Characteristics of Plant Extracts and Their Application in Sow Production: Postprint

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Abstract

Sow reproductive performance constitutes a critical determinant of production levels and economic efficiency in pig farming operations, yet a significant gap persists between the annual productivity of sows in China and that achieved in developed European and American countries. Although antibiotics employed as feed additives have improved sow reproductive performance to a certain degree, their excessive utilization in feed engenders issues such as the proliferation of drug-resistant bacteria and residues in meat products, thereby jeopardizing human health and the ecological environment. Plant extracts are plant-derived additive products obtained from botanical sources through physical or chemical methods, containing multiple natural bioactive substances. In recent years, the application of plant extracts as antibiotic alternatives in sow production has garnered extensive attention. This paper synthesizes domestic and international research progress to review the characteristics of plant extracts and their effects on sow production performance, aiming to provide a reference for further in-depth research on the application of plant extracts in sow production.

Full Text

Plant Extracts: Characteristics and Application in Sow Production

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Abstract

The reproductive performance of sows is a primary factor that determines production level and profitability in swine enterprises, while the number of piglets

per sow per year in China remains lower than in the USA and EU. Although antibiotics can improve sow performance, their overuse in diets has caused problems such as bacterial resistance and drug residues in pork products, which are harmful to human health and the ecological environment. Plant extracts are phytogenic products consisting of various natural active components, produced through physical or chemical extraction from natural plants. In recent years, plant extracts have attracted increased attention as alternatives to antibiotics in the sow industry. Referring to domestic and overseas research, this paper reviews the characteristics of plant extracts and their effects on sow performance, as well as practical application effects, to provide a reference for further study on the application of plant extracts in sow feeding.

Keywords: plant extracts; characteristics; sows; application

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1 Introduction

Sow reproductive performance is a critical factor determining production efficiency and economic returns in pig farming. However, the current piglets-per-sow-per-year figure in China still lags behind that of the United States and European Union. While antibiotics have been used to enhance sow performance, their excessive use in feed has led to serious issues including bacterial resistance and drug residues in pork products, posing risks to human health and the environment. Plant extracts, derived from natural plants through physical or chemical extraction processes, contain diverse bioactive compounds and have gained significant attention as potential antibiotic alternatives in sow production. This review synthesizes domestic and international research on the characteristics of plant extracts, their effects on sow performance, and practical application outcomes to provide a foundation for future research and application in sow nutrition.

1.1 Antioxidant Properties

Oxidative stress is a major concern during late gestation and lactation in sows, characterized by increased production of reactive oxygen species (ROS) and lipid peroxidation. Plant extracts rich in polyphenolic compounds can effectively scavenge free radicals and enhance antioxidant capacity. Studies have shown that dietary supplementation with plant extracts significantly reduces oxidative stress markers. For instance, supplementation with 15 mg/kg of certain extracts decreased 8-hydroxydeoxyguanosine (8-OHdG) and thiobarbituric acid reactive substances (TBARS) levels in sows [8]. Similarly, administration of 45 mg/kg reduced malondialdehyde (MDA) while increasing superoxide dismutase (SOD), total antioxidant capacity (T-AOC), and catalase (CAT) activities [9–11]. At 200 mg/kg, extracts have been shown to lower MDA and elevate glutathione

peroxidase (GSH-Px) activity [12]. These findings demonstrate dose-dependent antioxidant benefits that improve sow health and performance.

1.2 Effects on Production Performance

Plant extracts improve sow performance through multiple pathways, including enhanced lactation feed intake, reduced weight loss, and improved milk quality. Supplementation during gestation and lactation increases weaning weights and average daily gain (ADG) of piglets. Table 1 summarizes the effects of various plant extracts on sow performance. Key findings include: star anise supplementation increased weaning weight by 10.3–11.6% [31]; ginger extracts improved ADG by 11.6% [33]; and oregano essential oil enhanced piglet weight gain by 12.2–14.8% [8, 35]. Compound plant extracts containing multiple active components have shown even greater efficacy, with some formulations improving weaning weight by 13.4–19.4% [39–41]. These improvements are attributed to enhanced milk production, better nutrient digestibility, and reduced pathogen load.

1.3 Immune Function Enhancement

Plant extracts modulate immune function by increasing immunoglobulin levels and regulating cytokine production. Studies demonstrate that 200 mg/kg ginseng polysaccharide supplementation elevated IgG concentrations in sow colostrum and milk, improving passive immunity transfer to piglets [13]. Similarly, 200 mg/kg herbal supplementation increased IgG by 15% and IgA levels while reducing interleukin-6 (IL-6) [27]. At 90 mg/kg, extracts enhanced IL-2 production by 28% and increased IgG while decreasing IL-6 [13]. These immunomodulatory effects strengthen both innate and adaptive immunity, reducing sow susceptibility to mastitis-metritis-agalactia (MMA) syndrome and improving overall herd health.

1.4 Weaning-to-Estrus Interval (WEI)

Shortening the WEI is crucial for improving sow reproductive efficiency. Plant extracts can reduce WEI by alleviating oxidative stress and improving uterine recovery post-weaning. Research indicates that phytogenic supplementation decreases WEI by 7–21 days compared to control groups [20–22, 30]. The mechanism involves reduced inflammation and enhanced endometrial repair through antioxidant and antimicrobial actions. Oregano essential oil, for example, has been shown to improve farrowing rates and reduce culling due to reproductive failure [20, 21].

2 Mechanism of Action

The beneficial effects of plant extracts on sow performance are mediated through three primary mechanisms (Fig. 1):

Antioxidant Activity: Polyphenols and flavonoids scavenge ROS, upregulate antioxidant enzymes (SOD, CAT, GSH-Px), and reduce lipid peroxidation. This protects mammary tissue from oxidative damage during peak lactation [44, 45].

Antimicrobial Effects: Essential oils containing thymol, carvacrol, and eugenol disrupt bacterial cell membranes, inhibit pathogenic proliferation, and reduce endotoxin production. This decreases the incidence of swine urogenital disease (SUGD) and MMA syndrome [8, 21–22, 35–36, 38–39].

Immunomodulation: Bioactive compounds activate nuclear factor erythroid 2-related factor 2 (Nrf2) pathways, suppress NF- B signaling, and modulate cytokine expression (IL-2, IL-6, TNF-), thereby reducing inflammatory responses [46–49].

3 Gut Microbiota Modulation

Plant extracts positively influence gut microbiota composition by promoting beneficial bacteria (Lactobacillus, Bifidobacterium) and inhibiting pathogens (E. coli, Salmonella). This modulation increases short-chain fatty acid (SCFA) production, enhances gut barrier integrity, and reduces noxious gas emissions [50–53]. The prebiotic-like effects of certain polysaccharides support microbial balance, which is critical for nutrient absorption and immune development in both sows and piglets [54, 55]. Improved gut health translates to better feed efficiency and reduced post-weaning diarrhea in piglets.

4 Conclusion and Future Directions

Plant extracts represent viable alternatives to antibiotics in sow production, offering multifaceted benefits including antioxidant protection, immune enhancement, and microbiota modulation. While current research demonstrates positive effects on performance, immune status, and reproductive efficiency, several knowledge gaps remain. Future studies should focus on: (1) optimizing dosage and delivery methods for different production stages; (2) investigating synergistic effects of compound extracts; (3) elucidating precise molecular mechanisms; and (4) evaluating long-term impacts on sow longevity and piglet development. Standardized extraction protocols and quality control measures are essential for consistent field application. As the industry moves toward antibiotic-free production, plant extracts will play an increasingly important role in sustainable swine nutrition.

Table 1 Effects of plant extracts on performance of sows

Plant Name	Main Active Components	Duration of Supplement/d	Supplemental Dose/(mg/kg)	Treatment Effects (vs. Control)/%
Star anise	6-anethole, 6-shikimic acid	G85–L21	5.0	+10.3 (weaning weight)
Star anise	6-anethole, 6-shikimic acid	G85–L21	7.0	+11.6 (weaning weight)
Dan-shen root	Tanshinone IIA	G85–L28	3.0	+11.6 (ADG)
Ginger	Gingerol	G107–L26	2.5	+11.6 (ADG)
Soy	Isoflavones	L1–L18	3.2	+14.8 (weaning weight)
Fenugreek seed	Saponins	G90–L28	2.5	+12.2 (ADG)
Seaweed	Polysaccharides	G1–L21	3.6	+13.9 (weaning weight)
Milk thistle	Silymarin	G1–L19	2.4	+10.5 (weaning weight)
Ginseng	Ginsenosides	G109–L22	4.3	+11.1 (ADG)
Oregano	Carvacrol, thymol	G110–L21	2.1	+10.4 (ADG)
Yucca shidig-era	Saponins	L1–E1	5 g/d	+11.5 (weaning weight)
Quillaja saponaria	Saponins	G107–L23	10 g/d	+16.4 (weaning weight)
Plant ex-tracts com-pound	Mixed	G90–L28	3.4	+13.4 (weaning weight)
Plant ex-tracts com-pound	Mixed	G108–L25	2.6	+12.4 (ADG)
Plant ex-tracts com-pound	Mixed	G107–L28	2.1	+10.5 (weaning weight)

Note: "G" = gestation, "L" = lactation, "E" = estrus. For example, "G85-L21" indicates supplementation from day 85 of gestation to day 21 of lactation.

Fig. 1 Potential mechanism of plant extracts for affecting performance of sows

The figure illustrates three main pathways: (1) Antioxidant pathway -ROS scavenging and Nrf2 activation; (2) Antimicrobial pathway -inhibition of SUGD/MMA pathogens; (3) Immunomodulatory pathway -NF- B suppression and cytokine regulation.

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Note: Figure translations are in progress. See original paper for figures.