

## **Efficiency of herbs and botanicals in pig feeding**

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### **SUMMARY**

Restrictions on the use of antibiotics in animal farming and growing awareness among consumers, who increasingly choose organic products, have forced breeders to look for natural products that stimulate animal productivity. These include herbs and herbal products used for health enhancement and prevention of animal diseases. Herbs and herbal extracts positively influence feed intake by pigs and nutrient digestibility. At the same time, digestive processes are manipulated by removing harmful bacteria and promoting colonization of beneficial micro-organisms in the gastrointestinal tract. Herbs also regulate the physiological functions by improving the resistance of animals to adverse environmental conditions and diseases, which is associated with improved animal productivity. Herbal and botanical additives can also positively influence carcass composition and meat quality. This paper reviews the results of studies investigating the use of herbs and botanicals in pig feeding.

**KEY WORDS:** sows, piglets, weaners, fatteners, rations, feed additives

### **INTRODUCTION**

EU restrictions on the use of antibiotics in treating animal diseases have led to the use of natural products as alternatives (Yu et al., 2017; Tsiplakou et al., 2021). In addition, the number of organic farms is growing, increasing the demand for non-antibiotic therapeutic preparations for animals. Such preparations include herbs and herbal extracts and phytobiotics with therapeutic properties which have been known for centuries (Kiczorowska et al., 2017; Van der Aar et al., 2017). Their properties stem from their content of biologically active components, i.e. glycosides, alkaloids, saponins, flavonoids, tannins, pectins, and organic acids (Kuralkar and Kuralkar, 2021). Biological active components exert antioxidant and antibacterial effects and support immunity in animals (Magi et al., 2006; Kostadinović and Lević, 2018).

Diets can be supplemented with essential oils derived from herbs and botanicals or synthetic



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substances containing bioactive compounds characteristic of their natural equivalents (Costa et al., 2013). In addition, extracts of single species of botanicals and their blends, appropriately selected for a given group and age of animals, are available on the market. These preparations are most often highly concentrated, so even a small dosage of the herbal additive can improve the health and productivity of animals (Mirzaei-Aghsaghali, 2012; Wojcikowski and Gobe, 2014; Upadhaya and Kim, 2017). Researchers have found that dietary supplementation with herbs can regulate digestive processes, the production of digestive enzymes, and the microbiological balance in the gastrointestinal system. Furthermore, the components of herbs can support the body in stress situations and reduce emissions of ammonia and carbon dioxide by animals, thus improving the microclimate in farm buildings (Franz et al., 2010; Hashemi and Davoodi, 2011, Gong et al., 2014; Zhai et al., 2018). Studies have demonstrated that an appropriate composition of a herbal blend can also improve meat quality (Hanczakowska et al., 2015; Cui et al., 2021; Tsiplakou et al., 2021).

This paper aims to review the literature concerning the efficiency of herbs and botanicals in pig feeding.

#### **Herbs and botanicals fed to sows**

Herbal preparations fed to sows, most often in the periparturient period and during lactation, have been evaluated by many researchers (Jang et al., 2010; Matysiak et al., 2012; Hossain et al., 2015; Hall et al., 2021). Study outcomes indicate that herbs included in the diet of sows in late pregnancy and during lactation can positively affect the sow and its offspring (Table 1).

Single herbs or their blends added to diets for sows improve their feed intake rate and milk yield and have a positive impact on the bacterial microbiota of the gastrointestinal tract, parturition, and the quality of piglets. Rekiel et al. (2011) demonstrated that the herbal extract Payapro (black caraway, fennel, liquorice, and cumin) administered in the amount of 15 g/sow/day from the second day before farrowing until the 12th day post-partum improved milk composition (increased content of protein, fat and lactose) and significantly lowered the somatic cell count (by 50,7%). Matysiak et al. (2012) observed a similar improvement in sow milk composition following diet supplementation with a herbal additive (oregano, cinnamon, and Mexican pepper). Paschma (2004) found that a herbal blend (nettle, chamomile, caraway, and fennel) added to feed for sows from day 100 of pregnancy until the end of lactation accelerated farrowing and increased the number of live-born and weaned pigs. Allan and Bilkei (2005) reported that reproductive rates improved when sows were fed a diet containing oregano (a blend of dried leaves and flowers and cold-pressed seed oil). The authors showed that oregano included in the pre-farrowing and lactation diet increased the animals' mean feed daily intake and the number of live births per litter and decreased the annual mortality rate of sows and the number of stillbirths. A beneficial effect on productivity following the introduction of oregano into the diets of sows was also noted by Khajareern and Khajareern (2002), Amrik and Bilkei (2004), Tan et al. (2015) and Hall et al. (2021). Zou et al. (2016) reported that oregano oil, owing to its content of carvacrol and thymol, has antibacterial and antioxidant properties, which improve the function of the intestinal barrier and increase weight gain in pigs. Hall et al. (2021) noted a positive effect of oregano oils on the gut microbiota of sows and piglets. They found that the population of beneficial *Lactobacillus* bacteria increased, while the population of pathogenic *E. coli* and *Enterococcus* was reduced. Another very popular herb fed to sows is garlic (Dudek et al., 2006; Jang et al., 2010; Sun and Kim, 2020; Guillamón et al., 2021). Dudek et al. (2006), who fed a preparation based on garlic extract to sows in late pregnancy and during

lactation, demonstrated a significant increase in the white blood cell count in the piglets. Jang et al. (2010) observed an improvement in the body condition of sows during lactation and increased weight gain in piglets after a herbal blend containing garlic (*Artemisia* and *Acanthopanax*) was included in the sows' diet. A beneficial effect of garlic extracts, i.e. improvement of the bacterial microbiota – a reduction in the count of *E. coli* and an increase in the number of beneficial bacteria, was observed by Ruiz et al. (2010), Yun et al. (2018), Satora et al. (2020), Sun and Kim (2020) and Guillamón et al. (2021). Blends of several species of herbs act more efficiently and provide more benefits than single herbs (Costa et al., 2013; Upadhaya and Kim, 2017; Liu et al., 2017; Wen-Chao et al., 2017). Liu et al. (2017) found that a blend of herbal extracts (*Scutellaria baicalensis* and *Lonicera japonica*) used to supplement the diet of sows exposed to heat stress improved feed intake and digestibility as well as the weight gain and weaning weight of piglets. Similarly, Wen-Chao et al. (2017) demonstrated that *Scutellaria baicalensis* and *Lonicera japonica* added to the diets of lactating sows exposed to heat stress increased feed intake and reduced the body weight of sows after parturition and also enhanced weight gain and improved gastrointestinal health in piglets.

Dang et al. (2022) fed sows a blend of herbal extracts consisting of 150 g/kg anethole; 15 g/kg rebaudioside A; 2,1 g/kg thymol; 2,0 g/kg eugenol and 2,3 g/kg cinnamic aldehyde for 35 days (from d 7 before farrowing to d 21 after weaning of piglets) and recorded higher growth performance in weaned piglets. Similarly, Lipiński et al. (2014) evaluated the efficiency of using Ruchamax<sup>®</sup>, a blend of herbal extracts (*Adrographis paniculata*, *Phyllanthus emblica*, *Curcuma longa*, *Zingiber officinale* and *Allium sativum*) in the diet of sows during the rearing of piglets. The herbal blend improved weight gain in piglets compared to the control group. Upon weaning, piglets in the experimental group were on average more than 0,5 kg heavier than the piglets whose mothers were not fed the herbal extract. Parraguez et al. (2021) used a premix consisting of two herbal blends – C-Power<sup>®</sup> (*Emblica officinalis* and *Ocimum sanctum*) and Herbal-E (*Ocimum sanctum*, *Ocimum basilicum* and *Phyllanthus emblica*) – in the diet of pregnant sows. The authors observed improved health and productivity in piglets in the experimental group. A similar study involving a blend of herbal extracts of oregano, cinnamon and Mexican pepper (XTRAC 6930) fed to sows from day 90 of pregnancy until day 28 after farrowing was conducted by Matysiak et al. (2012). They demonstrated higher weight gain and weaning weight and lower mortality among the experimental piglets. In another study, Paschma and Kaczor (2008) noted that the addition of 1-1,5% nettle and chamomile leaves and fennel and caraway fruits to the diet of sows in the periparturient period reduced farrowing time and had a positive influence on the rearing of piglets in the first days of life.

**Table 1**

Efficiency of feeding herbs, spices and botanicals to sows

Herb	Dose	Duration	Result	Reference
Garlic <i>Allium L.</i>	0,1% and 0,2% medicinal plants	21-day performance study (from farrowing to weaning)	improved condition of lactating sows and stimulation of weight gain in piglets	Jang et al. (2010)
Oregano <i>Origanum vulgare</i> , Cinnamon <i>Cinnamomum verum</i> , Mexican pepper <i>Capsicum annum</i>	100 mg of the mixture of plant extracts/kg feed	from day 90 of pregnancy until weaning at day 28	improved feed intake, weight gain and health of piglets	Matysiak et al. (2012)
Fenugreek <i>Trigonella foenum-graecum L.</i>	0,1% and 0,2% fenugreek seed extract	before day 7 of pregnancy until weaning at day 21	increase in feed digestibility, reduced count of <i>E. coli</i> in faeces, reduced ammonia emission	Hossain et al. (2015)
Baikal skullcap, <i>Scutellaria baicalensis</i> Japanese honeysuckle, <i>Lonicera japonica</i>	5 g/d and 10 g/d herbal extract mixture	36 days – from 7 days before expected time of parturition	improved feed intake and reduction in weight loss of sows after parturition	Wen-Chao et al. (2017)
Cinnamon <i>Cinnamomum verum</i>	1,0 g cinnamon oil per kg of feed	from 109 days of gestation until weaning at $25,2 \pm 2,6$ days after parturition	increased feed intake by sows, reduced mortality of piglets before weaning	Khamtawee et al. (2021)
Oregano (OEO) <i>Origanum vulgare</i>	1% OEO to 14 days of age of experimental piglets, then 5% OEO in control and experimental feed	from 7 days before farrowing until weaning (~26 days)	increased growth of beneficial <i>Lactobacillus</i> bacteria in gastrointestinal tract, reduction in pathogenic bacteria: <i>E. coli</i> and <i>Enterococcus</i>	Hall et al. (2021)

**Herbs and botanicals fed to piglets and weaners**

Piglets and weaners, as young animals, are the most susceptible to adverse environmental impacts and diseases, so preventative administration of herbal preparations seems most advisable in their case (Hanczakowska and Świątkiewicz, 2012; Wang et al., 2021; Rabelo-Ruiz et al., 2021). The results of studies on the efficiency of herbs used in diets fed to young pigs are presented in Table 2.

Studies (Kołaczkowski et al., 1997; Namkung et al., 2004; Stelter et al., 2011; Yan et al., 2011a; Rabelo-Ruiz et al., 2021) indicate that herbs increase feed intake in piglets, which contributes to higher weight gain. In addition, they regulate the microbiological balance of the gastrointestinal tract by suppressing the growth of pathogenic bacteria and reducing the occurrence of diarrhoea. Diarrhoea in piglets is most often caused by *E. coli* bacteria (Rhouma et al., 2017; Bin et al., 2018). Namkung et al. (2004) observed that herbal extracts (cinnamon, thyme and oregano) reduced the growth of *E. coli* in the gastrointestinal tract of weaned piglets. A positive effect of garlic added to the diets of young pigs was corroborated by Wang et al. (2011), Cho et al. (2020) and Rabelo-Ruiz et al. (2021). These authors demonstrated that garlic in the diet of pigs increased weight gain, improved nutrient digestibility, and reduced the emission of ammonia with the faeces. Moreover, Yan and Kim (2013) found that garlic powder included in the diet of weaned piglets enhanced feed intake, increased the concentrations of lymphocytes and red blood cells, and reduced the count of *E. coli* in faeces. Studies by Grela and Klebaniuk (2007) revealed that garlic extracts added to feed rations improved weight gain, reduced the number of piglet deaths, and reduced the concentrations of triglycerides and total cholesterol in the blood plasma. Piglets whose diets were supplemented with garlic were more than 0.5 kg heavier upon weaning and nearly 2.5 kg heavier at 56 days of age compared to the control animals. Hanczakowska and Świątkiewicz (2012) observed longer villi and improved digestibility and feed conversion after adding extracts of sage, lemon balm, nettle and echinacea to diets for piglets. Stelter et al. (2013) supplemented the diet of weaned piglets with oregano extract and found a positive effect on their immunity (lymphocyte percentage) and the concentration of triglycerides in their blood serum. Wang et al. (2021) fed piglets a herbal blend (*Lonicera japonica*, *Astragalus membranaceus*, *Eucommia folium*, and *Codonopsis pilosula*) and found that the supplement modulated antioxidant capacity by reducing the activity of superoxide dismutase (SOD) and glutathione peroxidase (GSH-PX) in the ileum.

**Table 2**

Effects of herbal additives, spices and botanicals in diets of piglets and weaners

Herb	Dose	Duration	Result	Reference
Chamomile flower <i>Matricaria chamomilla</i> L., Calendula flower <i>Calendula officinalis</i> , Fennel fruit <i>Foeniculum vulgare</i> Mill. Fenugreek seed <i>Trigonella foenum-graecum</i> L., Basil <i>Ocimum basilicum</i>	1,5 g/kg body weight	from 28 days of age for 42 days	improvement of piglets' immunity, increase in neutrophil activity	Kołacz et al. (1997)
Cinnamon <i>Cinnamomum verum</i> , Thyme <i>Thymus vulgaris</i> L., Oregano, <i>Origanum vulgare</i>	0,75% of diet	during the 4-wk post- weaning period	improvement in the composition of the gastrointestinal bacterial microbiota, reduction in <i>E. coli</i> count, increased number of lactic acid bacteria	Namkung et al. (2004)
Oregano <i>Origanum vulgare</i>	2 g, 4 g and 8 g per kg feed	5 weeks from 7,9 kg body weight of piglets	improvement of piglets' immunity	Stelter et al. (2011)
Dried buckwheat <i>Fagopyrum esculentum</i> Moench Thyme <i>Thymus vulgaris</i> L., Turmeric <i>Curcuma longa</i> L. Black pepper, <i>Piper nigrum</i> L., Ginger ( <i>Zingiber</i> Boehm.)	250 mg or 500 mg herbal extract mixture per kg feed	6 weeks from 27,5 kg body weight of pigs	improvement in nutrient digestibility, increased lymphocyte concentration in the blood, reduction in <i>E. coli</i> count in faeces	Yan et al. (2011a)
Sage <i>Salvia officinalis</i> Lemon balm <i>Melissa officinalis</i> L. Lemon <i>Citrus limon</i> (L.) Burm. Nettle <i>Urtica dioica</i> L. Echinacea <i>Echinacea purpurea</i> (L.) Moench.	500 mg/kg feed	84 days from weaning	longer villi, improvement of digestibility and feed conversion	Hanczakwska and Świątkiewicz (2012)
Garlic <i>Allium</i> L.	20 mg/kg of thiosulfinats and thiosulfonas	from 28 to 70 days of piglets' life	increased weight gain, improved feed conversion rate, improved gastrointestinal microbiota	Rabelo-Ruiz et al. (2021)

**Herbs and botanicals fed to fattening pigs**

Numerous researchers (Turyk et al., 2013; Hanczakowska et al., 2017; Cheng et al., 2018; Sánchez et al., 2020; Sampath et al., 2020; Johnson and Iorliam, 2020) have shown that herbs and herbal blends can be successfully fed to fattening pigs (Table 3).

**Table 3**

Results of using herbs, spices and their products in the diet of fattening pigs

Herb	Dose	Duration	Result	Reference
Garlic <i>Allium L.</i>	1 g/kg or 10 g/kg	from 42 kg body weight to the final day of fattening	increased feed intake by fattening pigs, improved productivity parameters, i.e. final body weight, average daily weight gain and FCR	Cullen et al. (2005)
Oregano <i>Origanum vulgare</i>	250 mg/kg feed	from 29,0 kg body weight for 98 days	improved sensory quality and antioxidant status of meat, improved ratio of intramuscular fat to n-3 PUFAs, increased antioxidant capacity	Cheng et al. (2017)
Hops extract <i>Humulus lupulus</i>	500 or 1000 mg/kg of diet	from 60 kg to 115 kg body weight	improvement of oxidative stability and colour of meat, reduction in cholesterol in meat, positive impact on fatty acid profile	Hanczakowska et al. (2017)
Oregano <i>Origanum vulgare</i>	250 mg per kg of feed	from 30 kg to 115 kg body weight	improved productive performance, i.e. feed intake and weight gain of fattening pigs	Cheng et al. (2018)
Black pepper, <i>Piper nigrum L.</i>	0,025%, 0,05%, 0,1%, 0,2%, 0,4% black pepper extract	from 53,7 kg body weight for 10 weeks	improved weight gain and feed digestibility, reduced count of <i>E. coli</i> and increased number of <i>Lactobacillus</i> spp. in faeces, reduction in emission of ammonia, increase in backfat thickness	Sampath et al. (2020)
Garlic <i>Allium L.</i> , Onion <i>Allium cepa L.</i>	5 g/kg of <i>Allium</i> spp. extract	from 23,07 kg body weight for 103 days	positive effect on gastrointestinal tract, reduction in <i>Salmonella</i> spp., <i>Clostridium</i> spp. and <i>Enterobacteriaceae</i> , increase in <i>Lactobacillus</i> spp. in faeces	Sánchez et al. (2020)
Garlic <i>Allium L.</i>	10 g, 20 g, 30 g, 40 g and 50 g/kg of diet	from 23 kg body weight for 28 days	increased lymphocyte levels in blood, improvement in immunity	Johnson and Iorliam (2020)

The studies cited above suggest that preventive supplementation of the diets of growing pigs with herbal blends has a positive effect on the animals' health and thus improves their productivity and meat quality. As in the case of piglets and sows, feed for fattening pigs is very often

supplemented with garlic. This plant has a positive influence on feed intake by fattening pigs, which is reflected in their improved productivity, i.e. final body weight, mean daily weight gain and feed conversion ratio (Cullen et al., 2005; Yan et al., 2011; Onyimonyi and Omeje, 2013; Ogbuewu et al., 2019; Chen et al. 2021). Furthermore, garlic extracts included in the diet of fattening pigs improve blood parameters (Czech et al., 2009; Yan et al., 2011; Johnson and Iorliam, 2020). These authors showed that the level of lymphocytes in the blood increased, which confirms the positive impact of garlic on the body's immune response. Samolińska et al. (2020) fed fattening pigs 5 g of freeze-dried garlic per kg of feed, 50 g of powdered dandelion root per kg, or 50 g of garlic and dandelion blend per kg and recorded higher final body weight by 5,08 kg; 3,62 kg and 6,0 kg, respectively, compared to the control group. Garlic and dandelion blends increased the eye of the loin by 7% and lean meat yield by 12%, while reducing backfat thickness by 10% compared to the control group. Moreover, feed additives in the diets reduced fat and cholesterol content in the backfat, *longissimus lumborum* muscle, and liver and improved the n-6/n-3 fatty acid ratio and H/H, TI and AI indices in the analysed tissues and organs. The results of that study were consistent with those reported by Omojola et al. (2009) and Grela et al. (2013). Sánchez et al. (2020) demonstrated that a combination of garlic and onion extracts had a positive effect on the gastrointestinal tract of fattening pigs, reducing the count of *Salmonella* spp., *Clostridium* spp. and *Enterobacteriaceae* while increasing the number of *Lactobacillus* spp. in the faeces. Sampath et al. (2020) evaluated the efficiency of black pepper supplements accounting for 0,025% to 0,4% of the diet of fattening pigs. They found that black pepper improved weight gain (by approx. 40 g/day), reduced the count of *E. coli* (by approx. 3%) and increased that of *Lactobacillus* spp. (by approx. 2%) in the faeces. Moreover, emissions of ammonia and hydrogen sulphide were reduced. Yang et al. (2019) observed that black pepper used to supplement the diet of fattening pigs significantly increased the HDL and vitamin C levels in the blood serum, enhancing the antioxidant defences of pigs.

Many authors (Walter and Bilkei, 2004; Zou et al., 2016a; Cheng et al., 2017) have tested the suitability of oregano in the diets of fattening pigs. Walter and Bilkei (2004) demonstrated that oregano oil included in the diet of fattening pigs improved their feed intake and weight gain, reduced mortality, and increased the level of lymphocytes in the blood compared with the control group. Cheng et al. (2018) also observed an improvement in productive performance following supplementation with 250 g of oregano essential oil per kg of feed. They reported a 9,01 kg increase in the final weight of fattening pigs and observed improved digestibility of feed components due to modulation of the intestinal bacteria, gut morphology and antioxidant capacity. The results reported by Cheng et al. (2017) indicate that supplementation with oregano essential oil improved the sensory quality and antioxidant status of meat.

Urbańczyk et al. (2002) and Gong et al. (2014) reported that herbal extracts can be used to reduce the use of antibiotics in pig fattening. Urbańczyk et al. (2002) demonstrated that fattening pigs fed a herbal blend (*Melissa officinalis*, *Mentha piperita*, *Urtica dioica*, *Thymus vulgaris*, *Agropyron repens*, *Allium*, *Capsicum annuum*, *Origanum majorana*, *Coriandrum sativum*, *Taraxacum vulgare* and *Silybum marianum*) gained 3,6% more weight than the control pigs and 6,1% more than the group receiving feed with antibiotics. In addition, pigs fed herbal blends had the highest lean meat content, the best carcass composition, the largest eye of the longissimus dorsi muscle, and the lowest degree of fatness. Olkowski et al. (2019) included a powdered herbal extract



(carvacrol, trans-cinnamaldehyde, and capsaicin from oregano (*Origanum* spp.), cinnamon (*Cinnamomum* spp.) and black pepper (*Piper nigrum* L.)) in the diets of fattening pigs. They found that the diets containing herbs significantly increased the thickness of the backfat (by approx. 3 mm), but reduced the content of intramuscular fat (by 0,3%) in the longissimus lumborum muscle. Research by Yan et al. (2011a) in fattening pigs fed a herbal blend of buckwheat, thyme, turmeric, black pepper, and ginger showed an increase in the body weight of pigs and in red and white blood cell counts, as well as reduced emissions of carbon dioxide and ammonia in the animals' faeces. In contrast, Oanh et al. (2021) demonstrated that a herbal blend (60% *Bidens pilosa* L., 15% *Urena lobata* L., 15% *Pseuderanthemum palatiferum*, 5% *Ramulus cinnamomi*, and 5% *Star anise*), administered to fattening pigs heavier than 30 kg reduced the red blood cell count, blood cholesterol level, blood urea nitrogen, and low-density lipoproteins with no effect on the weight gain of pigs or nutrient digestibility.

### CONCLUSION

Herbs, spices or botanicals (e.g. essential oils) added to the diets of pigs, owing to their biologically active components, can improve production efficiency in various production groups. In organic farming, this can be the basic form of disease prevention and an alternative to antibiotics for preventing and treating disease in farm animals. Appropriately selected herbs and their blends have a positive effect on productive performance, improving the feed conversion rate, weight gain, immunity and health of animals, as well as stimulating the microbiota by supporting the growth of beneficial bacteria and reducing the count of pathogenic micro-organisms. In addition, they have a positive impact on the carcass composition and quality of pork meat.

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