Biological Functions of Artemisia argyi and Its Applications in Livestock Production: Postprint

Authors: Liu Chaoqi, Chang Juan, Wang Ping, Yin Qingqiang, Dang Xiaowei, Gao Tianzeng

Date: 2018-12-25T00:00:00+00:00

Abstract

Artemisia is a class of perennial plants in the family Asteraceae and genus Artemisia. The nutritionally active substances in Artemisia leaves include volatile oils, flavonoids, triterpenoids, and eudesmanes, which exhibit biological functions such as antibacterial, antiviral, antioxidant, anticancer, and immune-enhancing effects. Artemisia extract and its processed products, including Artemisia powder and Artemisia stalks, have been reported as functional feed additives or feed ingredients in livestock production, showing broad application prospects. This review summarizes the main nutritionally active substances of Artemisia and their omics functions, as well as the current status of Artemisia application in livestock production, aiming to provide a theoretical basis for the rational utilization of Artemisia in livestock production.

Full Text

Artemisia argyi: Biological Functions and Applications in Animal Production

LIU Chaoqi[1], CHANG Juan[1], WANG Ping[1], YIN Qingqiang[1]*, DANG Xiaowei[2], GAO Tianzeng[3]

[1]College of Animal Science and Veterinary Medicine, Henan Agricultural University, Zhengzhou 450002, China
[2]Henan Delin Biological Product Co. Ltd., Xinxiang 453000, China
[3]Henan Guang' an Biotechnological Co. Ltd., Zhengzhou 450001, China

Abstract: Artemisia argyi is a perennial plant belonging to the genus Artemisia in the Compositae family. The leaves of A. argyi contain various bioactive nutrients, including volatile oils, flavonoids, triterpenoids, and eudesmane compounds, which exhibit biological functions such as antibacterial, antiviral, antioxidant, anticancer, and immunity-enhancing activities. A. argyi extracts and

processed products such as mugwort powder and stalks have been reported as functional feed additives or ingredients in animal production, demonstrating broad application prospects. This review synthesizes current research on the main bioactive nutrients of A. argyi, their omics functions, and the status of its application in animal husbandry, aiming to provide a theoretical basis for the rational utilization of A. argyi in animal production.

Keywords: Artemisia argyi leaf; bioactive nutrient component; omics function; animal production

---

Artemisia argyi, commonly known as mugwort, is a perennial semi-shrub herbaceous plant in the Compositae family that exhibits strong adaptability. It grows naturally along roadsides, in forest lands, on barren slopes, and in hilly areas, and can be cultivated artificially across most regions of China. As a wild medicinal herb, A. argyi has been documented in both the *Compendium of Materia Medica* and *Miscellaneous Records of Famous Physicians* for its dried leaves' pharmacological effects in dispelling cold and dampness, warming meridians, activating collaterals, and providing anti-inflammatory, hemostatic, and cough-relieving benefits [1-2]. Beyond its medicinal value, A. argyi emits a distinctive aroma and serves as a nutrient-rich food ingredient for health products and food formulations, such as mugwort-purple sweet potato chiffon cake and mugwort-pumpkin health cake [3-4]. Currently, large-scale cultivation in Qichun County, Hubei Province and Nanyang City, Henan Province has established industrial clusters producing diverse products with an annual output value reaching hundreds of billions of yuan, creating employment opportunities for local farmers, increasing their income, and driving regional economic development [5].

In recent years, growing concerns over the side effects of long-term antibiotic use and increasing environmental awareness have intensified the search for antibiotic alternatives. As a herbaceous plant with nutritional value, A. argyi leaves are commonly used in traditional Chinese medicine and offer health benefits. Being a natural plant source, it leaves no residues and does not induce drug resistance, gradually gaining recognition as a valuable resource. However, reports on the application of A. argyi as a feed additive in animal production remain limited, primarily due to its complex composition and unclear mechanisms of action in animals. Traditional nutritional approaches analyzing single bioactive components cannot adequately evaluate its nutritional value, as interactions among various components can generate new properties and functions not present in individual compounds, resulting in unique collective attributes. Therefore, this review employs the theory of bioactive nutrient omics to analyze domestic and international research on A. argyi, summarizing its bioactive nutrients, omics functions, and application effects in animal production to provide theoretical references for developing and utilizing A. argyi-based bioactive nutrient omics products.

1.1 Bioactive Nutrients in Artemisia argyi

The leaves of A. argyi contain proteins, fats, polysaccharides, fiber, and mineral elements. The fat component includes various fatty acids, with polyunsaturated fatty acids being the most abundant at 60.42% [6]. These fatty acids serve as major constituents of cell membranes and demonstrate therapeutic effects against cancer and cardiovascular diseases while participating in growth, development, and gene regulation [7]. Polysaccharides extracted from A. argyi leaves can enhance animal immunity, reduce blood glucose, and inhibit bacterial and viral growth [8]. Research has shown that A. argyi leaves contain 13.1% crude protein and 5.69% crude fat (including various fatty acids), along with 16 amino acids and 14 mineral elements [9].

Beyond these conventional nutrients, A. argyi possesses compounds that exert nutritional regulation and health-promoting functions. Chemical analysis has identified the main bioactive nutrients as volatile oils, flavonoids, eudesmane compounds, and triterpenoids [2,10].

Volatile oils can be extracted from A. argyi leaves through various methods including organic solvent extraction, microwave-assisted extraction, ultrasonic extraction, pressurized extraction, and supercritical fluid extraction. These oils are complex mixtures containing hydrocarbons, alcohols, aldehydes, ketones, esters, monoterpenes, and sesquiterpenes [11-13]. The composition and content of volatile oils vary depending on geographical origin, harvest time, and extraction method. With technological advances, the number of identified compounds has increased from 20-30 to over 100. The most readily isolated and abundant compounds include 1,8-cineole, camphor, borneol, caryophyllene, caryophyllene oxide, -thujone, -thujone, and 4-terpineol [14-16].

Flavonoids typically refer to a series of compounds composed of two phenolic hydroxyl benzene rings connected through a central three-carbon bridge. Common extraction methods from A. argyi leaves include maceration, ultrafiltration, enzymatic hydrolysis, adsorption, microwave, ultrasonic, and supercritical fluid extraction, followed by chromatography, salting-out, and extraction for further purification [17]. Shen Xiangzhong [18] used ethanol and ether to extract crude flavonoids from A. argyi leaves and optimized purification conditions with AB-8 macroporous adsorption resin, achieving a 3.1-fold increase in crude flavonoid yield. Wei Xingxing et al. [19] optimized Soxhlet extraction conditions through orthogonal experiments, obtaining a total flavonoid yield of 3.85% under specific solid-liquid ratios, temperatures, and time conditions. A. argyi leaves contain numerous flavonoid compounds, including flavones, flavonols, anthocyanins, quercetin, dihydroflavones, dihydroflavonols, chalcones, flavan-3,4-diols, xanthones, and biflavonoids [10].

Triterpenoids are terpenoid compounds composed of 27-30 carbon atoms formed by several isoprene units after hydroxyl removal and head-to-tail connection, widely distributed in plants. They are typically extracted from A. argyi leaves using organic solvents such as chloroform or ether. Common triterpenoids

include , -amyrin, stigmasterol, , -amyrin acetate, -sitosterol, lupenone, fernenone, and 3 -methoxy-9 ,19-cyclolanost-23(E)-en-25,26-diol [20]. Research on eudesmane compounds remains limited, with few isolated substances including cryptomeridiol, 1-oxo-4 -acetoxyeudesma-2,11(13)-dien-12,8 -olide, yomogin, and 1-oxo-4 -acetoxyeudesma-2,11(13)-dien-12,8 -olide [21].

1.2.1 Antibacterial and Antiviral Functions

The natural environment harbors numerous microorganisms, including bacteria, fungi, and viruses, some of which are detrimental to animal health, such as *Staphylococcus aureus* and *Escherichia coli* that cause diarrhea. Controlling the proliferation of these pathogenic microorganisms in the intestinal tract represents an urgent research priority. Huang Xuequan et al. [22] found that liquid from boiled A. argyi demonstrated superior in vitro antibacterial activity against *E. coli* compared to seven other Chinese medicinal herbs. Ahameethunisa et al. [23] similarly observed that A. argyi extracts inhibited *E. coli* but showed no effect against *S. aureus* and *Enterococcus faecalis*. Other studies have demonstrated that active components extracted from A. argyi leaves using ultrasonic methods exhibit significant antibacterial effects against common pathogens including *S. aureus*, white staphylococcus, and *E. coli* [24-25]. Wei Bin et al. [26] found that decoction liquid from A. argyi leaves could inhibit *E. coli* activity and reduce its resistance to gentamicin. Nuerbiye Aobulikasimu et al. [27] obtained volatile oils and monomeric compounds (eucalyptol and 4-terpinenol) through steam distillation and silica gel column chromatography, which inhibited *Phytophthora*, *Aspergillus niger*, *Trichothecium roseum*, *Penicillium*, and *Alternaria*, suggesting potential as food anti-spoilage agents. Beyond antibacterial and antifungal effects, A. argyi extracts also demonstrate antiviral properties. Studies have shown that volatile oils and ethyl acetate extracts from A. argyi can effectively inhibit hepatitis B virus (HBV) infection of HepG2.2.15 cells in vitro, offering therapeutic potential for hepatitis B [28-29].

1.2.2 Antioxidant Function

Under normal physiological conditions, mitochondria produce hydrogen peroxide, superoxide anions, and hydroxyl radicals during cellular aerobic metabolism. Typically, the endogenous antioxidant system eliminates these substances to maintain homeostasis. However, environmental changes such as dietary shifts, temperature fluctuations, and humidity variations can cause excessive accumulation of these reactive species beyond the body' s elimination capacity, leading to oxidative stress that reduces animal performance, causes disease, and may result in death. Research has demonstrated that polysaccharides extracted from A. argyi leaves using hot water maceration and purification can effectively scavenge hydroxyl radicals in vitro, with scavenging capacity increasing proportionally with polysaccharide concentration [30-31]. Han et al. [32] obtained total phenols and flavonoids through sequential ethyl acetate fractionation and purification of A. argyi leaves, which showed high superoxide anion radical scavenging ac-

tivity. Melguizo-Melguizo et al. [33] extracted chlorogenic acid derivatives and conjugated luteolin, quercetin, and kaempferol using maceration and ultrasonic-assisted extraction, confirming their strong antioxidant properties through experimental validation.

1.2.3 Anticancer Function

When animal bodies are exposed to external carcinogenic factors, metabolic processes generate free radicals that accumulate around cell membranes, causing lipid peroxidation and attacking intracellular DNA, resulting in DNA damage and carcinogenesis. Additionally, peroxides produced by lipid peroxidation can induce mutations and cancer. Shoemaker et al. [34] added crude distillates from A. argyi leaves to various cancer cell lines, observing growth inhibition in all cases and suggesting potential as an antitumor agent. Flavonoids can inhibit the activity of certain cytochrome P450 enzymes or inactivate them, preventing the activation of chemical carcinogens into active intermediates and facilitating carcinogen detoxification. Furthermore, quercetin has been shown to inhibit tumor cell growth and differentiation, achieving anticancer effects [35]. Kim et al. [36] extracted relatively pure phenolic and flavonoid compounds from five Korean A. argyi varieties, demonstrating effective cancer cell inhibition in vitro. Seo et al. [37] isolated two flavonoid compounds (5,6-dihydroxy-7,3,4-trimethoxyflavone and 5,6,4-trihydroxy-7,3-dimethoxyflavone) from A. argyi leaves using methanol extraction and purification, which inhibited mouse colon cancer by 44.6% and 14.6%, respectively, without causing weight loss. These findings indicate that Artemisia plants represent an ideal source of functional food ingredients with anticancer properties.

1.2.4 Anti-inflammatory and Immunity-Enhancing Functions

When animal bodies encounter external disturbances, tissues and organs initiate defensive responses to mitigate damage, manifesting inflammatory symptoms such as redness, heat, and swelling. Shin et al. [38] found that A. argyi leaves and dehydromatricarin extracted from them could effectively reduce lipopolysaccharide-induced airway inflammation by decreasing inducible nitric oxide synthase (iNOS) gene expression and NF- B phosphorylation. Tian Lu [39] extracted chemical components from A. argyi leaves and demonstrated anti-inflammatory effects using both in vitro macrophage inflammation models and in vivo zebrafish wound infection models. Nam et al. [40] showed that jaceosidin extracted from A. argyi leaves could inhibit microglial inflammatory responses. Yin Meizhen et al. [41] extracted crude polysaccharides from A. argyi leaves using ethanol and purified water, which enhanced macrophage phagocytosis of ink particles and *Staphylococcus aureus*. Further research revealed that adding crude A. argyi polysaccharides to cultured mouse spleen cells significantly increased the activity of tumor necrosis factor and interleukin-2 (IL-2) secretion [42]. Yu Guipeng et al. [43] similarly demonstrated that A. argyi polysaccharides could enhance the immunomodulatory function of macrophages. Long

Xueming [44] prepared volatile oil emulsions from A. argyi leaf extracts and administered them to mice via gavage for seven consecutive days, with results indicating enhanced immunity.

1.2.5 Other Omics Functions

Beyond the aforementioned biological functions, certain compounds extracted from A. argyi leaves also exhibit anti-aging, neurodegeneration prevention, cough relief, and hemostatic effects. Xu et al. [45] dried A. argyi leaves into moxa sticks and observed that moxa smoke altered serotonin, dopamine, and norepinephrine levels in mouse brains—key neurotransmitters in the central nervous system closely associated with neurological function and aging. Ha et al. [46] extracted phenolic compounds (eupatilin and jaceosidin) from Qiai A. argyi that attenuated hydrogen peroxide-induced neurotoxicity, suggesting potential as a food source for preventing neuropathological changes.

2 Application of Artemisia argyi in Animal Production

The rich nutritional and bioactive components of A. argyi have attracted attention for both medicinal and health-promoting applications. Beyond its therapeutic use, safety trials have confirmed that A. argyi causes no toxic effects in animals [47]. When processed into powder and added to animal feed, A. argyi can improve livestock performance, antioxidant capacity, immunity, and product quality. The following summary of recent research across various livestock species provides a basis for A. argyi utilization.

2.1 Pigs, Chickens, and Geese

Research has shown that feeding pigs 2% A. argyi leaf powder can increase daily weight gain and feed conversion efficiency while reducing feeding costs in Sanjiang white pigs [48]. Hwang et al. [49] applied traditional acupuncture using heat from burning A. argyi at specific acupoints to pigs with *E. coli*-induced diarrhea, achieving an 81.8% recovery rate—higher than that obtained with neomycin treatment—demonstrating the effectiveness of traditional acupuncture in controlling early-stage *E. coli* diarrhea in pigs. Studies have also found that adding A. argyi extracts to diets before lipopolysaccharide injection to induce inflammation in broiler chickens prevented performance decline and reduced blood cortisol, interleukin-2, and immunoglobulin G levels compared to non-supplemented groups, indicating that A. argyi extracts can alleviate immune stress in broilers [50]. Wu Youhua et al. [51] reported that feeding broiler chickens different proportions of A. argyi leaf powder promoted immune system development and improved production performance. Xu Hongrui et al. [52] observed that feeding laying hens A. argyi leaf powder under heat stress conditions enhanced heat stress resistance, egg production performance, and egg quality. Similar benefits have been reported for meat geese, including improved survival rates [53].

2.2 Sheep and Cattle

Sun Kenian [54] reported that A. argyi leaves could increase weight gain and improve wool yield and quality in sheep. Additionally, A. argyi can be combined with other Chinese medicinal herbs as feed for pregnant ewes to meet their nutritional requirements during gestation [55]. Research on dairy cows has shown that supplementation at 600 g/head/day increased milk yield, improved color uniformity, reduced off-flavors, decreased somatic cell counts, and stabilized rumen pH [56-57].

2.3 Rabbits and Fish

Studies have demonstrated that A. argyi aqueous extract improved immune organ development, intestinal growth, growth performance, and meat quality in post-weaning meat rabbits [58-59]. Wang Hua et al. [60] found that oral administration of A. argyi water decoction and alcohol extract to Ira rabbits increased white blood cell counts and reduced serum aspartate aminotransferase activity, indicating enhanced immunity. Liu Hongli et al. [61] reported that A. argyi leaf powder at 3-6% supplementation did not affect nutrient apparent digestibility, nitrogen metabolism, or muscle quality, confirming its suitability as a feed resource for meat rabbits. Additionally, feeding various fish species in ponds with pellet feed containing A. argyi leaf powder increased growth rates to varying degrees, demonstrating its growth-promoting effects in fish [9].

3 Summary

Research on A. argyi has expanded in recent years, gradually revealing its components and biological functions. While most reports focus on its medicinal applications and health product development, systematic studies on the application of A. argyi and its processed products in animal production remain relatively scarce, with underlying mechanisms poorly understood. A. argyi is rich in nutrients, including proteins, amino acids, minerals, and vitamins, making it a valuable plant-based feed resource. Processing A. argyi leaves into powder for animal feed not only provides partial nutritional requirements but more importantly delivers pharmacological and health benefits, such as promoting growth, modulating immunity, enhancing antioxidant capacity, and providing anticancer effects. Future development should focus on two directions: first, investigating optimal supplementation ratios of A. argyi and its by-products for different animal species and developing A. argyi-based bioactive nutrient omics products to better utilize this feed resource; second, scientifically extracting or fermenting A. argyi components to enhance active ingredient content, creating green, environmentally friendly, and healthy feed additives as antibiotic alternatives—representing a novel approach for livestock industry development.

References:

[1] 何姿, 夏道宗, 吴晓敏, 等. 艾草总黄酮的提取工艺优化及抗氧化活性研究 [J]. 中华中医药学刊,2013,31(7):1550-1552.
[2] 任小菊, 徐皓, 陈文华, 等. 艾蒿主要化学成分和药理作用研究进展 [J]. 安徽农业科学,2017,45(6):112-114.
[3] 贾娟. 艾草紫薯戚风蛋糕的工艺研究 [J]. 中国果菜,2017,37(2):6-10.
[4] 邓志勇, 吴桂容, 李松玲. 艾草南瓜保健蛋糕工艺的研究 [J]. 安徽农业科学,2015,43(3):220-221,288.
[5] 何秀岚, 李世国, 聂全新. 安全优质高效艾草食品的生产与加工技术研究 [J]. 安徽农业科学,2004,32(5):995-996.
[6] 王艳荣, 何云, 苗志国, 等. "绿色" 饲料添加剂——艾叶的研究进展 [J]. 饲料工业,2009(10):38-40.
[7] 张晓图, 杜晨红, 丁小娟, 等. 多不饱和脂肪酸的生物学功能及其在动物生产中的应用 [J]. 动物营养学报,2017,29(9):3059-3067.
[8] 吴桂花. 艾叶挥发油和多糖提取工艺及生物活性研究 [D]. 硕士学位论文. 上海: 华东理工大学,2011.
[9] 陈维岩, 王贞友, 高宏伟, 等. 艾叶的化学分析及含艾叶饵料对鱼的饲效观察 [J]. 兽医大学学报,1989(2):189-194.
[10] HA G J,LEE Y H,KIM N K,et al.Nutritional chemical composition in the different parts of Artemisia argyi H[J].Journal of Agriculture & Life Science,2012,46(4):155-164.
[11] 王惠君, 王文泉, 卢诚, 等. 艾叶研究进展概述 [J]. 江苏农业科学,2015,43(8):15-19,44.
[12] 李华生, 骆航, 孙兴力, 等. 加压同步萃取艾叶挥发油、总黄酮和多糖的工艺研究 [J]. 中国食品添加剂,2016(10):83-89.
[13] HUANG H C,WANG H F,YIH K H,et al.Dual bioactivities of essential oil extracted from the leaves of Artemisia argyi as an antimelanogenic versus antioxidant agent and chemical composition analysis by GC/MS[J].International Journal Molecular Sciences,2012,13(12):14679-14697.
[14] ZHANG Y,KANG L P,TENG Z Q,et al.Comparison of volatile constituents in two types of mugwort leaves (produced in Qichun and Nanyang) using the headspace GC-MS[J].Journal of Acupuncture and Tuina Science,2016,14(3):164-169.
[15] 张元, 康利平, 詹志来, 等. 不同采收时间对艾叶挥发油及其挥发性主成分与毒性成分变化的影响 [J]. 世界科学技术: 中医药现代化,2016,18(3):410-419.
[16] 张小俊, 赵志鸿, 张壮丽, 等.HS-SPME-GC-MS 测定艾叶挥发性成分方法优化 [J]. 中国实验方剂学杂志,2014,20(21):66-71.
[17] 程慧. 艾叶中黄酮类化合物研究进展 [J]. 光明中医,2014,29(9):2015-2016.
[18] 申湘忠. 艾叶总黄酮的提取及纯化工艺条件 [J]. 湖北农业科学,2011,50(12):2519-2522.
[19] 卫星星, 曹琛, 高慧, 等. 正交试验优选艾叶总黄酮索氏提取工艺 [J]. 氨基酸和生物资源,2016,38(3):45-47.
[20] 孙蓉, 黄伟, 王会. 与功效、毒性相关的艾叶化学成分研究进展 [J]. 中国药物警戒,2009,6(11):676-679.
[21] 陈小露, 梅全喜. 艾叶化学成分研究进展 [J]. 今日药学,2013,23(12):848-851.
[22] 黄雪泉. 八种中草药体外抑制大肠杆菌的效果观察 [J]. 贵州畜牧兽医,2009,33(1):3-4.
[23] AHAMEETHUNISA A R,HOPPER W.Antibacterial activity of Artemisia

nilagirica leaf extracts against clinical and phytopathogenic bacteria[J].BMC Complementary and Alternative Medicine,2010,10:6.
[24] 冯丽娟, 孙智勇, 陈芳, 等. 三种方法提取的艾叶有效成分的抑菌作用比较 [J]. 食品工程,2011(4):35-37.
[25] 潘百明, 何彩梅, 梁昌祥, 等. 艾叶挥发油对禽致病性大肠杆菌的药敏试验 [J]. 中国家禽,2017,39(17):67-68.
[26] 韦嫔, 谭艾娟, 吕世明, 等. 中药消除致病性大肠杆菌耐药性的研究 [J]. 江苏农业科学,2017,45(11):127-129.
[27] 努尔比耶·奥布力喀斯木, 热娜·卡斯木, 杨璐, 等. 艾叶挥发油化学成分分析和抗真菌活性的研究 [J]. 新疆医科大学学报,2017,40(9):1195-1198,1202.
[28] 赵志鸿, 王丽阳, 郑立运, 等. 艾叶挥发油对 HBV 的抑制作用 [J]. 郑州大学学报: 医学版,2015,50(2):301-304.
[29] 赵志鸿, 侯迎迎, 郑立运, 等. 艾叶乙酸乙酯提取物对 HBV 的抑制作用 [J]. 郑州大学学报: 医学版,2013,48(6):783-785.
[30] 谭冰, 严焕宁, 黄锁义, 等. 艾叶多糖的提取、含量测定及对羟自由基清除作用的研究 [J]. 中国执业药师,2012,9(3):10-13.
[31] LAN M B,ZHANG Y H,ZHENG Y,et al.Antioxidant and immunomodulatory activities of polysaccharides (Artemisia argyi) leaf[J].Food Science Biotechnology,2010,19(6):1463-1469.
[32] HAN B S,XIN Z Q,MA S S,et al.Comprehensive characterization and identification of antioxidants Folium artemisiae argyi using high-resolution tandem mass spectrometry[J].Journal of Chromatography B,2017,1063:84-92.
[33] MELGUIZO-MELGUIZO D,DIAZ-DE-CERIO E,QUIRANTES-PINÉ R,et al.The potential of Artemisia vulgaris leaves as a source of antioxidant phenolic compounds[J].Journal of Functional Foods,2014,10:92-200.
[34] SHOEMAKER M,HAMILTON B,DAIRKEE S H,et al.In vitro anticancer activity of twelve Chinese medicinal herbs[J].Phytotherapy Research,2005,19(7):649-651.
[35] 白凤梅, 蔡同一. 类黄酮生物活性及其机理的研究进展 [J]. 食品科学,1999,20(8):11-13.
[36] KIM R J,KANG M J,HWANG C R,et al.Antioxidant and cancer cell growth inhibition activity of five different varieties of Artemisia cultivars in Korea[J].Journal of Life Science,2012,22(6):844-851.
[37] SEO J M,KANG H M,SON K H,et al.Antitumor activity of flavones isolated from Artemisia argyi[J].Planta Medica,2003,69(3):218-222.
[38] SHIN N R,PAPK S H,KO J W,et al.Artemisia argyi attenuates airway inflammation in lipopolysaccharide induced acute injury model[J].Laboratory Animal Research,2017,33(3):209-215.
[39] 田璐. 艾叶化学成分分析及其抗炎功效研究 [D]. 硕士学位论文. 广州: 暨南大学,2017.
[40] NAM Y,CHOI M,HWANG H,et al.Natural flavone jaceosidin is a neuroinflammation inhibitor[J].Phytotherapy Research,2013,27(3):404-411.
[41] 尹美珍, 阮启刚, 余桂朋, 等. 艾叶多糖对体外培养巨噬细胞吞噬功能的影响 [J]. 时珍国医国药,2012,23(1):162-163.
[42] 尹美珍, 胡岗, 苏振宏, 等. 艾叶多糖对小鼠免疫细胞分泌细胞因子及其活性的影响 [J]. 时珍国医国药,2013,24(7):1610-1611.
[43] 余桂朋, 尹美珍, 黄志, 等. 艾叶多糖对小鼠腹腔巨噬细胞吞噬功能及 NO 生成的影响 [J]. 湖北理工学院学报,2012,28(5):54-58.

[44] 隆雪明. 艾叶挥发油的免疫作用及其对部分细胞因子 mRNA 表达的影响 [D]. 硕士学位论文. 长沙: 湖南农业大学,2008.
[45] XU H F,ZHAO B X,CUI Y X,et al.Effects of moxa smoke on monoamine neurotransmitters SAMP8 mice[J].Evidence-Based Complementary Alternative Medicine,2013,2013:178067.
[46] HA G J,LEE D S,SEUNG T W,et al.Anti-amnesic and neuroprotective effects of Artemisia argyi H. (Seomae mugwort) Extracts[J].Korean Journal Science Technology,2015,47(3):380-387.
[47] 张鹏飞, 李倜宇, 史彬林, 等. 艾蒿对动物的生物学作用研究 [J]. 饲料研究,2015(20):24-27.
[48] 陈金文, 陈维岩, 高宏伟, 等. 艾叶粉作猪饲料添加剂试验 [J]. 饲料研究,1991(9):29-30.
[49] Hwang Y C,JENKINS E M.Effect of acupuncture on young pigs with induced enteropathogenic Escherichia diarrhea[J].American Journal Veterinary Research,1988,49(9):1641-1643.
[50] ZHANG P F,SHI B L,SU J L,et al.Relieving effect of Artemisia argyi aqueous extract on immune stress broilers[J].Journal Animal Physiology Animal Nutrition,2017,101(2):251-258.
[51] 吴有华, 刘力, 王敬, 等. 艾叶粉对肉鸡免疫器官指数及生长的影响 [J]. 江西畜牧兽医杂志,2014(6):14-16.
[52] 徐红蕊, 陈小连, 时建青, 等. 艾叶对热应激蛋鸡抗氧化功能、产蛋性能和蛋品质的影响 [J]. 浙江大学学报: 农业与生命科学版,2017,43(1):113-119.
[53] 吴珊. 肉鹅饲料:CN201710582706.7[P].2017-09-22.
[54] 孙克年. 艾叶的开发利用 [J]. 饲料研究,1997(6):17-18.
[55] 秦建军. 受孕母羊的混合饲料:CN201610280547.0[P].2016-09-07.
[56] 夏晨, 邬彩霞, 赵国琦.TMR 中添加艾叶对乳风味的影响 [J]. 中国奶牛,2011(24):18-24.
[57] 顾小卫. 紫苏、陈皮和艾叶对奶牛乳风味、乳品质、瘤胃内环境及血液生化指标的影 [D]. 硕士学位论文. 扬州: 扬州大学,2010.
[58] 周孝琼, 王华, 李炳贵, 等. 艾叶水提液对肉兔生长性能及肉品质的影响 [J]. 湖北农业科学,2016,55(18):4767-4770.
[59] 周孝琼, 李炳贵, 陈慧芳, 等. 艾叶水煮醇提液对肉兔生长性能的影响 [J]. 江苏农业科学,2016,44(7):295-297.
[60] 王华, 周孝琼, 陈慧芳, 等. 艾叶水煎醇提液对肉兔血液及生化指标的影响 [J]. 动物医学进展,2017,38(8):67-70.
[61] 刘洪丽, 左文山, 王城, 等. 饲粮中添加艾叶粉对生长肉兔营养物质表观消化率、氮代谢和肌肉品质的影响 [J]. 动物营养学报,2018,30(2):755-762.

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