International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(4): 494-502

Received: 18-05-2017
Accepted: 20-06-2017

AK Patil
Department of Animal Nutrition, College of Veterinary Science & A.H., Jabalpur, M.P., India

D Thakur
Department of Animal Nutrition, College of Veterinary Science & A.H., Jabalpur, M.P., India

Anamika
Department of Animal Nutrition, Khalsa College of Veterinary and Animal Sciences Amritsar, Punjab, India

K Govill
Department of Animal Nutrition, College of Veterinary Science & A.H., Jabalpur, M.P., India

CD Malapure
Department of Animal Nutrition, College of Veterinary Science & A.H., Jabalpur, M.P., India

Dinesh Kumar
Department of Veterinary Science & A.H., College of Agriculture, JNKVV, Tikamgarh, MP, India

Pavan Kumar Yadav
Assistant Professor, Department of Veterinary Physiology and Biochemistry, Faculty of Veterinary and Animal Sciences, IAS, Banaras Hindu University, Varanasi, UP, India

Correspondence
Pavan Kumar Yadav
Assistant Professor, Department of Veterinary Physiology and Biochemistry, Faculty of Veterinary and Animal Sciences, IAS, Banaras Hindu University, Varanasi, UP, India

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) [42] as well as immunomodulatory and anticoccidial 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) [14] which gives aloe vera its antiinflammatory, immunomodulatory, wound healing, antiviral, antifungal, antitumor, antidiabetic and antioxidant effects (Christaki and Florou-

Paneri, 2010) [15]. Number of studies have suggest that many benefits of aloe vera are due to its polysaccharides contained in gel, which compose a large part of dry matter in this gel (Hamman, 2008) [40]. Almost 60% of dry matter of aloe vera gel is composed of polysaccharides (McAnalley, 1989) [65] and active compound is acemannan which has immunomodulatory, antimicrobial, and antitumour effects (Choi and Chung, 2003) [14], antioxidants, wound healing, immune-modulatory and antidiabetic activites (Pandey *et al.*, 2010) [77].

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) [24] which is responsible for its medicinal and growth promoting properties. The aloe vera leaf gel contains about 98% water (Bozzi *et al.*, 2007) [11] 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. Vitamin B_1 (thiamine), niacin, Vitamin B_2 (riboflavin), choline and folic acid (Lawless and Allen, 2000) [58]. Also contains many minerals like calcium (involved in teeth and bone formation, muscle contractions and heart health), magnesium (provides strength to teeth and bones, maintains healthy muscles and nervous system, activates enzymes), zinc (speeds up wound healing, mental quickness assists with healthy teeth, bones, skin, immune system, and digestive aid), manganese (activates enzymes, builds healthy bones, nerves and tissues), chromium (assists with protein metabolism and balancing of blood sugars), selenium which all influence our brain performance. Additional minerals found in aloe vera include copper, iron, potassium, phosphorus and sodium, aloe vera also contains the trace minerals of rhodium and iridium used in cancer and tumor research experiments. Many of the medicinal effects of aloe leaf extracts have been attributed to the polysaccharides found in the inner leaf parenchymatous tissues (Davis *et al*., 1994) [25], but it is believed that these biological activities should be assigned to a synergistic action of the compounds contained therein rather than a single chemical substance (Domkat *et al.*, 2013) [29]. The chemical constituents of aloe vera leaves including the pulp and exudate are shown in Table 1.

Table 1: Chemical composition of Aloe vera (Ni and Tizard, 2004; Dagne *et al.*, 2000; Choi and Chung, 2003; Surjushe *et al.*, 2008) [14, 18, 73, 91]

Class	Compounds	Properties
Anthraquinones/ anthrones	Aloe-emodin, aloetic-acid, anthranol, aloin A and B, isobarbaloin, emodin, ester of cinnamic acid	Aloin and emodin-analgesics,antibacterials and antivirals
Carbohydrates	Pure mannan, acetylated mannan, acetylated glucomannan, glucogalactomannan, galactan, galactogalacturan, arabinogalactan, pectic substance, xylan, cellulose	Alprogen- antiallergic, anti-inflammatory
Chromones	8-C-glucosyl-7-O-methylaloediol A, 8-C-glucosyl-(S)- aloesol, 8-C-glucosyl-7-O-methyl-(S)-aloesol, 8-C-glucosyl-7-O-methylaloediol, 8-C-glucosyl-noreugenin, isoaloeresin D, isorabaichromone, neoaloesin A	Anti-inflammatory
Enzymes	Alkaline phosphatase, amylase, carboxypeptidase, catalase, cyclooxidase, cyclooxygenase, lipase, oxidase, phosphoenolpyruvate carboxylase, superoxide dismutase	Bradykinase- reduce excessive inflammation while others help in the breakdown of sugars and fats
Inorganic compounds	Calcium, chlorine, chromium, copper, iron, magnesium, manganese, potassium, phosphorous, sodium, zinc	Essential for proper functioning of various enzymes
Miscellaneous	Arachidonic acid, γ-linolenic acid, steroids (campestrol, cholesterol, β-sitosterol), triglicerides, triterpenoid, gibberillin, lignins, potassium sorbate, salicylic acid, uric acid	
Amino acids	Alanine, arginine, aspartic acid, glutamic acid, glycine, histidine, hydroxyproline, isoleucine, leucine, lysine, methionine, phenylalanine, proline, threonine, tyrosine, valine	
Proteins	Lectins, lectin- like substance	Lignin- penetrative effect into skin Saponins- soapy substances, antiseptic properties
Saccharides	Mannose, glucose, L-rhamnose, aldopentose	
Vitamins	B_1, B_2, B_6, C, β-carotene, choline, folic acid, α-tocopherol	Vitamin A, C and E- antioxidant

Table 2: Proximate composition and biochemical activity of Aloe vera leaves (Ahmeda and Hussainb, 2013) [1]

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

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) [55] 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) [22]. 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 gains in birds fed aloe vera supplemented feed as compared to control group. However, Odo *et al*. (2010) [74], 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) [5] 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) [20] observed that the feeding of aloe vera accelerated the growth of new cells, thereby resulting to increase 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 impairs 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 aqous 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) [35] 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) [96] have 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 green-house 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 Demeyer, 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 arborescence* 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. Authours, 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*, *Crytococcus neoformans, Penicillium maneffei*, *F. oxysporum, Phythium* sp. and *R. solani* (Khaing, 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 paraprilosis, Candida krusei* 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. altemata, 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 *Ttichophyton mentugrophytes.*

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 veragel* (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 (Darabighane *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 believed 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. Iji *et al*. (2010) [47] has divided 40 male wistar rats into four groups of ten rats per group. Group I which served as the control received 0.9% physiological saline while those in groups II, III and IV received aloe vera gel (100, 250 and 500 mg/kg) respectively, for four weeks. There was significant ($P<0.001$) reduction in plasma total cholesterol, triglycerides and LDL-cholesterol ratio compared with the control. In a similar manner, those animals that were administered with 500 mg/kg gel had significantly higher ($P<0.001$) HDL-cholesterol ratio than those of the control. This study showed that, chronic administration of aloe vera gel extract showed cholesterol lowering action. Similar to this Chandrakar *et al.* (2008) [13] also observed cholesterol lowering action when animals fed to different doses (3, 4, 5 and 6 mg/kg/day) of raw extracts of aloe vera leaves along with cholesterol, there was significant decrease in serum cholesterol levels.

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 humoral 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, 97]. 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 C_3H 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 dendrite 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) [93] 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) [30] 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 spermatogenic activity by increasing sperm parameters. This study strongly proposes that aloe vera specially its gel fortifies spermatogenesis and can be a good candidate for manufacturing fertility drugs. Contrary to this study,

Oyewopo *et al.* (2011) [76] 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) [48]. 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) [79]. 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) [88].

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) [16]. 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) [69]. The abuse of aloe vera latex containing laxatives is associated with melanosis coli, which may play a role in the development of colorectal cancer (Siegers *et al.,* 1993) [89]. 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) [69]. 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) [63].

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

1. Ahmeda M, Hussainb F. Chemical composition and biochemical activity of aloe vera (*Aloe barbadensis* Miller) Leaves. International Journal of Chemical and Biochemical Sciences. 2013; 3:29-33.
2. Akhtar M, Hai A, Awais MM, Iqbal Z, Muhammad F, Anwar MI. Immunostimulatory and protective effects of aloe vera against coccidiosis in industrial broiler chickens. Veterinary Parasitology. 2012; 186:170-177.
3. Alagesan P, Alamelu M, Suresh S. Spreading eco-friendly disease management in sheep Myrada KVK's efforts. 2005.
4. Alemdar S, Agaoglu S. Investigation of *in vitro* antimicrobial activity of aloe vera juice. Journal of Animal and Veterinary Advances. 2009; 8:99-102.
5. Alemi F, Mahdavi A, Ghazvinian K, Ghaderi M, Darabighane B. The effects of different levels of aloe vera gel powder on antibody titer against Newcastle disease virus and performance in broilers. Proc. International Poultry Scientific Forum, Georgia World Congress Center, Atlanta, Georgia. 2012; 23-24:01-47.
6. Asanuma N, Iwamoto M, Hino T. Effect of the addition of fumarate on methane production by ruminal microorganisms *in vitro*. Journal of Dairy Science. 1999; 82:780-787.
7. Ayaz MM, Akhtar M, Hayat CS, Hafeez MA, Haq AU. Prevalence of coccidiosis in broiler chickens in Faisalabad, Pakistan. Pakistan Veterinary Journal. 2003; 23:51-52.
8. Bland J. Effect of orally consumed aloe vera juice on gastrointestinal function in normal humans. Preventive Medicine. 1985; 14:152-154.
9. Boadi D, Benchaar C, Chiquette J. Mitigation strategies to reduce enteric methane emission from dairy cows: update review. Canadian Journal of Animal Science. 2004; 84:319-335.
10. Boudreau MD, Beland FA. An evaluation of the biological and toxicological properties of *Aloe barbadensis* (Miller), aloe vera. Journal of Environmental Science and Health. 2006; 24:103-154.
11. Bozzi A, Perrin C, Austin S, Arce F. Quality and authenticity of commercial aloe vera gel powders. Food Chemistry. 2007; 103(1):22-30.
12. Calabro S, Musco N, Tudisco R, Grossi M, Calabrò V, Ferrara M, Cutrignelli MI, Infascelli F. Effect of *Aloe Arborescens* on *in vitro* Rumen Fermentations. Journal of Nutritional Ecology and Food Research. 2013; 1:117-123.
13. Chandrakar M, Palekar S, Chirade S, Almas S, Hafiz M. Hypocholesterolemic effect of aloe vera extract on high cholesterol fed *Calotes versicolor daudin*. Asian J. Exp. Science. 2008; 22(3):295-298.
14. Choi S, Chung MH. A review on the relationship between aloe vera components and their biologic effects. Seminars in Integrative Medicine. 2003; 1:53-62.
15. Christaki EV, Florou Paneri PC. Aloe vera: A plant for many uses. Journal of Food, Agriculture and Environment. 2010; 8:245-249.
16. Cooke WT. Laxative abuse. Acta Gastro-Enterologica Belgica. 1981; 44:448-458.
17. Cowan MM. Plant products as antimicrobial agents. Clinical Microbiology Reviews. 1999; 12:564-582.
18. Dagne E, Bisrat D, Viljoen A, Van Wyk BE. Chemistry of aloe species. Current Organic Chemistry. 2000; 4**:**1055-1078.
19. Dai B, Jiang L, Chen S. Effects of medicinal herb and polysaccharide from aloe on gut microflora, immune function and growth performance in broiler. China Poultry. 2007; 29:21-24.
20. Danhoff IE, McAnally BH. Stabilized aloe vera, its effect on human skin cells. Drugs in the Cosmetic Industry. 1988; 133:52-196
21. Darabighane B, Zarei A, Shahneh AZ. The effects of different levels of aloe vera gel on ileum microflora population and immune response in broilers: a comparison to antibiotic effects. Journal of Applied Animal Research. 2012; 40:31-36.

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.
23. Das S, Mishra B, Gill K, Ashraf MS, Singh AK, Sinha M *et al*. Isolation and characterization of novel protein with antifungal and anti-inflammatory properties from aloe vera leaf gel. International Journal of Biological Macromolecules. 2011; 48(1):38-43.
24. Davis RH. Aloe vera- A scientific approach. New York: Vantage Press Inc. 1997, 290-306.
25. Davis RH, Donato JJ, Hartman GM, Haas RC. Anti-inflammatory and wound healing activity of a growth substance in aloe vera. Journal of the American Podiatric Medical Association. 1994; 84:77-81.
26. Davis RH, Parker WL, Samson RT. Isolation of a stimulatory system in an aloe extract. Journal of the American Podiatric Medical Association. 1991; 81:473-478.
27. Delespaux V, Koning HD. Drugs and drug resistance in African trypanosomiasis. Drug Resistance Updates. 2007; 10:30-50.
28. Djeraba A, Quere P *In vivo* macrophage activation in chickens with Acemannan, a complex carbohydrate extracted from aloe vera. International Journal of Immuno-pharmacology. 2000; 22:365-372.
29. Domkat LC, Habibu T. Comparative studies of the aqueous extracts of *Ocimun gratissmum*, aloe vera, *Brassica oleracea* and *Ipopoea batatas* on some biochemical parameters in diabetic rats. International Journal of Pharmacy and Biological Sciences. 2013; 6:23-29.
30. Estakhr Javdan. Spermatogenic activity of aloe vera in adult male rats. Pharmacology online. 2011; 2:886-889.
31. Fajimi AK, Ayodeji IO, Ajayi FT, Ogundola FI. Efficacy studies of topically administered aloe vera in rabbits naturally infested with psoroptic mange mites. Moor Journal of Agricultural Research. 2002b; 3(2):199-202.
32. Femenia A, Sanchez ES, Simal S, Rossello C. Compositional features of polysaccharides from aloe vera (*Aloe barbadensis M*) plant tissues. Carbohydrate Polymers. 1999; 39:109-117.
33. Fujita K, Teradaira R, Nagatsu T. Bradykinase activity in aloe extract. Biochemical Pharmacology. 1976; 25:205.
34. Fujita K, Yamada Y, Azuma K, Hirozawa S. Effect of leaf extracts of *Aloe arborescens M* spp. *natalensis* Berger, active against the human fungal pathogen *Trichophyton mentagrophytes*. Antimicrobial Agents and Chemotherapy.1978; 14:132-136.
35. Gadzirayi CT, Mupangwa JF, Mutandwa E. Effectiveness of *Aloe excelsa* in controlling coccidiosis in broilers. Journal of Sustainable Development in Africa. 2005; 7:1.
36. Getachew G, Makkar HPS, Becker K. Tropical browses: contents of phenolic compounds *in vitro* gas production and stoichiometric relationship between short chain fatty acid and *in vitro* gas production. The Journal of Agricultural Science. 2002; 139:341-352.
37. Guo F, Williams B, Kwakkel R, Verstegen M. *In vitro* fermentation characteristics of two mushroom species, an herb and their polysaccharide fractions, using chicken cecal contents as inoculum. Poultry Science. 2003; 82:1608-1615.
38. Guo FC, Williams BA, Kwakkel RP, Li HS, Li XP, Luo JY *et al*. Effects of mushroom and herb polysaccharides as alternatives for an antibiotic on the cecal microbial ecosystem in broiler chickens. Poultry Science. 2004b; 83:175-182.
39. Halliwell B, Aeschbach R, Lo Liger J, Aruoma OI. The characterization of antioxidant. Food and Chemical Toxicology. 1995; 33:601-617.
40. Hamman JH. Composition and applications of aloe vera leaf gel. Molecules. 2008; 13(8):1599-616.
41. Hammer KA, Carson CF, Riley TV. Antimicrobial activity of essential oils and other plants extracts. Journal of Applied Microbiology. 1999; 86:985-990.
42. Hardy B. The issue of antibiotic use in the livestock industry: what have we learned? Animal Biotechnology. 2002; 13:129-147.
43. Harlev E, Nevo E, Lansky EP, Ofir R, Bishayee A. Anticancer potential of aloes: antioxidant, anti-proliferative and immune-stimulatory attributes. Planta Medica. 2012; 78:843-852.
44. Hassanbeigy Z, Roustaee M, Haghighian M. Effect of aloe gel on broiler performance. Proc. 5th Iranian Congress on Animal Science, 2012.
45. He CL, Fu BD, Shen HQ, Jiang XL, Wei XB. Fumaric acid, an antibacterial component of aloe vera. African Journal of Biotechnology. 2011; 10:2973-2977.
46. Helderman JH, Womble D. Enhancement of allo-responsiveness of human lymphocytes by acemannan (Carrisyn). International Journal of Immunopharmacology. 1988; 10(8):967-74.
47. Iji OT, Oyagbemi AA, Azeez OI. Assessment of chronic administration of aloe vera gel on haematology, plasma biochemistry, lipid profiles and erythrocyte osmotic resistance in wistar rats. Nigerian Journal of Physiological Sciences. 2010; 25:107-113.
48. Im SA, Oh ST, Song S, Kim, MR, Kim DS, Woo SS *et al*. Identification of optimal molecular size of modified aloe polysaccharides with maximum immunomodulatory activity. International Immunopharmacology. 2005; 5:271-279.
49. IPCC. Guidelines for national greenhouse inventories. Agriculture, forestry and other land use. Emissions from livestock and manure management. 4:10.1-10.87. Isfahan, Iran, 2007, 973-977.
50. Jiang L, Feng Y, Yang X, Zhou X, Yang D. Effects of gel polysaccharide and acemannan from aloe vera on broiler gut flora, microvilli density, immune function and growth performance. Chinese Journal of Veterinary Science. 2005; 25:668-671.
51. Johnson KA, Johnson DE. Methane emissions from cattle. Journal of Animal Science. 1995; 73:2483-2492.
52. Karaca K, Sharma JM, Nordgren R. Nitric oxide production by chicken macrophages activated by acemannan, a complex carbohydrate extracted from aloe vera. International Journal of Immunopharmacology. 1995; 17:183-188.
53. Kaur C, Kapoor HC. Antioxidants in fruits and vegetables the millennium's health. Journal of Food Science and Technology. 2001; 36:703.
54. Khaing TA. Evaluation of the antifungal and antioxidant activities of the leaf extract of aloe vera (*Aloe barbadensis M.*) World Academy of Science. Engineering and Technology. 2011, 75.
55. Khan MJA, Khan SH, Naz S, Gilani SS, Shafi J, Hassan F *et al*. Effect of dietary supplementation of aloe vera leaves on growth performance and immunity of fayoumi chicks. Pakistan Journal of Nutrition. 2014; 13(4):191-195.

56. Kinsella JE, Frankel E, German B, Kanner J. Possible mechanism for the protective role of antioxidants in wine and plant foods. Food Technology. 1993; 47:85-89.
57. Kwon KH, Hong MK, Hwang SY, Moon BY, Shin S, Baek JH *et al*. Antimicrobial and immunomodulatory effects of aloe vera peel extract. Journal of Medicinal Plants Research. 2011; 5:5384-5392.
58. Lawless J, Allan J. The Clinical Composition of Aloe vera In: aleo vera natural wonder cure. Thorsons, Publishing Ltd, London, United Kingdom. 2000, 161-171.
59. Lee JK, Lee MK, Yun YP, Kim Y, Kim JS, Kim YS *et al*. Acemannan purified from aloe vera induces phenotypic and functional maturation of immature dendritic cells. International Immunopharmacology. 2001; 1:1275-84.
60. Lillehoj HS, Min W, Dalloul RA. Recent progress on the cytokine regulation of intestinal immune responses to Eimeria. Poultry Science. 2004; 83:611-623.
61. Lillehoj HS, Trout JM. Avian gut-associated lymphoid tissues and intestinal immune responses to Eimeria parasites. Clinical Microbiology Reviews. 1996; 9:349-360.
62. Marizvikuru M, Evison B, Michael C, Tinyiko EH. The *in vitro* studies on the effect of aloe vera and *Aloe spicata* (L.) on the control of coccidiosis in chickens. International Journal of Applied Research in Veterinary Medicine. 2006; 4:128-133.
63. Mascolo N, Izzo AA, Borelli F, Capasso R, DiCarlo G, Sautebin L *et al*. Healing powers of aloes. In: T. Reynolds ed. Aloes: The Genus Aloe, edition, Boca Raton, 2003; 38:209-238.
64. Mbanga J, Mangoma N, Saidi B. An evaluation of the antimicrobial activities of *Aloe barbadensis, A. chabaudii* and *A. arborescens* leaf extracts used in folklore Veterinary Medicine in Zimbabwe. Journal of Animal and Veterinary Advances. 2010; 9:2918-23.
65. McAnalley BH. Process for preparation of aloe products, Google Patents. 1989.
66. Mehala C, Moorthy M. Effect of aloe vera and *Curcuma longa* (turmeric) on carcass characteristics and biochemical parameters of broilers. International Journal of Poultry Science. 2008; 7:857-861.
67. Mitsch P, Zitterl-Eglseer K, Kohler B, Gabler C, Losa R, Zimpernik I. The effect of two different blends of essential oil components on the proliferation of *Clostridium perfringens* in the intestines of broiler chickens. Poultry Science. 2004; 83:669-75.
68. Mmereole F. Evaluation of the dietary inclusion of aloe vera as an alternative to antibiotic growth promoter in broiler production. Pakistan Journal of Nutrition. 2011; 10:1-5.
69. Mori H, Sugie S, Niwa K, Takahashi M, Kawai K. Induction of intestinal tumours in rats by chrysazin. British Journal of Cancer. 1985; 52:781-783.
70. Mueller SO, Eckert I, Lutz WK, Stopper H. Genotoxicity of the laxative drug components emodin, aloe-emodin and danthron in mammalian cells: topoisomerase II mediated. Mutation Research. 1996; 371:165-173.
71. Mwale M, Bhebhe E, Chimonyo M, Halimani TE. The *in vitro* studies on the effect of aloe vera and *Aloe spicata* (L.) on the control of coccidiosis in chickens. The Journal of Applied Research in Veterinary Medicine. 2006; 4:2-5.
72. Nevel VCJ, Demeyer DI. Influence of pH on lipolysis and biohydrogenation of soybean oil by rumen contents *in vitro*. Reprod Nutr Dev. 1996; 36:53-63.
73. Ni Y, Tizard IR. Analytical methodology: the gel-analysis of aloe pulp and its derivatives. In aloes the Genus Aloe; Reynolds, T., Ed.; CRC Press: Boca Raton. 2004; 111-126
74. Odo BI, Ekenyem BU, Nwamo AC. Effects of aloe vera as leaf protein concentrate on growth performance of cockerels. International Journal of Poultry Science. 2010; 9:426-28.
75. Olupona JA, Omotoso OR, Adeyeye AA, Kolawole OD, Airemionkhale AP, Adejinmi OO. Effect of aloe vera juice application through drinking water on performance, carcass characteristics, hematology and organoleptics properties in broilers. Poultry Science. 2010; 88(1):42.
76. Oyewopo AO, Oremosu AA, Akang EN, Noronha CC, Okanlawon AO. Effects of aloe vera (A*loe barbadensis*) aqueous leaf extract on testicular weight, sperm count and motility of adult male sprague-dawley rats. Journal of American Science. 2011; 7(4).
77. Pandey R, Mishra A. Antibacterial activities of crude extract of *Aloe barbadensis* to clinically isolated bacterial pathogens. Applied Biochemistry and Biotechnology. 2010; 160:1356-1361.
78. Patel DS, Shah PB, Managoli NB. Evaluation of *in-vitro* anti-oxidant and free radical scavenging activities of *Withania somnifera* and aloe vera. Asian J. Pharm. Tech. 2012; 2(4):143-147.
79. Peng SY, Norman J, Curtin G, Corrier D, McDaniel HR, Busbee D. Decreased mortality of Norman murine sarcoma in mice treated with the immunomodulator, Acemannan. Molecular biotherapy. 1991; 3:79-87.
80. Plaskett LG. Aloe vera against infections, Newsletter 9, Publ. Biomedical Information Services Ltd., Launceston, Cornwall, UK. 1997.
81. Pogribna1 M, Freeman JP, Paine D, Boudreau MD. Effect of aloe vera whole leaf extract on short chain fatty acids production by *Bacteroides fragilis*, *Bifidobacterium infantis* and *Eubacterium limosum*. Letters in Applied Microbiology. 2008; 46(5):575-80.
82. Qiao J, Li HH, Zheng CJ, Feng ZY, Wang W. Dietary supplementation with aloe vera polysaccharide enhances the growth performance and immune function of weaned piglets. Journal of Animal and Feed Sciences, 2013; 22:329-334.
83. Reig M, Toldra F. Veterinary drug residues in meat: concerns and rapid methods for detection. Meat Science. 2008; 78:60-67.
84. Ro JY, Lee B, Kim JY, Chung Y, Chung MH, Lee SK. Inhibitory mechanism of aloe single component (Alprogen) on mediator release in guinea pig lung mast cells activated with specific antigen-antibody reactions. Journal of Pharmacology and Experimental Therapeutics. 2000; 292:114-21.
85. Sachan J, Kumar R, Vaswani S, Kumar V, Roy, D. Effect of addition of herbs on *in vitro* rumen fermentation and digestibility of feed. Indian Journal of Animal Research. 2010; 48(1):88-90.
86. Saks Y, Barkai-Golan R. Aloe vera gel activity against plant pathogenic fungi. Postharvest Biology and Technology. 1995; 6:159-165.
87. Shah MAA, Song X, Xu L, Yan R, Song H, Ruirui Z *et al*. The DNA-induced protective immunity with chicken's interferon gamma against poultry coccidiosis. Parasitology Research. 2009; 107:747-750.
88. Shamaan NA, Kadir KA, Rahmat A, Ngah WZ. Vitamin C and aloe vera supplementation protects from chemical

hepato-carcinogenesis in the rat. *Nutrition.* 1998; 14:84-6852.
89. Siegers CP, Hertzberg-Lottin E, Otte M, Schneider B. Anthranoid laxative abuse-a risk for colorectal cancer. Gut. 1993; 34:1099-1101.
90. Sirohi SK, Pandey N, Goel N, Singh B, Mohini M, Pandey P *et al*. Microbial activity and ruminal methanogenesis as affected by plant secondary metabolites in different plant extracts. International Journal of Civil and Environmental Engineering. 2009; 1:1.
91. Surjushe A, Vasani R, Saple DG. Aloe vera: a short review. Indian Journal of Dermatology. 2008; 53(4):163-166.
92. Tizard IR, Ni Y. Carbohydrates, immune stimulating. In: Encyclopedia of immunology, Delves P.J., Roitt I.M. (eds). Academic Press Inc., San Diego, CA. 2nd ed., 1998, 427–431.
93. Valle Paraso M, Vidamo P, Anunciado R, Lapitan A. Effects of aloe vera (*Aloe barbadensis*) on the white blood cell count and antibody titre of broiler chickens vaccinated against Newcastle disease. Philippine Journal of Veterinary Medicine. 2005; 42:49-52.
94. Verstegen MW, William BA. Alternatives to the use of antibiotics as growth promoters for monogastric animals. Animal Biotechnology. 2002; 13:113-127.
95. Yang Y, Iji P, Choct M. Dietary modulation of gut microflora in broiler chickens: a review of the role of six kinds of alternatives to in feed antibiotics. World's Poultry Science Journal. 2009; 65:97-114.
96. Yim D, Kang SS, Kim DW, Kim SH, Lillehoj HS, Min W. Protective effects of aloe vera based diets in *Eimeria maxima* infected broiler chickens. Experimental Parasitology. 2011; 127:322-325.
97. Zhang L, Tizard IR. Activation of a mouse macrophage cell line by cemannan: The major carbohydrate fraction from aloe vera gel. Immunopharmacology. 1996; 35:119-128.