Aloe Vera as potential emerging herbal feed additive: A boon for livestock rearing

AK Patil, D Thakur, Anamika, K Govill, CD Malapure, Dinesh Kumar and Pavan Kumar Yadav

Abstract

Aloe vera (Aloe vera (L.) burm. f.) is a member of Asphodelaceae (Liliaceae) family and mainly grows in the tropical or subtropical part of Africa, Asia, Europe and America, whereas in India, found in Rajasthan, Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu. Aloe vera known for its medicinal value from ancient history of India, Egypt, Greece, Rome and China and have been mentioned throughout recorded history and given a high ranking as an all-purpose herbal plant. There are over 250 species of aloe grown around the world. However, only two species are grown today commercially, with Aloe barbadensis Miller and Aloe aborescens being the most popular. Presently, the use of aloe vera has gained great attention because of its use as herbal feed additive in livestock and poultry feeds. Animal nutritionist is trying to exploit the potential use of aloe vera as a growth promoter and in this connection they have done lots of studies related to nutrition.

Keywords: Aloe vera, feed additive, medicinal importance

1. Introduction

Recently the ban on the use of antibiotic as a growth promoters (AGP) in animal feeds, due to their residual effect in animal products as well as development of bacterial resistance in animals and human body, have make a way to look for alternatives of antibiotics in order to eliminate their impact on animals (Yang et al., 2009) [95]. Many feed additives like prebiotics, probiotics, organic acids and plant extracts have beneficial effects on animal production. Medicinal herbs properties to improve digestibility, antimicrobial, anti-inflammatory, antioxidant and immune-stimulant activity must be exploited in feeding of animals as well as safe food product for human beings. Now a day’s aloe vera popularly used by naturopaths, yoga gurus, alternative medicine promoters and feed additives. Given the significance of healthy animal food as well as human health, a broader range of research is dedicated to replace antibiotic growth promoter (AGP) with other additives, especially probiotics, prebiotics, enzymes, organic acids, and herbs (Verstegen and Williams, 2002) [94]. Many studies have been carried out on using additives, including medicinal herbs, as alternatives to antibiotics, with direct or indirect effects on animal growth and performance. Medicinal herbs, as a new class of additives to animal and poultry feeds have beneficial properties such as antioxidant, antimicrobial, and antifungal (Hardy, 2002) [43] as well as immunomodulatory and anticooccidial effects, which lead to increased use of herbs. Furthermore, many countries around the world, with plenty resources of different kinds of medicinal herbs, can use these herbs as natural feed additives for animals and poultry. The main emphasis is on those herbs that are used to supplement feeds, are helpful in achieving a larger number of objectives (improving nutrient utilization and growth performance, immunity response, intestinal microflora, and controlling particular diseases); in other words the focus is on multifunctional herbs.

The most important part of aloe vera is leaf which is composed of two main sections: latex and gel (Boudreau and Beland, 2006) [10]. The gel is composed of about 98.5-99.5% water (Femenia et al., 1999) [32], and the remaining dry matter contains more than 75 biologically active ingredients (Boudreau and Beland, 2006) [10] which have medicinal effects that are useful in treating diseases. Major ingredients of aloe vera include anthraquinones, polysaccharides, vitamins, enzymes and low molecular weight compounds (Choi and Chung, 2003) [44] which gives aloe vera its antiinflammatory, immunomodulatory, wound healing, antiviral, antifungal, antitumor, antidiabetic and antioxidant effects (Christaki and Florou-
2. Chemistry of Aloe Vera
The chemistry of aloe vera is quite complex and it has more than 200 different types of bioactive molecules (Davis, 1997) which is responsible for its medicinal and growth promoting properties. The aloe vera leaf gel contains about 98% water (Bozzi et al., 2007) whereas, total solid content of aloe vera gel is 0.66% and soluble solids are 0.56%. On DM basis aloe gel consists of polysaccharides (55%), sugars (17%), minerals (16%), proteins (7%), lipids (4%) and phenolic compounds (1%). The gel also contains number of vitamins including the important antioxidant, vitamins A, C and E.

Table 1: Chemical composition of Aloe vera (Ni and Tizard, 2004; Dagne et al., 2000; Choi and Chung, 2003; Surjushe et al., 2008)

<table>
<thead>
<tr>
<th>Class</th>
<th>Compounds</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthraquinones</td>
<td>Aloe-emodin, aloetic-acid, antranhol, aloin A and B, isobarbaloin, emodin, ester of cinnamic acid</td>
<td>Aloein and emodin-analgesics,antibacterials and antivirals</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>Pure mannann, acetylated mannann, acetylated glucomannan, glucogalactomannan, galactan, graftedactaglacturan, arabinogalactan, pectic substance, xylan, cellulose</td>
<td>Alprogen- antiallergic, anti-inflammatory</td>
</tr>
<tr>
<td>Chromones</td>
<td>8-C-glucosyl-7-O-methylaloeild A, 8-C-glucosyl-(S)-aloesol, 8-C-glucosyl-7-O-methylaloeild, 8-C-glucosyl-noreugenin, isoaloesin D, isorabichromone, neoaloesin A</td>
<td>Anti-inflammatory</td>
</tr>
<tr>
<td>Enzymes</td>
<td>Alkaline phosphatase, amylase, carboxypeptidase, catalase, cyclooxygenase, cyclooxygenase, lipase, oxidase, phosphoenolpyruvate carboxylase, superoxide dismutase</td>
<td>Bradykinase- reduce excessive inflammation while others help in the breakdown of sugars and fats</td>
</tr>
<tr>
<td>Inorganic compounds</td>
<td>Calcium, chlorine, copper, iron, magnesium, manganese, potassium, phosphorous, sodium, zinc</td>
<td>Essential for proper functioning of various enzymes</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Arachidonic acid, γ-linolenic acid, steroids (campestrol, cholesterol, β-sitosterol), triglycerides, triterpenoids, gibberillic acid, lignins, potassium sorbate, salicylic acid, uric acid</td>
<td></td>
</tr>
<tr>
<td>Amino acids</td>
<td>Alanine, arginine, aspartic acid, glutamic acid, glycine, histidine, hydroxyproline, isoleucine, leucine, lysine, methionine, phenylalanine, proline, threonine, tyrosine, valine</td>
<td></td>
</tr>
<tr>
<td>Proteins</td>
<td>Lectin, lectin-like substance</td>
<td>Lipin- penetrative effect into skin Saponins-soapy substances, antiseptic properties</td>
</tr>
<tr>
<td>Saccharides</td>
<td>Mannose, glucose, L-rhamnose, aldopentose</td>
<td>Vitamin A, C and E- antioxidant</td>
</tr>
</tbody>
</table>

Table 2: Proximate composition and biochemical activity of Aloe vera leaves (Ahmeda and Hussainb, 2013)

<table>
<thead>
<tr>
<th>Attributes</th>
<th>%</th>
<th>Biochemical activity in 1/10 i.e. 1 mL extract/10 mL distilled water</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash</td>
<td>16.88</td>
<td>Superoxide dismutase (IU/mg)</td>
<td>2830.19</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>73.35</td>
<td>Peroxidase (IU/mg)</td>
<td>3.72</td>
</tr>
<tr>
<td>Crude protein</td>
<td>6.86</td>
<td>Catalase (IU/mg)</td>
<td>2.80</td>
</tr>
<tr>
<td>Crude fat</td>
<td>2.91</td>
<td>Amylase (IU/mg)</td>
<td>24.02</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>0.004</td>
<td>Reducing sugar (mg/ml)</td>
<td>123.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total soluble sugars (mg/ml)</td>
<td>363.03</td>
</tr>
</tbody>
</table>

3. Biological activities of aloe vera in livestock and poultry
3.1 Effects of aloe vera supplementation on growth performance
Higher body weight gain, better feed conversion efficiency (FCE) and production of milk, meat and eggs are important economic goals in livestock and poultry farming. Earlier these goals are achieved by feed additive like antibiotics, but ban on application of antibiotic growth promoter (AGP) have affected these goals, resulting in poor growth performance and production of animals. Many researchers have done to examine potential effects of feed additives, like prebiotics, probiotics, organic acids and herbs, on growth performance and production compared to those of antibiotics. An experiment conducted by khan et al. (2014) on birds fed diet supplemented with 1 % or 2 % aloe vera leaves had greater body weight gain, better feed intake and FCR than those fed diets without aloe vera leaves.
An experiment comparing the effects of aloe vera gel (mixed with feed) and AGP (virginiamycin) indicated that AGP resulted in better growth performance compared to the performance of groups that received aloe vera gel (at 1.5%, 2% and 2.5%), and the control group while no significant difference was observed between the antibiotic group and the 2% aloe vera gel group in terms of body weight gain and FCR (Darabighane et al., 2011b) [23]. These results are agreed with findings of Mehala and Moorthy (2008) [66]. Similar to this finding, Mmereole (2011) [68] also observed that at 1% dietary inclusion of aloe vera leaves powder in broiler diet, there was significant difference in body weight gain in birds fed aloe vera supplemented feed as compared to control group. However, Odo et al. (2010) [70], reported that, higher weight gain in birds fed 5% level of inclusion aloe vera than those of 10% and explained that aloe vera in large quantitative exerts a powerful purgative effect but in smaller quantity. In an another study, Alemi et al. (2012) [2] reported a better growth performance in broilers treated with 0.75% and 1% aloe vera gel powder compared to the 0.5% aloe vera gel powder group and the control group. In support of this, Danhoff and McAnally (1988) [50] observed that the feeding of aloe vera accelerated the growth of new cells, thereby resulting to increased body weight. Contrary to above studies, Hassanbeigy Lakeh et al. (2012) [44] have observed that the supplementation of aloe vera gel (0.6, 1.2, 1.8, 2.4 and 3 m/L) in broiler drinking water had no effect on feed intake over the total experiment period however, higher body weight gain and the smallest FCR was observed in the 1.8 m/L aloe vera gel group. Das et al. (2011) [23] stated that the addition of 10 ml aqueous extract of aloe gel per litre of drinking water in broiler have beneficial effect on body weight gain and feed conversion efficiency that could be due to diversified antimicrobial activity of aloe vera gel. Actually, polysaccharides of aloe vera (mainly, acemannan) has prebiotic like effect which increase the number of lactobacillus colonies and reduce gram negative bacteria (Darabighance et al., 2012) [21]. The fermentation product of lactobacillus is short chain fatty acid that will reduce the pH of lower intestine and create favorable environment for gram negative bacteria. Olupona et al. (2010) [75] have also observed that supplementation of aloe vera in drinking water had beneficial effect on final body weight, weekly body weight gain, and average feed intake. There are limited studies on aloe vera as herbal feed additives in pigs. However, in an experiment Qiao et al. (2013) [82] found that the 0.05% aloe vera polysaccharide (AVP) shown better effect on growth of weaned piglets than 0.02% AVP. They also found that, supplementation with higher concentrations of AVP not only increased ADG, but decreased the incidence of diarrhoea and weaning stress as well.

3.2. Anti-coccidial activity
Coccidiosis is one of the dreaded diseases in poultry that affects mainly intestine that leads to impair feed utilization, decreases broilers growth and egg production of laying hens and causes death of birds Lillehoj et al. (2004) [60]. Generally, Eimeria (E.) species responsible for coccidiosis in chickens include *E. tenella*, *E. necatrix*, *E. acervulina*, *E. maxima*, *E. brunetti* and *E. mitis* (Ayaz et al., 2003; Shah et al., 2009) [7, 87]. These species infect epithelial cells of the bird’s intestine causing enteritis, bloody diarrhea and immune-suppression in chickens that paves the way to secondary disease conditions. Therefore, poultry disease management and maintenance of the immune functions for maximum consistent production performance and growth in poultry industry are fundamental requirements for profitable farming. An excellent way to meet these requirements is to use anticoccidial drugs, chemotherapeutic and biological agents including vaccines (Lillehoj and Trout, 1996; Mehala and Moorthy, 2008) [61, 66]. Nevertheless, development of resistant pathogenic strains and drug residues in animal products used by the human beings are the major constraints in this regard (Delespaux and Koning, 2007; Reig and Toldra, 2008) [27, 83]. The increasing resistance to avian coccidiosis to anticoccidial drugs currently used by the poultry industry together with the requirement for drug and antibiotic free production systems has meant that it is now important to look for new ways to control the diseases. In this regard, aloe vera has been shown to have diverse biological activities. It has been used therapeutically for centuries and is of particular interest due to its historic reputation as a curative agent and dietary supplement (Mehala and Moorthy, 2008) [66].

In an experiment Akhtar et al. (2012) [2] observed that the orally administration of aloe vera extract (ethanol and aqueous extract) in the broiler chicken has significantly lowered the oocyst count in faeces with compared to control group. They also found that the broilers that received aqueous extract of aloe vera pulp had the lowest mean score lesion in caeca and intestine in comparison to the control group and the group that received ethanol extract of aloe vera pulp. Similar to this, Mwale et al. (2006) [71] also found that the increase in aloe vera and aloe spicata content significantly decreases coccidian oocyst count. A comparative study has done by Gadzirayi et al. (2005) [55] and reported that the anticoccidial effects of *A. excelsa* were comparable with sulphachlopyrazine sodium monohydrate in terms of improved live weight gains and reducing oocyst output in broiler chickens. Aloe vera treatments show tonic effects on the intestinal tract by benefiting microflora and reducing bowel putrefaction as well as reducing inflammation (Bland, 1985) [8].

In an *in vitro* trial done by Marizvikuru et al. (2006) [62] to know the effect of three concentrations (15%, 30% and 45%) of Aloe vera (L) and *A. spicata* on the inhibition of the sporulation of avian coccidiaoocysts. Both aloe extracts showed a concentration dependant anticoccidial effect though, *A. spicata* inhibited sporulation to a greater extent than aloe vera. Similar to this, Yim et al. (2011) [60] also found that dietary supplementation of *A. vera* resulted in significantly lower gut lesion scores and reduced faecal oocyst shedding of *E. maxima* in broiler chickens. They also suggested that reduced faecal oocyst shedding; a protective role against eimeria infection in aloe-based chicken diets could be associated more with cell-mediated responses than antibody responses.

3.3. Antimethanogenic effect
Rumen is a diverse and unique microbial ecosystem composed of bacteria, protozoa, fungi and bacteriophage. In rumen hydrogen is produced during the anaerobic fermentation of nutrients. This hydrogen can be used during the synthesis of volatile fatty acids (VFAs) and microbial protein synthesis. The excess hydrogen from NADH is eliminated primarily by the formation of methane produced by methanogens. Methane is one of the greenhouse gasses which have 21 times more global warming potential than carbon dioxide (IPCC, 2007). Methane produced in ruminants represents a substantial loss of 7-9% of gross energy intake which reduces the potential conversion of feed energy to metabolizable energy. Hence, the inhibition of
methanogenesis has long been considered from nutritional aspects and more recently from the perspectives on greenhouse gas emissions.

It is a challenging task for the animal nutritionist and rumen microbiologist to make livestock industry economical and eco-friendly by controlling heat production and methane emissions from the ruminants. To combat this problem, many attempts like concentrate supplementation, use of lipid supplementation (Nevel and Demeeyer, 1996) [72] antibiotic growth promoters such as monensin and lasalocid, different categories of feed additives like halogenated methane analogues, bacteriocins, propionate enhancers, acetogens, fats, ionophores, defaunating agents, formate etc. (Asanuma et al, 1999; Boadi et al, 2004) [6, 9] had been tried, but the goal could not be successfully achieved either due to some harmful effects on animal itself or due to the presence of their residues in the animal products. Contrary to this, plants containing secondary metabolites are being used in the ethno-veterinary medical practices since long back and have yielded good effects on the animal health. One of the most promising known therapeutic plants is surely aloe. The middle part of leaves containing gel, made up of carbohydrates (acemannan), anthraquinones, enzymes, inorganic compounds, amino acids, vitamins and a miscellaneous (including salicylic acid). These potentially active chemical constituents give aloe well known therapeutic properties like wound healing, antiinflammatory, immune-stimulating etc. Calabro et al. (2013) [12] observed that a significant effect of Aloe arborescens supplementation on the in vitro fermentation characteristics of feedstuffs. The supplementation of 120 mg aloe higher than that advised for in vivo, has beneficial effect on gas production compared to the lowest dosage. The close association between SCFA and gas production in vitro is an indicator of energy availability to the animal (Getachew et al., 2002) [36]. Hence, the increased volatile fatty acids production due to the aloe supplementation probably means higher milk yield and quality, especially in terms of fat. A. arborescens has interesting effect on the rumen microbial in vitro activity, stimulating microbial metabolism thereby increasing the volatile fatty acids production in the rumen. These effects may be attributed to the plant extracts rich in some active chemical compounds (flavonoid) that increase degradation of cell wall constituents, yield and efficiency of microbial protein synthesis (Sirohi et al., 2009) [90]. Similar to this, Sachan et al. (2014) [85], had supplement five herbs namely Trigonella foenum-graecum (Methi), Acacia concina (Shikakai), Trachyspermum ammi (Ajwain), Cinnamomum tamala (Tejpatta) and Aloe barbadanis (Aloe vera ) at the rate of 1.5%, 2.5% and 4.0% of ration and found that the addition of these herbs had no any adverse effect on rumen pH. There was significant (P<0.05) improvement in IVDMD and IVOMD (%) of feed after addition of Trigonella foenum-graecum (66.22, 69.63) as compared to control (56.33, 61.37) respectively. Similarly, addition of aloe vera also tended to improve the IVDMD and IVOMD of feed in respect to control. Addition of other herbs Acacia concina (Shikakai), Trachyspermum ammi (Ajwain), Cinnamomum tamala (Tejpatta) did not show any improvement in the feed digestibility. Authors, concluded that Trigonella foenum-graecum, and Aloe barbadanis are the potential fermentation modifier. In agreement of this, Sirohi et al. (2009) [90] also reported that among the different extracts tested, IVDMD (%) increased by 15.42% after addition of Aloe-barbadanis.

3.4. Antifungal activity

There are many studies showing that resistance to infections enhanced by aloe either in animals, whether the infective agent is a bacterium, virus or fungus (Plaskett et al., 1997; Fujita et al., 1976) [33, 80]. The aloe extract showed the significant antifungal activity against numbers of fungi like, Aspergillus niger, Cryptococcus neoformans, Penicillium mannefii, F. oxysporum, Phythium sp. and R. solani (Khairg, 2011) [54]. Candidiasis infections are mainly caused by Candida (fungus) in a variety of places like a soral (thrush), vaginal and gastrointestinal tract. These are normally treated with the help of antifungal drugs, but aloe vera can remove candidiasis infections with its natural antifungal properties. Aloe vera shows its antifungal activities against other fungi such as Candida paraparosis, Candida krasei and Candida albicans (Das et al., 2011) [23]. Saks and Golan (1995) [86] reported that, the gel extract from leaves of aloe vera possesses inhibitory action on spore germination and mycelial growth of four common post harvest fungi, P. digitatum, A. alternata, B. cinerea, and P. expansum. The present study is in agreement with Fujita et al. (1978) [34] in which they confirmed the antifungal properties of aloe species, Aloe arborescens Miller spp. Natulensis Berger, active against the human fungal pathogen Trichophyton mentagrophytes.

3.5. Antiparasitic activity

Endo and ecto-parasites are very common in domestic animals especially in grazing animals, and they cause large economic losses. Alagesan et al. (2002) [3] made comparison between the following four sets of ingestible i.e albendazole, neem oil, extract of neem seed with bittergourd, garlic, edible banana stem and aloe vera and reported that the aloe vera has strong antiparasitic activity. Similar to this, (Fajimi et al., 2002b) [31] have also observed the beneficial effect of Aloe variegata, spread over mange lesions.

3.6. Effects on intestinal microflora

Maintenance of intestinal microflora is an important factor contributing to improved growth performance and immune response in animals. Extract of herbs play a significant role in balancing and improving intestinal microflora in animals. Pogribna et al. (2008) [81] reported that dietary supplement of aloe vera, may alter the production of short chain fatty acids and number of intestinal microflora. Many studies have been carried out on using additives, including herbs, as alternatives to antibiotics, with direct or indirect effects on intestinal microflora. Many studies have shown antimicrobial properties of herb extracts (Cowan, 1999; Hammer et al., 1999) [17, 41] which can improve intestinal microflora population and enhance health of digestive systems through reduction in number of disease making bacteria (Mitsch et al., 2004) [67]. Number of studies have reported antibacterial effects of Aloe vera gel (Kwon et al., 2011; Pandey and Mishra, 2010; Mbanga et al., 2010; Alemdar and Agaoglu, 2009) [4, 57, 64, 77]. These studies, indicates that aloe vera supplementation in broilers’ have beneficial effect on improving intestinal microflora, its ecosystem and gut morphology; increase in aloe vera gel in broiler feeds (1.5%, 2%, and 2.5%) leads to increased Lactobacillus count and decreased E. coli count (Daraghinehane et al., 2012) [21]. In addition, Jiang et al. (2005) [50] also have reported an increase in Lactobacillus and Bifidobacteria count as well as a reduction in E. coli when acemannan (0.1% and 0.05%), polysaccharide (0.1%) and aloe vera gel (0.1%) were added to broiler feed. In another study, Dai et al. (2007) [19] found that herbs and
polysaccharide contained in aloe vera can reduce *E. coli* count while increasing the number of *Lactobacillus* and *Bifidobacteria.

Although the exact mechanism by which aloe vera affects intestinal microflora in broilers is unknown, it is likely that this effect is similar to the antibacterial effects of some herbs, or likely that the polysaccharide contained in aloe vera (acemannan) has mechanism like that of prebiotics (Guo et al., 2003, 2004 b) [37, 38], where as some researchers believes that the antibacterial effects of aloe vera to its fumaric acid content (He et al., 2011) [45].

### 3.7. Antioxidant effect

Reactive oxygen species (ROS) is continuously produced during normal physiological events and they can easily initiate the per-oxidation of membrane lipids, leading to the accumulation of lipid peroxides. Under pathological conditions, ROS is overproduced and results in oxidative stress. Antioxidants are substances that delay or prevent the oxidation of cellular oxidizable substrates. They exert their effect by scavenging reactive oxygen species, activating a battery of detoxifying proteins or preventing the generation of reactive oxygen species (Halliwell et al., 1992) [39]. In recent years, there has been an increasing trend in finding natural antioxidants, which can protect the body from free radicals and retard the progress of many chronic diseases (Kaur et al., 2001; Kinsella et al., 1993) [53, 56].

Patel et al. (2012) [78] observed that both the plants (somnifera and aloe vera) possess excellent antioxidant and free radical scavenging activity. Screening of both the plant at different doses (100, 150 and 200 µg/ml) help to reveal the potential of individual plants. Both the plant possess almost equivalent hydrogen peroxide scavenging activity while the total antioxidant capacity was found much better in *Withania somnifera* as compare to aloe vera. The antioxidant activity of both the plant might be attributed to its polyphenolic content and other phytochemicals constituents.

### 3.8. Hypocholesterolemic effect

High blood cholesterol is a major risk factor for heart disease and stroke in human being. Daily supplementation with aloe vera stimulates immune system and improves wound healing. Although the exact mechanism by which aloe vera affects intestinal microflora in broilers is unknown, it is likely that this effect is similar to the antibacterial effects of some herbs, or likely that the polysaccharide contained in aloe vera (acemannan) has mechanism like that of prebiotics (Guo et al., 2003, 2004 b) [37, 38], where as some researchers believes that the antibacterial effects of aloe vera to its fumaric acid content (He et al., 2011) [45].

### 3.9. Immunostimulation/Immunosuppression

The immunomodulating effects of aloe-based carbohydrates are thought to function via activation of macrophage cells and stimulation of the antigen processing. Activated macrophage cells generate NO, secrete cytokines such as TNF-α and IL-6 and present cell surface markers. In a study, aqueous and ethanolic extracts from the aloe vera pulp exerted stimulatory effects on humorral and cellular immune responses in chickens. The higher cellular immune responses in aloe vera administered chickens may be due to the aloe polysaccharides, especially acemannan (ACM), which activated the macrophages to produce inflammatory cytokines such as IL-1, IL-6 and TNF (Zhang and Tizard, 1996) [97]. The ability of aloe vera to stimulate the immune system is attributed to polysaccharides present in the aloe vera gel (Davis et al., 1991) [26]. Acemannan was found to have immunomodulatory activity. It activates macrophages, enhance cytokine release, stimulate interactions between macrophages, T-lymphocytes and B-lymphocytes and enhance the generation of cytotoxic T-lymphocytes.

An important property of aloe vera that has been the subject of many in vivo and in vitro experiments is improvement in immune response, probably due to the acemannan contained in aloe vera (Harlev et al., 2012; Djeraba and Quere, 2000; Zhang and Tizard, 1996; Karaca et al., 1995) [28, 43, 52, 91]. Acemannan is a β-(1-4)-linked acetylated mannan having mannose that can attach to mannose receptors in macrophages (Karaca et al., 1995) [52] and activate these macrophages. Acemannan is potentiating antibody production against coxsackie virus and reduce radiation induced skin reactions in C57BL/6 mice. Acemannan is also responsible for enhancing the alloresponsiveness of human lymphocytes (Helderman, 1988) [46] as well as induced the phenotypic and functional maturation of immature dendritic cells 60 and also stimulate the phagocytosis and the candidicidal activity of macrophages (Lee et al., 2001) [59]. Alprogen inhibit calcium influx into mast cells, thereby inhibiting the antigen-antibody-mediated release of histamine and leukotriene from mast cells. Ro et al. (2000) [84] in a study on mice that had previously been implanted with murine sarcoma cells, acemannan stimulates the synthesis and release of interleukin-1 (IL-1) and tumor necrosis factor from macrophages in mice, which in turn initiated an immune attack that resulted in necrosis and regression of the cancerous cells. In an experiment on aloe vera effects on immunity of broilers, Valle-Paraso et al. (2005) [95] reported that, broilers treated with 2% aloe vera gel (with their drinking water) showed significant increase in antibody titer against Newcastle disease virus (NDV) on days 37 and 52, compared to the control groups. Similar to this study Darabighane et al. (2012) [22] also reported an increase in antibody titer against NDV on days 24 and 38 by adding aloe vera gel to broiler feeds (at 1.5, 2 and 2.5%). In another study, Alemi et al. (2012) [5] added aloe vera gel powder (at 0.5, 0.75 and 1%) to broiler feeds and reported an increase in antibody titer against NDV.

### 3.10. Effects on reproductive performance

Estakhr and Javdan, (2011) [36] was carried an experiment to access the effect of aloe vera on reproduction, for that he administered aloe vera leaf pulp extract, gel extract and a mixture of both to three groups of 10 week old male wistar rats for 56 consecutive days and found that in all groups except control group the weights of the testes have increased. Epididymal sperm counts and sperm motility have been significantly increased compared to control groups. The testosterone level has remarkably increased in treated groups. As per these results, aloe vera has strong spermagenetic activity by increasing sperm parameters. This study strongly proposes that aloe vera specially its gel fortifies spermagenesis and can be a good candidate for manufacturing fertility drugs. Contrary to this study,
Oyewopo et al. (2011) suggest that aloe vera has potential antifertility effects in the male rat.

3.11. Antitumor Effects
Polysaccharides isolated from aloe vera have been reported to have antitumor activity and the antitumor activity of acemannan has been examined in several animal species. A modified aloe vera polysaccharide, G2E1DS2 isolated from cellulose treated aloe vera gel was shown to activate macrophages and exhibit potent antitumor activity when injected into the peritoneum of mice implanted with sarcoma cells (Im et al., 2005). Similarly, intra peritoneal administration of both enriched and commercial forms acemannan to mice implanted with murine sarcoma cells significantly reduced the tumor burden and increased the survival rate (Peng et al., 1991). Supplementation of the cancer induced rats with vitamin C or aloe vera gel extract significantly inhibited the development and severity of carcinogenesis as reflected in the reduction of the percentage surface area of enzyme positive foci (Shamaan et al., 1998).

3.12. Adverse or Toxic Effects
Consumption of aloe vera latex is also associated with watery diarrhoea leading to electrolyte imbalance and hypokalemia (Cooke et al., 1981). Other side effects include weight loss, central nervous system disturbances and abnormalities and kidney dysfunction. Compounds in aloe vera latex are also considered genotoxic and may be mutagenic (Mueller et al., 1996). The abuse of aloe vera latex containing laxatives is associated with melanosi coli, which may play a role in the development of colorectal cancer (Siegers et al., 1993). Intestinal tumours were induced in rats that consumed a diet containing chrysazin, a synthetic anthraquinone with dihydroxy groups like other natural anthraquinones (Mori et al., 1985). In addition, compounds in aloe vera latex are suspected to interact with certain oral conventional drugs in particular corticosteroids and cardiac glycosides (Mascolo et al. 2004).

4. Conclusion
Aloe vera, as an additive to livestock and poultry feed, has great potentials for improving nutrient utilization, intestinal health, immune response and growth performance. It has potential benefits as antimicrobial agents and used for controlling coccidiosis in poultry. Advantages of aloe vera added to feeds depend on several factors like form of use [powder, gel, extract (ethanolic or aqueous), polysaccharide extracted from gel], dosage, genetics of animals, ingredients of diet and farm management. Therefore, more studies are required to determine effective dosage and form of use as feed additives in livestock.

5. References
22. Darabighane B, Zarei A. The effects of the different levels of aloe vera gel on oocysts shedding in broilers with coccidiosis. Planta Medica. 2011b; 77:2.


88. Shamaan NA, Kadir KA, Rahmat A, Ngah WZ. Vitamin C and aloe vera supplementation protects from chemical...