal.,* 2009). However, among many species of fungi white rot fungi have been reported to be suitable for treatment of roughages so far. Zadrazil *et al.* (2008) found that, the white rot fungi have the capacity to attack lignin polymers, open aromatic rings and release low molecular weight fragments.

It is known that forage legumes are comparatively low in sulphur-containing aminoacids and their availability to ruminants is further adversely affected during rumen digestion (Croissant, 1976). This leads to the reduction of the optimum for animal growth level of essential amino acids. Plant genetic modification with genes encoding for a sulphur amino acid-rich proteins, resistant to rapid rumen degradation can compensate this deficiency. Agronomic researchers around the globe are currently using recombinant DNA technology to create new and altered species of plants. High-oil Corn reduces the amount of feed required for a livestock diet, and this in turn reduces the volume of manure (European

Commission, 2000). Furthermore, Conventional high-oil crops often have lower yield or protein content than their lower oil counterparts, whereas traits introduced via biotechnology can modify oil accumulation only at specific growth stages and in targeted tissues to minimize such deleterious effects. Biotech modification of the oil composition of feeds, such as raising the level of oleic acid, may also improve the quality of the resulting animal products for processing and human nutrition (European Commission, 2000).

7. Improving nutritive value of conserved feed

Molasses is of particular relevance to smallholder farmers in developing countries in the tropics where sugar-cane is produced and processed (Vazirigohar *et al*., 2014). Enzymes are essential for the breakdown of cell-wall carbohydrates to release the sugars necessary for the growth of the lactic acid bacteria (Vazirigohar *et al*., 2014). Although resident plant-enzymes and acid hydrolysis produce simple sugars from these carbohydrates, addition of enzymes derived from certain bacteria, e.g. *Aspergillus niger* or *Trichoderma viridi* (Henderson and McDonald, 1977; Henderson *et al.,* 1982) increases the amount of available sugars. Commercial hemicellulase and cellulase enzyme cocktails are now available and improve the fermentation process considerably (Hooper *et al.,* 1989). However, prices of these products preclude their viability for farm level application, especially in developing countries.

In order to improve the effectiveness of microbial inoculants in breaking down structural carbohydrates to glucose, detailed knowledge of the lactobacilli bacteria is essential (Vazirigohar *et al*., 2014). Work already undertaken on the molecular biology of *Lactobacillus plantarum* and other species (Armstrong and Gilbert, 1991) suggest that the rapid progress in this area will make it possible to construct novel genes encoding highly active fibre-degrading enzymes. Such genes could then be inserted into strains of *L. plantarum indicating* biotechnological impute to facilitate the process (Akinfemi, 2009).

8. Defaunation in Ruminants

Protozoa, unlike bacteria, are not vital for the development and survival of the ruminant host, and their elimination (defaunation), although producing a less stable rumen environment, has been found to reduce gaseous carbon and nitrogen losses (Fuller, 1989). It has been established that ruminants can survive with or without these organisms; however, manipulating their population may affect protein metabolism in the rumen (Wael *et al.,* 2008).

The control of the rumen protozoal population by inhibition compounds would seem attractive because their eukaryotic cell nature would allow them to be susceptible to a number of compounds that would have little or no effect on the prokaryotic bacterial cells (McDonald *etal.,* 2010). However, the rumen methanogenic micro-organisms could also be sensitive because of their archaebacteriai cell nature and loss of these hydrogen-gas-utilizing methanogenic organisms would drastically disrupt the entire rumen fermentation system (Vazirigohar *et al*., 2014). The metabolism of other bacterial species would also have to be genetically engineered to provide a hydrogen sink. One possibility would be to engineer Eubacterium limosum, a relatively numerically minor species in the rumen, to preferentially form acetate and butyrate from HP and carbon dioxide.

In another study (Hsu *et al.,* 1991), defaunation did not decrease total free amino acid concentrations in ruminal fluid, but it altered the profile of free amino acids. Although defaunation increased ruminal bacterial numbers, no increases in total microbial CP or OM concentrations in ruminal contents were observed (Vazirigohar *et al*., 2014). As indicated in (Diaz *etal.,* 1993), for sheep based forage diets as protozoal population reduced (84%), the degradability of the dry matter at 24 h also increased significantly. An important implication of this study is the possibility of developing a practical way to maintain a reduced number of protozoa in ruminants while at the same time being a source of nutrients (Vazirigohar *et al*., 2014).

SUMMARY AND CONCLUSION

The way of biotechnology application to agriculture and livestock production will have a remarkable impact on the future of biotechnology. It offers a range of tools to advance our understanding, management and use of crop and other livestock feed resources for livestock production and productivity in different social and economic benefits of man. Biotechnology in animal production in developing countries has been applied only in a few areas such as conservation, animal improvement, healthcare and augmentation of feed resources. Adopting biotechnology has benefitted by in animal improvement and economic returns to the livestock entrepreneurs and small producers. Biotechnology in feed limitation mitigation is critically looked into to feed protein rich feed to the alarmingly growing world population. In this area biotechnology provide room to utilize unutilized, less quality and minimize feed-food competition.

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REFERENCES

Akinfemi, A., O. A. Adu and F. Doherty, (2009). Assessment of the nutritive value of fungi treated maize cob using in vitro gas production technique. Livestock Research for Rural Development, Volume 21, Number 11, November 2009. ISSN 0121-3784.

Alexandratos, N. and Bruinsma, J. (2012). *World agriculture towards 2030 /2050: the 2012 revision. ESA Working Paper No. 03*. (FAO, Rome, 2012). http://www.fao.org/docrep/016/ap106e/ap106e.pdf

Amare, S. (2012). Qualitative and quantitative aspects of animal feed in different agro-ecological and Agriculture: Livestock in the Balance FAO, Rome, 2009.

Bauman, D.E., Mather, I., Wall, R. and Lock, A.L. (2006). Centennial issue – major advances in dairy science in the last twenty-five years: major advances associated with the biosynthesis of milk. *Journal of Dairy Science* **89**, 1235–1243. doi:10.3168/jds.S0022-0302 (06)72192-0.

Bell, A.W. and Greenwood, P.L. (2013). Optimizing maternal cow, grower and nisher performance in beef production systems. In 'Optimization of feed use efficiency in ruminant production systems'. FAO Animal Production and Health Proceedings, No. 16. Rome. (Eds HPS Makkar, D Beever) Proceedings of the FAO Symposium, 27 November 2012, Bangkok, Thailand. (FAO and Asian-Australasian Association of Animal Production Societies) Available at http://www.fao.org/docrep/018/i3331e/i3331e.pdf [Verified 20 November 2015]

Belury, M.A. (2002). Dietary conjugated linoleic acid in health: physiological effects and mechanisms of action. *Annual Review of Nutrition* **22**, 505–531. doi:10.1146/annurev.nutr.22.021302.121842

Bimrew Asmare (2014). "Biotechnological Advances for Animal Nutrition and Feed Improvement." *World Journal of Agricultural Research*, vol. 2, no. 3 (2014): 115-118. doi: 10.12691/wjar-2-3-5.

Butler, G. (2014). Manipulating dietary PUFA in animal feed: implications for human health. *The Proceedings of the Nutrition Society* **73**,87– 95. doi:10.1017/S0029665113003790

Bergen, W.G. (2007). Contribution of research with farm animals to protein metabolism concepts: a historical perspective. *The Journal of Nutrition* **137**, 706–710.

Butterwick, R.F. (2015). Impact of nutrition on ageing the process. Bridging the gap: the animal perspective. *British Journal of Nutrition* **113** (Suppl. 1), S23–S25. doi:10.1017/S0007114514003900

Celi, P., Chauhan, S.S., Cottrell, J.J., Dunshea, F.R., Lean, I.J., Leury, B.J. and Liu, F. (2014). Oxidative stress in ruminants: enhancing productivity through antioxidant supplementation. Available at http://www.feedipedia.org/content/ oxidative-stress-ruminants-enhancing-productivity-through-antioxidantsupplementation [Verified 20 November 2015]

Chubb, L.G. (1983). Anti-nutritive factors in animal feedstuffs. In: Haresign W. (ed), *Recent Advances in Animal Nutrition*. Butterworths, London, UK. pp. 21-37.

Croissant, G., Meton, B., Miller, D. and Kellog, W. (1976) Biotechnology Journal. New Mexico State University Agricultural Experiment Station, Las Cruces.

Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S. and Courbois, C. (1999). Livestock to 2020: The next Food revolution. Food, Agriculture, and the Environment. Discussion Paper 28. IFPRI/FAO/ILRI,IFPRI, Washington, D.C.

Diaz, A., Avendano, M. and Escobar, A., (1993). Evaluation of*Sapindus saponaria* as a defaunating agent and its effects on different ruminal digestion parameters. Livestock research for rural development. Volume 5, No. 2.

Drouillard, J.S., Seyfert, M.A., Good, E.J., Loe, E.R., Depenbusch, B. and Daubert, R. (2004). Flaxseed for finishing beef cattle: effects on animal performance, carcass quality, and meat composition. In 'Proceedings of the 60th Flax Institute',17–19 March, Fargo, ND. pp. 108–117.

Dschaak, C.M. (2012) Use of Rumen Modifiers to Manipulate Ruminal Fermentation and Improve Nutrient Utilization and Lactational Performance of Dairy Cows. http://digitalcommons.usu.edu/etd/1238

Edwards, H.M., Douglas, M.W., Parsons, C.M. and Baker, D.H. (2000) Protein and Energy Evaluation of Soybean Meals Processed from Genetically Modified High-Protein Soybeans. *Poultry Science*, **79**, 525-527. http://dx.doi.org/10.1093/ps/79.4.525

Ehui, S., Li-Pun, H., Mares, V. and Shapiro, B. (1998). The role of livestock in food security and environmental protection. Outlook on Agriculture 27(2):81-87.

Etherton, T.D., Bauman, D.E., Beattie, C.W., Bremel, C.W., Cromwell, G.L., Kapur, V., Varner, G., Wheeler, M.B., Wiedmann, M., *et al*. (2003) Biotechnology in Animal Agriculture: An Overview. The Council for Agricultural Science and Technology.

European Commission (2000). The Europeans and Biotechnology (Eurobarometer 52.1). European Commission, Brussels.

FAO (2009). How to feed the world in 2050, Rome. Available at http://www. fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_ World_in_2050.pdf [Verified 20 November 2015]

FAO (2013*a*). Quality assurance for microbiology in feed analysis laboratories. Animal production and health manual 16. (Rome) Available at http://www.fao.org/docrep/018/i3287e/i3287e.pdf [Verified 20 November 2015]

FAO (2012b). Biofuel co-products as livestock feed – opportunities and challenges. (Ed. HPS Makkar) (Rome) Available at http://www.fao. org/docrep/016/i3009e/i3009e.pdf [Verified 20 November 2015]

FAO (2013). Quality assurance for microbiology in feed analysis laboratories. Animal production and health manual 16. (Rome) Available at http://www.fao.org/docrep/018/i3287e/i3287e.pdf [Verified 20 November 2015]

Farmer, C. and Petit, H.V. (2009). Effects of dietary supplementation with different forms of flax in late-gestation and lactation on fatty acid profiles in sows and their piglets. *Journal of Animal Science* **87**, 2600–2613. doi:10.2527/ jas.2008-1588

Fahmy, W.G., Bahaa, A.O., Murphy, M.R., Nombekela, S.W., Corley III, R.N. and Zhu, J.S. (1998). Effect of Defaunation and Amino Acid Supplementation on Growth and Amino Acid Balance in Sheep. University of Illinois Extension. http://www.livestocktrail.illinois.edu/dairynet/paperDisplay.cfm?ContentID=238

Fuller, R., (1989). Probiotics in man and animals. A review. Journal of Applied Bacteriology, 66, 365-378.

Gregg, K. (2003). Enhancement of microbial detoxification by gene transfer. In: *Proceedings of the 7th International Symposium on Ruminant Physiology, Sendai, Japan*. Academic Press, San Diego, USA. p. 58.

Henderson, A.R. and McDonald, P. (1999). The effect of cellulase preparations on the chemical changes during the ensilage of grass in laboratory silos. *Journal of the Science of Food and Agriculture* 28:486-490.

Henderson, A.R., McDonald, P. and Anderson, D. (2002). The effect of cellulase preparation derived from *Trichoderma vivide* on the chemical changes during the ensilage of grass, lucerne and clover. *Journal of the Science of Food and Agriculture* 33:16-20.

Hooper, P.G., Sharp, R., Rowlinson, P. and Armstrong, D.G. (2009). *An Assessment of the Potential of a* Lactobacilli *Inoculant as a Silage Additive. British Society of Animal Production, Winter Meeting, 13-15 March*. Paper 63. Scarborough, UK.

Hsu, J.T., Fahey, Jr. GC, Merchen, N.R. and Mackie, R.I. (1991). Effects of Defaunation and Various Nitrogen Supplementation Regimens on Microbial Numbers and Activity in the Rumen of Sheep. J. Anim. Sci. 69: 1279-1289.

Ip, C., Chin, S.F, Scimeca, J.A. and Pariza, M.W. (1991). Mammary cancer prevention by conjugated dienoic derivative of linoleic acid. *Cancer Research* **51**, 6118–6124.

Jankowski, J., Kubi nska, M. and Zdu nczyk, Z. (2014). Nutritional and immunomodulatory function of methionine in poultry diets – A review. *Annals of Animal Science* **14**,17–31. doi:10.2478/aoas-2013- 0081.

Jones, R.J. and Megarrity, R.G. 1986. Successful transfer of DHP degrading bacteria from Hawaiian goats to Australian ruminants to overcome the toxicity of *Leucaena*. *Australian Veterinary Journal* 63:259-262.

John Ruane and Maria Zimmermann, (2001). Report of the first six email conferences of the FAO Electronic Forum on Biotechnology in Food and Agriculture.

Kim, J. H., M. Hosobuchi Kishimoto, T. Seki, H. Taguchi and D. D. Y. Ryu, (1985). Cellulose production by solid state fermentation system. Biotech. And Bioenge. 27:1450-1454.

Kitessa, S., Liu, S., Briegel, J., Pethick, D., Gardner, G., Ferguson, M., Allingham, P., Nattrass, G., McDonagh, M., Ponnampalam, E. and Hopkins, D. (2010). Effects of intensive or pasture finishing in spring and linseed supplementation in autumn on the omega-3 content of lamb meat and its carcass distribution. *Animal Production Science* **50**, 130–137. doi:10.1071/AN09095.

Lebbie, S.H.B. and Kagwini, E. (1996). Small Ruminant Research and Development in Africa. Proceedings of the Third Biennial Conference of the African Small Ruminant Research Network, UICC, Kampala, Uganda, 5-9 December 1994. ILRI (International Livestock Research Institute) Nairobi, Kenya. 326 pp.

Leng R.A., (2010). Application of biotechnology to nutrition of animals in developing countries. FAO, Animal Production And Health Paper 90

Leonard, S.G., Sweeney, T., Bahar, B., Lynch, P. and O'Doherty, J.V. (2010). Effect of maternal fish oil and seaweed extract supplementation on colostrums and milk composition, humoral immune response, and performance of suckled piglets. *Journal of Animal Science* **88**, 2988–2997. doi:10.2527/ jas.2009-2764.

Miflin, B.J., Kreis, M., Bright, S.J.W. and Shewry, P.R. (1985). Improving the amino acid content of cereal grains. In: Copping L.G. and Rodgers P. (eds), *Biotechnology and its Application to Agriculture.* Monograph 32. Lavenham Press, Suffolk, England. pp. 71-78.

Makkar, H.P.S. and Beever, D. (2013). Optimization of feed use efficiency in ruminant production systems. FAO animal production and health proceedings, no. 16. Rome. Proceedings of the FAO Symposium, 27 November 2012, Bangkok, Thailand. (FAO and Asian-Australasian Association of Animal Production Societies) Available at http://www.fao.org/ docrep/018/i3331e/i3331e.pdf [Verified 20 November 2015]

Mateo, R.D., Carroll, J.A., Hyun, Y., Smith, S. and Kim, S.W. (2009). Effect of dietary supplementation of n-3 fatty acids and elevated concentrations of dietary protein on the performance of sows. *Journal of Animal Science* **87**, 948–959. doi:10.2527/jas.2008-0964.

McDonald, P., R. A. Edwards, J. F. D. Greenhalgh, C. A. Morgan, L. A. Sinclair and R. G. Wilkinson, (2010). Animal Nutrition. Pearson Books.

Mossa, F., Walsh, S.W., Ireland, J.J. and Evans, A.C.O. (2015). Early nutritional programming and progeny performance: is reproductive success already set at birth? *Animal frontiers* **5**,18–24. doi:10.2527/af.2015-0004.

Nellemann, C., MacDevette, M., Manders, T., Eickhout, B., Svihus, B., Prins, A.G. and Kaltenborn, B.P. (2009). The environmental food crisis – the environment's role in averting future food crisis. (United Nations Environment Programme: Kenya) Available at http://www.grida.no/ les/publications/FoodCrisis_lores.pdf [Verified 20 November 2015]

Saker, K.E. (2006). Nutrition and immune function. *The Veterinary Clinics of North America. Small Animal Practice* **36**, 1199–1224. doi:10.1016/ j.cvsm.2006.09.001

Scaglia, G., Rodriguez, J., Gillespie, J., Bhandari, B., Wang, J.J. and McMillin, K.W. (2014). Performance and economic analyses of year-round forage systems for forage-fed beef production in the Gulf Coast. *Journal of Animal Science* **925**, 5704–5715.

Scheirlinck, T., DeMeutter, J., Arnaut, G., Joos, H., Claeyssens, M. and Michiels, F. (1990). Cloning and xpression of cellulase and xylanase genes in Lactobacillus plantarum, Appl. Microbiol. Biotechnology. 33: 534-541

Sharp, R., O'Donnell, A.G., Gilbert, H.J. and Hazlewood, G.P., (1992). Growth and survival of genetically manipulated Lactobacillus plantarum in silage, Appl. Environ. Microbiol. 58: 2517-2522.

Shewry, P.R. and Kreis, M. 1987. Biotechnology and improvement of feeds. *Proceedings of the Nutrition Society* 46:379-385.

Soetan, K.O. and Abatan, M.O. (2008). Biotechnology: A key tool to Breakthrough in Medical and Veterinary Research- A Review. Biotechnol. Mol. Biol. Rev., 3(4): 088-094. Available online at http://www.academicjournals.org/BMBR

Tacoli, C., Bukhari, B. and Fisher, S.(2013). *Urban poverty, food security and climate change*. (International Institute for Environment and Development, London, 2013). http://pubs.iied.org/pdfs/10623IIED.pdf

Tesfaye, D. (2008). Assessment of Feed Resources and Rangeland Condition in Metema District of North Gondar Zone, Ethiopia. Haramaya University Inventory and Monitoring. Addis Ababa University, Faculty of Science, Addis Ababa, Ethiopia, pp: 103.

The Royal Society. *Reaping the benefits: science and sustainable intensification of global agriculture*. (The Royal Society, London, 2009). http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2009/4294967719.pdf

Thornton, P.K., (2010). Review livestock production: recent trends, future prospects. *Phil. Trans. R. Soc.* B, 365: 2853-2867.

Vasta, V., Luciano, G., Ben Salem, H., Biondi, L., Priolo, A. and Makkar, H.P.S. (2011). The impact of plant secondary compounds on animal product quality. In 'International symposium on nutrition of herbivores. Aberystwyth, Wales, 6–9 September 2011'.

Vazirigohar, M., Dehghan-Banadaky, M., Rezayazdi, K., Krizsan, S.J., Nejati Javaremi, A. and Shingfield, K.J. (2014). Fat source and dietary forage-toconcentrate ratio influences milk fatty-acid composition in lactating cows. *Animal* **8**, 163–174. doi:10.1017/S175173111300181X.

Wael, G. Fahmy, Ali, O. Bahaa, Michael R. Murphy, Siyabulela W. Nombekela, Robert N. Corley, III, and Jin S. Zhu. (1998). Effect of Defaunation and Amino Acid Supplementation on Growth and Amino Acid Balance in Sheep. University of Illinois Extension, available at http://www.livestocktrail.illinois.edu/dairynet/paperDisplay.cfm? Content ID=238 accessed on 13/03/2013.

Zadrazil, F. Puniya, A.K. and Singh, K. (1995). Biological upgrading of feed components. Biotechnology in Animal Feeding. Pp 55-69. (Eds.) Wallae, R. J., Chesson, A. and Weinheim, V. C. H.

Zinash, S. and B. Seyoum (2011). Utilization of feed resources and feeding systems in the central zone of Ethiopia. Proceedings of the third national livestock improvement conference. Addis Ababa, Ethiopia. 24-26 May 1989, Institute of Agricultural Research, pp: 129-132.

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