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The Potential of *Aloe Vera* as a Herbal Feed Additive for Livestock- A Review

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ABSTRACT

Aloe barbadensis (*Aloe vera*) is one of the most important medicinal succulent and perennial plant which belongs to *Liliaceae* family and its leaves have several medicinal and therapeutic properties. *Aloe vera* leaves contain more than 200 nutrients and plant bioactive compounds especially anthraquinones, anthrones, chomones, flavonoids, tannins, polysaccharides and saponins. These active principles posses growth stimulatory, immunomodulatory, antiinflammatory, antiviral, antifungal, wound healing, antidiabetic and antioxidant properties. The major mortality in livestock is recorded due to enteric infections. To overcome these implications, the excessive or repetitive prophylactic use of drugs against problems is not only costly but also renders animals and human body prone to development of drug resistance; it prompted researchers to look for alternative of drugs to control the disease. Phytogenic feed additives are a new class of feed additives for poultry and livestock industry that have gained attention as a result of their beneficial properties like antibacterial, antifungal, anti-inflammatory and growth promoters. Realizing this, a number of phytogenic feed additives (PFA) have been identified for their use as feed additive including *Aloe vera* which in turn may improve the performance of livestock. Presently, Animal nutritionists have carried out lot of studies to harvest the potential of *Aloe vera* as herbal feed additive. In this review article, major studies have been included which were carried out by various researchers to find out the effect of *Aloe vera* as herbal feed additive on growth, health and economic parameters of livestock.

KEYWORDS: Aloe vera, blood, feed additive, feed cost, growth, parasite

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1. INTRODUCTION

India has the largest livestock population of 535.78 million in the world with 20.45% of buffaloes, 35.94% cattle, 27.80% goat, 13.87% sheep, 1.69% pigs and 0.23% others of the total livestock (20th Livestock Census, 2019). The livestock sector accounts for about 4.2% of the total GDP (Economic Survey, 2019-20). The young calves are highly susceptible to enteric bacterial imbalance, resulting in poor growth and high mortality and, about 30% mortality is recorded due to gastrointestinal infection (Nehru et al., 2017).

To overcome such implications, various feed additives and supplements can be incorporated in the ration to boost livestock performance by increasing their growth rate, better feed conversion efficiency, greater livability and reduced mortality in calves. These feed additives are described as "growth promoters" and usually called as non-nutrient feed additives (Singh and Panda, 1992; Ansari et al., 2008). Earlier many feed additives like antibiotics and hormones like diethyl stilbesterol were used for calves as major growth promoters. Antibiotics as growth promoters appear to act by reducing the pathogenic bacteria and modifying the microflora in the gut of the animal (Radostits et al., 1994). The problem of residual effect of antibiotics in animal products and bacterial strains resistance to antibiotics in animals and human body; became a reason to worldwide denouncement over their use in feed. It prompted researchers to look for alternative of drugs to control the disease and a number of medicinal plants have been identified for their use as herbal feed additive including aloe vera which in turn may improve the performance of livestock (Yadav et al., 2017a). Other commonly used feed additives are prebiotics, probiotics, synbiotics, enzymes, acidifiers and phytobiotics (Yang et al., 2009).

Many researchers have been conducted studies to explore the use of phytogenic feed additives in animal nutrition (Steiner, 2009). The phytogenic feed additives are generally recognized as safe and commonly used items in the food industry (Varel, 2002; Nehme et al., 2021). The antimicrobial, antiviral, antifungal and antioxidant effects of phytogenic feed additives are well described *in vitro* (Cowan, 1999; Craig, 1999). The intestinal microflora, gut morphology, gastric emptying and activity of endogenous digestive secretions as well as performance characteristics are considered to be influenced by dietary phytogenic feed additives (Windisch et al., 2009).

Among all the medicinal plant, *Aloe barbadensis* (*Aloe vera*) is one of the most important medicinal succulent, perennial and spiky cactus plant. *Aloe barbadensis* (*Aloe vera*) belongs to *Liliaceae* family (Ahlawat and Khatkar, 2011) and its leaves have several medicinal and therapeutic properties (Qiao et al., 2013). It is an African native plant found in the tropical or subtropical parts of Africa and also found in several warm climatic zones of world including Asia, America, and Europe (Ahlawat and Khatkar, 2011; Giannakoudakis et al., 2018), whereas in India, found in Rajasthan, Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu. There are over 350 species of aloe, but only a few species, mainly *Aloe barbadensis* and *Aloe arborescens* are grown commercially (Ahlawat and Khatkar, 2011). *Aloe vera* leaves contain many plant bioactive compounds especially anthraquinones, anthrones, chomones, flavonoids, tannins, polysaccharides and saponins (Das and Srivastav, 2015; Darabighane and Nahashon, 2014). Due to presence of these active principles, it is used as health promotor due to its growth promoter (Bhati et al., 2017; Ahmed et al., 2017), immunomodulatory, anti-inflammatory, antiviral, antifungal, antitumor, wound healing, antidiabetic and antioxidant properties (Christaki and Florou Paneri, 2010; Sharma et al., 2014; Maan et al., 2018).

2. MORPHOLOGY AND CHEMICAL CONSTITUENTS OF *ALOE VERA*

The most important part of *Aloe vera* is leaf which is composed of three main layers (Figure 1). The upper thick green layer is called rind and contains phloem, xylem and vascular bundles to transport nutrients. It has protective function and synthesizes Carbohydrates and Proteins (Surjushe, 2008; Eshun and He, 2004). The middle layer (aloe latex) is called 'sap' which contains a bitter liquid, seen as a yellow substance having anthraquinones and glycosides. The inner layer is a gel-like substance, for which *Aloe vera* is mainly cultivated, which is colourless, viscous, semisolid and transparent. The inner layer contains 99% water, glucomannans, amino acids, lipids, sterols and vitamins (Boudreau and Beland, 2006). The gel is composed of about 98.5-99.5% water (Femenia et al., 1999) and the remaining dry matter contains more than 75 biologically active ingredients (Boudreau and Beland, 2006; Darabighane and Nahashon, 2014) which have medicinal effects that are useful in treating diseases.

The whole plant contains other active components, such as minerals, sugars, vitamins, enzymes and amino acids. Phytochemicals present include saponins, tannins and flavonoids (Das and Srivastav, 2015), sterols resins, acetylated mannans, terpenoids, acidic compounds, lectins, polymannans and anthrones (Boudreau and Beland, 2006). Other potentially active constituents include chromones, anthraquinones and lignin, enzymes and salicylic acid (Joseph and Raj, 2010), as summarised in previous studies (Hamman, 2008; Surjushe et al., 2008). Several investigations have indicated that many of the benefits of *Aloe vera* are due to the polysaccharides in the gel fraction

(Hamman, 2008). The active polysaccharides compound is acemannan which is one of the most potent immune compound found in plants (Darabighane et al., 2011) and have immunomodulatory, antimicrobial, anti-tumour, antioxidant, wound healing, immune-modulatory and antidiabetic effects.

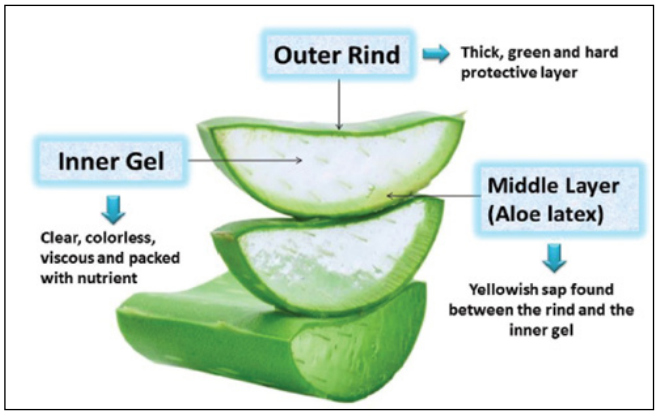

Figure 1: Anatomy of *Aloe vera* leaf (Source: Ebrahim et al., 2020)

Glycosides (anthraquinones) are present in high levels. Shelton (1991) reported that the gel contains monosaccharides (mannose-6-phosphate), polysaccharides (main glucomannan known as acemannan), C-glucosyl chromone and a glycoprotein called alprogen (Hutter et al., 1996). Results of chemical analysis in previous research using whole leaves (on a dry matter basis) showed that it contains 6.86–15.4% crude protein (Femenia et al., 1999; Ahmed and Hussain, 2013), 2.85% crude fat, 60.34–72.17% crude fibre (Femenia et al., 1999) and 14.65–16.88% ash (Ahmed and Hussain, 2013). *Aloe vera* gel contains 2% protein and 38% carbohydrates; glucose, mannose, galacturonic acid, galactose, xylose, fucose, rhamnose and arabinose (Luta et al., 2009). *Aloe vera* is a natural source of minerals (potassium, chromium, iron, sodium, magnesium, calcium, copper, zinc and manganese) and vitamins (thiamine, folic acid, niacin, B12, A, C and E) (Shelton, 1991). These minerals play a basic role in the formation of enzymes, which are involved in metabolic pathways (Sharma et al., 2014). The plant has a high enzyme content, which helps the body to absorb basic nutrients (Mulu et al., 2015). Amylase is one of the main enzyme, and the plant also contains biochemical catalysts such as oxidase, carboxypeptidase, alkaline phosphatase (Nandal and Bhardwaj, 2012), isozymes of superoxide dismutase, proteolytic enzymes called carboxypeptidase, and glutathione peroxidase (Sabeh et al., 1996). These enzymes have a positive effect on metabolism. *Aloe vera* leaves contain more than 200 naturally occurring nutrients and plant bioactive compounds (Davis, 1997; Ahlawat and Khatkar, 2011) especially phenolics including anthraquinones, anthrones, chomones, flavonoid and tannins, acetylated polysaccharides, and saponins (Ahlawat and Khatkar, 2011; Giannakoudakis et al., 2018). In 2000, Lawless and Allen studied the dry matter content of aloe gel and found that it consists of polysaccharides (55%), sugars (17%), minerals (16%), proteins (7%), lipids (4%) and phenolic compounds (1%). *Aloe vera* contains many aloe biologically active substances, including minerals, proteins, enzymes, carbohydrates, vitamins, saponins and anthraquinones (Choi and Chung, 2003; Surjushe et al., 2008).

3. BIOLOGICAL IMPACTS OF *ALOE VERA* IN LIVESTOCK AND POULTRY

3.1. Effect of Aloe vera on growth performance

The growth is defined as a relative irreversible change in measured dimensions. Growth is an accelerating phase which is exhibited by true increase in structural mass in terms of hyperplasia and hypertrophy of cells.

Growth rate is governed by various factors including genetic makeup of the animal, environment and nutritional status. Nutritional status influences the growth directly and indirectly. The body measurements show an increasing trend with advancement of age and increase in body weight but the change depends on the nutritional status and well being of animals which is directly affected by the type of feed ingredients used in feeding. The main objective of management of calves is to obtain optimum growth as per their genetic potential so that they can attain early maturity and subsequently reduced age at first calving.

Yadav et al. (2017a) conducted an experiment to study the effect of feed supplementation of *Aloe vera* on the growth of crossbred cattle calves. The *Aloe vera* was supplemented into the feed @ 2 g and 4 g per kg body weight for the treatment group T_1 and T_2 of the calves. The basal ration without *Aloe vera* supplementation was used for T_0 treatment group as control. The ration was fed to the calves for 9 weeks and effect on body weight was observed. Results showed that the initial mean body weights of calves in T_0, T_1 and T_2 treatment groups were almost same (27.603±0.91, 27.797±0.55 and 27.641±0.57 kg) respectively. At the end of experimental period (9 weeks) the average body weight gain in the each corresponding group was 24.559, 28.348 and 30.324 kg respectively. The *Aloe vera* supplementation had significant effect on body weight gain in treatment groups as compare to the control group starting from 6th week onwards. The T_1 and T_2 treatment groups showed significant difference with each other from 8th week to the end of experiment.

Yadav et al. (2017a) also observed that the overall average daily body weight gains (ADG, g/day) were 376, 433 and 480 in T_0, T_1 and T_2 treatment group respectively. The overall average daily body weight gain was significantly

higher in *Aloe vera* supplemented treatment groups as compared to control.

Alibabaei et al. (2016) observed the effect of *Aloe vera* gel on weight gain of new born *Holstein friesian* calves upto 8 weeks and concluded that 15 ml daily *Aloe vera* gel supplementation in feed of calves did not reveal any significant difference in weekly weight gain in treatment and control groups during eight week from birth.

Ghane et al. (2010) studied the effect of different level of *Aloe vera* supplementation on the growth performance of *Holstein friesian* calves during the 2-month treatment and observed substantial increase in body weight in treatment groups supplemented with *Aloe vera* but noticed no significant difference as compare to control.

Gosh et al. (2010) studied the effect of garlic extract (herbal feed additive) feeding on the performance of 12 crossbred calves and observed that there was a significant difference in mean body weight gain and feed intake in the garlic supplemented treatment group compared to the control group.

Bhati et al. (2017) conducted a study on eight rathi calves to observe the effect of *Aloe vera* supplementation on their performance. The complete diet without *Aloe vera* were given to the calves in the control group and calves in treatment group were fed with the complete diet plus *Aloe vera* @ 3% of total diet as herbal feed additive. Bhati et al. (2017) concluded that final body weight in *Aloe vera* supplemented group was higher than control group (124.28 kg vs. 126.87 kg). The average daily weight gain (297.01 g vs 340.64 g) was significantly higher in *Aloe vera* treated group compared to control group.

Ahmed et al. (2017) carried out an investigation on 24 lambs; by dividing them into 4 treatment groups of 6 each. Dried, powdered leaves of *Aloe ferox* @ 0, 50 g, 100 g and 250 g per lamb were given daily after mixing with feed to each out of four treatment groups for 10 weeks. They concluded that all aloe treated groups showed higher body weight than control. However, sheep which were given 250g of *Aloe ferox* treatment, had the greatest average daily gain of 57.74 g, while the control treatment had the least average daily gain of 14.88 g.

Qiao et al. (2013) was studied the effect of dietary supplementation of *Aloe vera* polysaccharide @ 0.05%, 0.1% and 0.2% on weaned piglets for 28 days and observed that there was significant difference in average daily gain of body weight in case of 0.1% dietary supplementation of *Aloe vera* polysaccharide as compare to control.

Yadav et al. (2017a) carried out a 9 weeks study on crossbred cattle calves to reveal the impact of feed supplementation of *Aloe vera* on body measurements i.e. body length, body height, chest girth. *Aloe vera* was supplemented into the feed @ 2 g and 4 g kg^{-1} body weight for the treatment group T_1 and T_2 of the calves and used T_0 treatment group as control. At the end of experiment, it was observed that the overall change in body length (cm) was significantly higher in *Aloe vera* supplemented groups (11.32 cm in T_1 and 12.32 cm T_2) than control group (8.85 cm). The statistical analysis showed that *Aloe vera* had no significant effect on height at withers in treatment groups as compared to control group. However, the total change in height at withers of calves was substantially higher in *Aloe vera* supplemented groups than control group. The overall change in chest girth was higher in *Aloe vera* supplemented groups (16.10 cm in T_1 and 18.15 cm in T_2) than control group and it was observed that *Aloe vera* had the significant effect on chest girth in higher treatment group as compare to control.

Majid et al. (2018) studied the effect of dietary supplementation of *Aloe vera* extract @ 50 mg kg^{-1} and 500 mg kg^{-1} body weight on body weight gain and tibia length of rat pup and concluded that 500 mg kg^{-1} body weight supplementation of *Aloe vera* extract produced significant increase in body weight and tibial length of rat pups. Heinrichs et al. (2003) reported no significant differences of mannan-oligosaccharide (one of major component of *Aloe vera*) supplementation on body measurements like heart girth, hip height, wither height and hip width of calves. Silva et al. (2012) reported no significant effect of feeding mannan-oligosaccharide on body measurements of wither height, hearth girth and hip width of calves.

3.2. Effect of Aloe vera on feed intake and nutrient utilization

Yadav et al. (2017b) carried out an experiment in crossbred calves for nine weeks to reveal the effect of dietary supplementation of *Aloe vera* on the dry matter intake, @ 2 g and 4 g per kg body weight in the treatment group 1 (T_1) and treatment group 2 (T_2) respectively. The study revealed that the DMI in the initial phase were almost equal (2.44±0.01, 2.48±0.07 and 2.52±0.01 kg) in control and treatment groups. In the end of experiment DMI in groups were 6.87±0.03, 7.83±0.18 and 9.30±0.15 kg in control, treatment group 1 and treatment group 2 respectively. The results showed that the *Aloe vera* had the statistically significant effect on DMI in treatment groups. Treatment groups started trend of significantly higher intake over control group from 4th week onwards and retain until the end of experiment. Beside this, treatment group 2 (T_2) also showed significantly higher intake as compare to treatment group 1 (T_1) from the same extent. Average daily DMI were higher in treatment groups (669 g in T_1 and 757 g in T_2) as compare to control (603 g).

Qiao et al. (2013) conducted an experiment to reveal the effect of dietary supplementation of *Aloe vera* polysaccharide

@ 0.05%, 0.1% and 0.2% on weaned piglets for 28 days and observed that there was no significant increase in average daily feed intake and feed to gain ratio in case of dietary supplementation of *Aloe vera* polysaccharide @ 0.05%, 0.1% and 0.2% as compare to control. Bhati et al. (2017) conducted an experiment to observe the effect of *Aloe vera* supplementation @ 3% of total diet as herbal feed additive on dry matter intake of rathi calves and concluded that DMI (kg/100 kg BW) in *Aloe vera* supplemented group was slightly higher than control group (3.51 kg vs. 3.48 kg) but not statistically different compared to control group.

Yadav et al. (2017c) also concluded that supplementation of *Aloe vera* in different physical forms in dietary regimen of broilers improved protein and energy utilization efficiency, FCR and reduced feed consumption and mortality without affecting growth performance. Allam et al. (1999) conducted an experiment to evaluate the effect of garlic, *Nigella sativa*, fenugreek and chamomile on goat performance and concluded that herbs improved feed conversion efficiency, economic returns and decreased feed cost kg^{-1} of milk compared with control. Kraszewski et al. (2002) observed increased feed intake, significant higher body weights, daily gain, improved utilization of nutrients from herbs (*Mentha piperita, Urtica dioica, Matricaria, Chamomilla recutita, Thymus vulgaris, Salvia officinalis, Foeniculum vulgare, Viola tricolor* and *Trigonella*). Wawrzynczak et al. (2000) reported higher feed intake, significant higher daily weight gain and improved feed conversion efficiency in calves of treatment groups fed with herbal mixture (included the *Mentha piperita*, *Thymus vulgaris*, *Salvia officinalis*, *Viola tricolor*, *Chamomilla recutita* and *Urtica dioica*) as feed additives in concentrate. The best results were revealed in the treatment group given with 1% herbs as feed additive in concentrate.

3.3. Effect of Aloe vera on hematological parameters

Ghane et al. (2010) studied the effect of different level of *Aloe vera* supplementation on the white blood cells count of twenty four *Holstein friesian* calves during the 2-month treatment and observed significant higher count of white blood cells in *Aloe vera* treated groups as compare to control group. A similar feeding trial was conducted on growing crossbred calves by supplemented *Aloe vera* leaf powder (2 g kg^{-1} body weight and 4 g kg^{-1} body weight) and found that the mean haemoglobin, packed cell volume percentage, total leucocyte count, neutrophil and lymphocyte number across the period were significantly higher in treatment groups.

Bhati (2001) conducted a study on rathi calves to observe the effect of *Aloe vera* supplementation on Hb and PCV and divided the calves into four treatment groups as follows: T1: Complete feed (control), T_2: Complete feed+brahmi, T3: Complete feed+*Aloe vera*, T_4: Complete feed+brahmi and *Aloe vera*. At the end of experiment, the mean value of Hb was found to be 11.18, 11.24, 11.20 and 11.26 g dl^{-1} in T_1, T_2, T_3 and T_4 treatment group. The statistical analysis of data showed non significant effect of *Aloe vera* and brahmi on supplementation in complete feed. The average values of packed cell volume for T_1, T_2, T_3 and T_4 treatment groups were observed to be 31.26, 31.27, 31.29 and 31.30 %, respectively. The analysis of variance revealed non significant effect of use of herbs as feed additive in complete feed on packed cell volume.

Valle paraso et al. (2005) observed the effect of oral supplementation of *Aloe vera* on the immune response of broiler chicken to NCD. They observed that 2% solution prepared from extract of fresh *Aloe vera* was effective in increasing mean antibody titers to NCD. There was a significant increase in total WBC count along with absolute differential count of monocytes, lymphocytes and heterophils.

Altug et al. (2010) evaluated the effect of *Aloe vera* and β-glucan on lymphocyte subsets, haematological parameters and immunoglobulin concentration following vaccination in dogs. They observed that there was increase in platelet count, WBC's, peripheral blood mononuclear lymphocyte counts, peripheral blood polymorphonuclear lymphocyte counts, neutrophils, monocytes, PCV, haemoglobin concentration. The CD3, CD4 and CD8 Tlymphocyte and B-lymphocyte ratio as well as serum IgG and IgM concentration were also increased. Madan et al. (2008) observed that administration of *Aloe vera* extract to Swiss albino mice (300 mg kg^{-1} i.p.) for five days led to significantly increased in total white blood cells count. Further, it increased humoral immune response, as demonstrated from the increased in plaque-forming cells in the spleen and circulating antibody titer.

Mmereole (2008) reported increase TEC, PCV, TLC, MCH, MCV, MCHC values in *Aloe vera* treated group as compared to antibiotic supplemented group in broilers. Singh et al. (2013) reported higher Hb, PCV, TLC, total plasma glucose and serum calcium values in group containing diet supplemented with *Aloe vera* as compare to control group. Akanmu et al. (2020) investigated the effect of three plants (*Moringa oleifera, Jatropha curcas and Aloe barbadensis*) extracts used as anti methanogenic dietary additives, on the haematological parameters in sheep by oral administration of these extracts for 75 days. Akanmu et al. (2020) observed that most haematological parameters were not affected by plant extract used as anti-methanogenic additives, except for higher white blood cell (WBC) and lymphocytes counts recorded in lambs in the *Aloe vera* treatment. Mahdavi et al. (2012) found a significant increase in total white blood cell count, red blood cell count, and haemoglobin in groups treated with *Aloe vera* gel powder compared to the control group, with the 1% *Aloe vera* gel powder group showing

the highest haemoglobin, red blood cell, and white blood cell count. Olugbenga et al. (2014) investigated the effect of *Aloe vera* gel treatment on haematological parameters in wild African buck and concluded that there was significant rise in WBC, RBC, MCH and MCHC parameters on treatment with *Aloe vera* gel at concentration of 3% and 4% over duration of 15 days.

Clement et al. (2015) conducted an experiment to observe the effect of prolong consumption of crude *Aloe barbadensis* (*Aloe vera*) gel on haematological indices in rats and concluded that Hb, TEC, TLC, DLC and total platelet count were significantly higher in case of rats, received 0.26 ml of *Aloe vera* extract for 4 weeks as compared to control. Lymphocytes were also significantly higher in group treated with *Aloe vera* for 4 weeks as compared with control group. Yadav et al. (2017d) analyzed the effect of supplementation of *Aloe vera* on the performance of broilers. The dietary treatments were basal diet as control group (T_1) and three groups with basal diet mixed with *Aloe vera* powder @ 0.5% in feed (T_2), gel @ 2% in feed (T_3) and fresh *Aloe vera* juice @ 2% in drinking water (T_4), respectively. It was concluded that there was significant increase in haematological values for Hb, PCV, TEC and TLC in T_3 and T_4 groups.

3.4. Effect of Aloe vera on biochemical parameters

Ghane et al. (2010) studied the effect of different level of *Aloe vera* supplementation on the serum cholesterol level of twenty four *Holstein friesian* calves during the 2-month treatment and significant reduction in average cholesterol level was observed in treatment groups when compared to the control groups. Bhati (2001) conducted a study on rathi calves to observe the effect of *Aloe vera* supplementation on blood glucose and serum protein; and divided the calves into four treatment groups as follows: T_1: Complete feed (control), T_2: Complete feed + brahmi, T_3: Complete feed+*Aloe vera*, T_4: Complete feed+brahmi and *Aloe vera* and concluded that herbs did not reveal any significant effect on blood glucose and serum protein level in claves. Yimam et al. (2014) observed the effect of *Aloe vera* based composition on blood glucose levels in alloxan diabetic mice. There was a significant decrease in serum glucose level after intra-peritoneal administration of aloe based composition.

Rajasekaran et al. (2001) studied the effect of oral administration of *Aloe vera* gel in alloxan induced diabetes mellitus in experimental rabbits. *Aloe vera* gel at a concentration of 500 mg kg^{-1} body weight showed a significant decrease in blood glucose level and serum lipid profile confirming the hypoglycemic and hypolipaemic effects of *Aloe vera*. Akinmoladun and Akinloye (2004) investigated the effect of *Aloe vera* on lipid profile and fasting blood sugar concentration of rabbits fed with high cholesterol diet. They observed that total plasma cholesterol and fasting blood glucose levels were decreased as compared to control group indicating hypoglycemic and hypolipaemic effects of *Aloe vera*. Zhang et al. (2007) conducted an experiment to see the effect of *Aloe vera* and propolis preparation on blood biochemical indices of broilers. They observed that there were significantly higher contents of serum globulins, dextrose, urea nitrogen and calcium as well as activity of SGOT in broilers of *Aloe vera* treated group. Eevuri and Putturu (2013) found that *Aloe vera* supplementation in broilers significantly reduced the serum cholesterol, serum triglycerides and increased the humoral response against NCD vaccine.

Akanmu et al. (2020) conducted an experiment to reveal the effect of three plants; *Moringa oleifera, Jatropha curcas and Aloe barbadensis* extracts on the serum biochemical parameters in sheep by oral administration of these extracts for 75 days and found that supplementation of lambs with above three extracts did not significantly affect blood urea nitrogen (BUN), glucose, cholesterol, total serum protein, albumin, globulin, SGOT and SGPT concentration in the serum. Yadav et al. (2017d) conducted an experiment to reveal the effect of supplementation of *Aloe vera* on the serum biochemicals parameters of broilers, three groups provided with basal diet mixed with *Aloe vera* powder @ 0.5% in feed (T_2), gel @ 2% in feed (T_3) and fresh *Aloe vera* juice @ 2% in drinking water (T_4), respectively and it was found that alkaline phosphatase, SGOT, SGPT, total bilirubin and uric acid increased significantly in T_3 and T_4 groups as compared to control. Hosseini *et al.* (2013) conducted an experiment to reveal the effect of *Aloe vera* on albumin glycation reaction in vitro and concluded that *Aloe vera* extract can significantly inhibit albumin glycosylation and could also break albumin-glucose bond in 0.1 g/dl concentration, thus *Aloe vera* had significant hypoglycemic effect.

3.5. Effect of Aloe vera on gut parasites

Yadav et al. (2017b) conducted a trial on crossbred calves to observe the effect of dietary supplementation of *Aloe vera* (both @ 2 g and 4 g kg^{-1} body weight) on internal parasitic load of the calves and found that at the end of experiment lower egg g^{-1} was observed in treatment group with higher *Aloe vera* dose (87.5±23.93) as compare to treatment group with lower *Aloe vera* dose (100±20.41) and control (100±14.43). The analysis of variance showed that *Aloe vera* had no significant effect on internal parasitic load in treatment groups. Ahmed et al. (2017) studied the effect of *Aloe ferox* leaves on the gastrointestinal nematodes after using *Aloe ferox* leaf powder @ 0, 50 g, 100 g and 250 g per lamb in four different treatment groups and concluded that feeding of 250 g aloe result in maximum and significant reduction in egg per gram. Maphosa et al. (2010) conducted

a study to validate the in vitro effect of extracts of *Aloe ferox, Leonotis leonurus and Elephantorrhiza elephantina* on the egg and larvae of the nematode parasite *Haemonchus contortus* of goats and concluded that inhibition of egg hatching and larval development increased significantly with increasing concentrations of the extracts as compared to albendazole and water as control. *Aloe ferox* extracts had showed 100% inhibition at concentrations of 20 mg/ml.

Maphosa and Masika (2012) studied the effect of extracts of *Aloe ferox, Leonotis leonurus and Elephantorrhiza elephantina* on gastrointestinal nematodes in natural mixed infections in goats for 9 days and concluded that there was significant reductions in strongyle eggs by *Aloe ferox* extract at dose levels of 500 mg kg^{-1} on days 3, 6 and 9, while reductions in eimeria species oocysts were observed on days 3, 6 and 9 for animals that received 500 mg kg^{-1} doses. Alagesan et al. (2005) made comparison between the following four sets of ingestible i.e albendazole, neem oil, vegetable extract (extract of neem seed with bittergourd, garlic, edible banana stem) and *Aloe vera* during a study conducted on 40 sheep for 28 days in 2002 and reported that the *Aloe vera* has strong antiparasitic activity and result into maximum weight gain and epg reduction as compared to other three treatments. Yim et al. (2011) showed that broilers received *Aloe vera* powder (0.1%, 0.3% and 0.5%) had lesser fecal oocyst shedding count compared to infected group fed with the standard diet. Akhtar et al. (2012) found in their study that fecal oocyst shedding in broilers orally administered with ethanol and aqueous extracts of *Aloe vera* pulp at 300 mg kg^{-1} body weight day^{-1} for three consecutive days was significantly lower compared to the infected control group. Moreover, 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.

3.6. Economics/cost of feeding of Aloe vera

The scientific literature similar to this experimental protocol is very scanty but supported experiments are discussed as follows. Moorthy et al. (2009) observed that a significant difference in return over feed cost in 0.1 percent *Aloe vera* fed group compared to other treatment groups. It can be concluded that inclusion of 0.1 percent *Aloe vera* in *White Leghorn* diet is economical compared to its combination with turmeric and probiotic at 0.1 percent level. Eevuri and Putturu (2013) found that *Aloe vera* supplementation in broilers decreased the mortality rates and the cost of feed has been decreased by 6.2 to 13.5%. Thus *Aloe vera* supplementation in diet resulted in more return over feed cost to the farmer. Saini et al. (2021) concluded that feed cost per kg body weight gain was found lowest in buffalo calves fed with *Aloe vera* leaves @ 4 g kg^{-1} body weight than buffalo calves fed with *Aloe vera* leaves @ 2 g/Kg body weight and with standard diet only (no *Aloe vera* leaves).

3.7. Toxic effects of Aloe vera

The Effects like watery diarrhoea leading to electrolyte imbalance and hypokalemia are among the most common toxic effects of *Aloe vera* (Cooke et al., 1981). Other adverse effects are weight loss, central nervous system disturbances and abnormalities in excretory organ. Compounds in *Aloe vera* are thought of genotoxic and mutagenic (Mueller *et al.,* 1996) in nature. The active compounds in *Aloe vera* are also suspected to act on standard oral medications especially 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. Advantages of *Aloe vera* as herbal feed additive depend on several factors like form of use (powder, gel and extract) dosage, genetics of animals, ingredients of diet and farm management. Therefore, more number of studies is warranted to determine effective dosage and form of use as feed additives in different category of livestock.

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