# Postprint on the Application of Yucca Extract in Harmful Gas Emission Reduction and Healthy Livestock Farming

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## Abstract

Yucca schidigera extract (YSE) contains main active components including steroidal saponins, resveratrol, and Yucca polyphenols, which possess broad biological functions. Early research on YSE focused on rumen fermentation in ruminants to reduce harmful gases produced during their production process. In recent years, reports on YSE as a feed additive for improving animal health and promoting growth have been increasingly documented. This paper summarizes the role of YSE in mitigating harmful gas emissions from animal production, mainly introducing its emission reduction effects on the two main harmful gases produced during livestock production—methane and ammonia, and respectively summarizes the effects of YSE on improving health and promoting growth in different livestock and experimental animals.

## Full Text

## Preamble

**Application of Yucca schidigera Extract in Mitigating Harmful Gases and Promoting Healthy Husbandry in Livestock**

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**Abstract:** The main active components in Yucca schidigera extract (YSE) are steroidal saponins, resveratrol, and yucca polyphenols, which possess extensive biological functions. Early research on YSE focused on ruminal fermentation in ruminants to reduce harmful gas emissions during their growth. In recent years, increasing reports have documented YSE as a feed additive for improving animal

health and growth performance. This paper summarizes the role of YSE in mitigating harmful gases in animal production, primarily focusing on its effects in reducing two major harmful gases—methane and ammonia—produced during livestock production. It also reviews the effects of YSE on health improvement and growth promotion in different livestock and experimental animals.

**Keywords:** Yucca schidigera; ruminal fermentation; healthy husbandry; growth; livestock

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Yucca belongs to the Agavaceae family, native to the desert regions of southwestern United States and northern Mexico, and has been introduced and cultivated in southern China. The main active components of Yucca schidigera extract (YSE) are saponins and polyphenols[1-2]. The dry matter of yucca stems contains up to 10% steroidal saponins, making it one of the richest sources of saponins[3]. Early applications of YSE in animal production mainly focused on regulating gastrointestinal function, manifested as reducing harmful gas emissions from livestock and poultry, primarily attributed to its saponin components[1,4]. Yucca epidermis is rich in polyphenolic compounds such as resveratrol and yucca polyphenols[2]. Resveratrol can effectively scavenge hydroxyl radicals ( · OH-), superoxide anion radicals ( · O2-), and inhibit the formation of reactive oxygen species (ROS) in cells, protecting the body from lipid peroxidation damage in cell membranes and DNA caused by ROS[5]. Yucca polyphenols, structurally similar to resveratrol, also possess free radical scavenging functions[1-2]. With in-depth analysis of these components, recent research has focused on exploring their applications in healthy husbandry.

## 1.1 Harmful Gas Reduction Effects and Mechanisms

YSE can reduce methane[6-7] and ammonia[8] production in the rumen of ruminants. Under different experimental conditions, the effects of YSE on ruminal gas production vary[6,9]. Results also differ when evaluating YSE' s impact on methane production based on dry matter and digestible dry matter levels[10]. To avoid side effects of yucca on ruminal fermentation and feed digestion, saponin levels should be controlled within 10 g/kg (dry matter basis)[11]. However, some studies have shown that YSE does not effectively reduce methane[12-14], ammonia, or nitric oxide production[13] in ruminants.

YSE contains two components that can inhibit ruminal ammonia production: saponins and polysaccharides, but their mechanisms differ. Saponins can indirectly reduce ammonia production in the rumen through their antiprotozoal capacity[15]. Yucca saponins can bind to cholesterol on protozoal cell membranes, causing membrane rupture and cell lysis, leading to reduced protozoal populations in the rumen[3]. It should be noted that the antiprotozoal ability of saponins (i.e., their ability to bind cholesterol) requires an intact saponin structure, meaning both the main chain and side chains must be present[3]. In

addition to antiprotozoal activity, yucca saponins can also inhibit Gram-positive bacteria[16] and suppress deamination[17], all of which contribute to reduced ammonia concentration in the rumen. The polysaccharide fraction can directly reduce ammonia content, but its inhibitory capacity is very limited[15].

YSE reduces ruminal methane production through multiple pathways. It is generally believed that YSE primarily inhibits methane production by suppressing hydrogen-producing bacteria[15]. Additionally, YSE' s toxicity to protozoa also reduces methane production[11]. Since protozoa and methanogenic bacteria have a symbiotic relationship in the rumen[12], when YSE is added to the diet, the protozoal population decreases, leading to a decline in methanogenic bacteria and ultimately affecting methane production[17]. Another hypothesis suggests that YSE significantly increases rumen microbial numbers, shifting the rumen environment to favor propionate-producing bacteria proliferation[10]; propionate competes with methane for available hydrogen[18], and increased propionate production leads to reduced ruminal methane production[19].

## 1.2 Applications in Healthy Husbandry

Dietary supplementation of YSE can reduce dry matter intake in dairy cows while increasing feed conversion efficiency to milk[20]; it can improve average daily gain (ADG), feed conversion ratio (FCR), and apparent nutrient digestibility in sheep[8].

Studies have shown that low doses of yucca saponins can directly stimulate the growth of some ruminal bacteria, including cellulolytic bacteria, thereby improving feed digestibility without being affected by its antiprotozoal capacity[21]. High doses of yucca saponins mainly exert their effects on ruminal environment through antiprotozoal activity[21]. Yucca saponins also inhibit the growth of some ruminal and intestinal bacteria, such as Streptococcus bovis[15] and Escherichia coli K-12[22]. Polyphenolic compounds in YSE also have antibacterial effects; for example, yuccaol C can reduce the synthesis of inducible nitric oxide synthase protein through nuclear factor- B[23]. Phenolic substances in YSE inhibit key enzymes in the arachidonic acid metabolic pathway, indicating their anti-inflammatory and antiplatelet effects[24]. YSE can affect reproductive performance in dairy cows by increasing ammonia levels in the reproductive tract[4]. However, some reports indicate that YSE can inhibit the development of antral follicles in sheep[25].

## 2.1 Harmful Gas Reduction Effects and Mechanisms

YSE can significantly reduce harmful gas levels in pig and chicken housing and manure, such as ammonia, trimethylamine, dimethylamine, isobutyric acid, and hydrogen sulfide, through various application methods: as a feed additive[26-28]; direct spraying on manure[29]; addition to manure together with microbial preparations[29]; or spraying on bedding[30]. Among these methods, the combination of YSE as an additive with microbial preparations is particularly effective

in reducing harmful gas content in pig and poultry manure and housing[26,29]. Additionally, different application durations affect YSE' s efficacy[29], making the selection of optimal application time critical.

The mechanism behind YSE' s ammonia reduction in monogastric animals remains inconclusive. However, since ureaamine is part of volatile ammonia in manure and is inherently volatile, YSE' s effect on reducing ammonia in manure may be influenced by this factor[28]. Furthermore, YSE can alter manure moisture content[27], which is directly related to uric acid degradation[31], and uric acid promotes ammonia volatilization[32]. Therefore, YSE may reduce ammonia production in monogastric animals through this indirect regulatory mechanism. Additionally, the antibacterial capacity of yucca saponins contributes to reducing harmful gases in poultry manure[29].

## 2.2 Applications in Healthy Husbandry

Dietary YSE supplementation can increase egg production[33], egg weight[33-34], feed efficiency (FE)[34-35], body weight and weight gain in laying hens[35]; it can also improve ADG[36-37], dressing percentage[36], reduce FCR[37-39], enhance protein and energy efficiency[39], decrease mortality[40], and reduce fecal dry matter and crude ash content in broilers[26]. YSE can increase eviscerated carcass weight and breast muscle weight in broilers[39], reduce breast muscle redness value[40], and decrease aggressive behavior among birds[39].

YSE can enhance disease resistance in poultry by increasing Newcastle disease antibody titers[35], potentially synergizing with coccidiosis vaccines[37], and reducing cholesterol concentrations in serum and egg yolk of laying hens[34]. YSE also improves intestinal health in poultry by inhibiting Escherichia coli proliferation in the intestines of laying hens and broilers[34,40] and promoting intestinal tissue development in laying hens[35]. Additionally, YSE can increase antioxidant enzyme activity and serum immunoglobulin G concentration in laying hens[33], and increase the relative weight of the bursa of Fabricius in broilers[40].

YSE can be used as a single additive in poultry feeding[36] or formulated as composite additives with other substances such as caprylic acid[34], Quillaja saponaria powder[38], yeast cell wall[35], and natural zeolite[26]. The effects of YSE on poultry vary at different times[33,41-42]. Therefore, in production practice, both dosage and timing of supplementation should be considered to align with the concept of precision feeding for cost reduction and efficiency improvement.

Supplementing YSE in sow diets can improve postpartum thermoregulatory capacity and show trends toward reducing dystocia incidence and pre-weaning piglet mortality[43]. Additionally, YSE can inhibit ovarian granulosa cell proliferation by downregulating proliferating cell nuclear antigen gene expression, promote granulosa cell apoptosis by regulating anti-apoptotic gene bax expression, and stimulate progesterone secretion while inhibiting testosterone secretion[44].

Adding YSE to diets can promote intestinal development in piglets, thereby improving intestinal health[45]. Co-supplementation of YSE and sodium butyrate capsules in weaned piglet diets tends to increase the relative weights of stomach and pancreas, as well as the relative weight of the small intestine[45].

## 3.1 Mice and Rats

Many studies on YSE have used mice or rats as models, providing valuable insights for application in humans and other animals. Whole yucca extract, saponin extract, and non-saponin extract can all effectively reduce serum urea concentration in rats and significantly decrease the activity of urea cycle enzymes (arginase and argininosuccinate lyase)[46], which benefits kidney function. YSE can not only enhance antioxidant levels in normal rats[47] but also alleviate nitrite-induced oxidative stress[48] and arsenic-induced oxidative stress and tissue lesions in mice[49]. YSE can regulate animal energy metabolism, hormone levels, blood lipids, and other biochemical parameters, showing great potential for preventing human nutritional disorders such as obesity[50]. For example, YSE can reduce elevated blood glucose, total cholesterol, LDL cholesterol, HDL cholesterol, triglyceride concentrations, and aspartate aminotransferase and alanine aminotransferase activities in mice fed high-fat diets[50]; it can decrease blood cholesterol, triglyceride, and LDL concentrations, increase blood leptin and insulin concentrations, and reduce total thyroid hormone and free component concentrations in rats[51].

## 3.2 Special Animals and Pets

Current research on YSE in special animals and pets includes studies on rabbits and dogs. YSE can improve immune and antioxidant functions in rabbits[52], increase conception rates by stimulating ovarian progesterone secretion[53], and reduce blood ammonia[52], total cholesterol, and HDL concentrations[52]. Adding YSE to diets can reduce intestinal gas production and fecal ammonia content in Beagle dogs, but high doses (750 mg/kg) may cause side effects[54], manifested as increased mean corpuscular hemoglobin content and alanine aminotransferase activity, with a trend toward increased blood cholesterol concentration[54]. Additionally, YSE can reduce dietary fat digestibility in Beagle dogs[55].

# 4 Summary

This paper detailed research on YSE application as a feed additive in animal production. YSE can not only reduce harmful gas emissions during livestock production and harmful gas concentrations in manure but also has the potential to improve livestock health and growth performance. Traditionally, livestock growth performance has been the primary indicator for evaluating feed additive efficacy, but this approach has significant limitations. Currently, livestock enterprises exert enormous pressure on the environment, animal health status remains concerning, food safety issues are still serious, coupled with fluctuat-

ing feed costs and reduced profit margins in animal husbandry. These factors require livestock enterprises to seriously consider aspects such as production efficiency, animal health, environmental impact, and product quality and safety as starting points for problem-solving, benefit enhancement, and social responsibility fulfillment. The use of YSE in livestock aligns with the current concept of healthy husbandry, giving it broad application prospects.

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