KRMIVA

OPTIMIZING GUT HEALTH AND PERFORMANCE THROUGH A PHYTOGENIC FEED ADDITIVE

OPTIMIZIRANJE ZDRAVLJA I RADA CRIJEVA FITOGENSKIM DODATKOM HRANI

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SUMMARY

The significance of gut health for optimized feed efficiency has become more evident in present times of volatile prices for feed ingredients. Several feeding strategies may be implemented in order to secure gut health and performance of farm animals. Among potential alternatives, phytogenics represent a relatively new and promising group of substances that may help the animal to achieve its genetic potential for growth performance better. Originating from plant materials, phytogenics have flavouring properties as well as biological activities. Antimicrobial, antiviral, antioxidant and many other biological activities have been found in various phytogenic compounds. However, the mode of action of phytogenics is versatile and still needs further scientific evaluation in many cases. A beneficial impact on gut microflora, level of microbial toxins in the gut and nutrient digestibility was reported in a recent study with pigs. Moreover, it has been speculated that phytogenics may stimulate the secretion of saliva and digestive enzymes. Recent research findings, obtained in experiments with a phytogenic blend of oregano, anise and citrus essential oils, are reviewed in the present paper, indicating that these substances have a pronounced impact on performance and health status of poultry, swine and calves. Considerable improvements in daily weight gain, feed conversion ratio and feed intake were obtained when phytogenics were included in the feed of different species.

Key words: Phytogenics, flavouring, performance, gut health

INTRODUCTION

Modern animal production is facing several challenges. Growing demand for animal products and volatile or rising prices for raw materials require the implementation of optimal production conditions with the aim to secure high animal performance. Phytogenic feed additives have gained considerable attention in the feed industry and to an increasing extent producers are incorporating them into their feeding programs. Today, 70–80% of the companies have been or are using phytogenics in broiler and pig feeds (World Poultry, 2008).

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Phytogenic compounds have traditionally been used as flavours and spices in human nutrition and medicine, as well as for food preservation. There are a large number of herbs and spices that may be considered as Natural Growth Promoters in animal nutrition, of which the most frequently used are presented in Table 1. Most of these plants contain a considerable number of active substances which determines their *in vivo* efficacy.

Table 1. Herbs and spices frequently used in phytogenic feed additives
Tablica 1. Začinske biljke i mirodije često korištene u fitogenskim dodacima

Herb/spice Zač. biljke/mirodije	Latin name Latinsko ime	Plant family Ime porodice	Main constituents Glavni sastojci
Oregano - Origano	*Oreganum vulgare*	Labiateae	Carvacrol, thymol
Thyme - Majčina dušica	*Thymus vulgare*	Labiateae	Thymol, carvacrol
Garlic - Češnjak	*Allium sativum L.*	Alliaceae, Liliaceae	Diallyldisulfide, alliin, alliciin
Horseradish - Hren	*Armoracia rusticana*	Brassicaceae	Allyl-isothiocyanate
Chili, Cayenne pepper Feferon, kajenska paprika	*Capsicum frutescens*	Solanaceae	Capsaicin
Peppermint - Ljuta metvica	*Mentha piperita*	Labiateae	Menthol, carvacrol
Cinnamon - Cimet	*Cinnamomum cassia*	Lauraceae	Cinnamaldehyde
Anise - Anis	*Pimpinella anisum*	Apiaceae, Umbelliferae	Anethol

It is evident that this category of feed additives covers a large variety of substances with an even bigger number of active ingredients, including carvacrol, thymol, cinnamaldehyde and anethol, just to mention a few important examples. Phytogenic feed additives are either available in a solid, dried and ground form or as extracts or essential oils. Usually, phytogenics vary seriously in their chemical ingredients, depending on their composition and influences of climatic conditions, locations or harvest time. Hence, differences in efficacy between phytogenic products which are currently available at the market can be attributed mainly to differences in their chemical composition (Steiner, 2006).

Essential oils are odoriferous, secondary plant products which contain most of the plant's active substances, being mainly hydrocarbons (e.g. terpenes, sesquiterpenes), oxygenated compounds (e.g. alcohol, aldehydes, ketones) and a small percentage of non-volatile residues (e.g. paraffin, wax) (Losa, 2000). They are obtained from the raw materials, basically through steam distillation.

In comparison to Antibiotic Growth Promoters (AGPs), phytogenics do usually not bear the risk of cross-resistances and residues in animal products. Improvements in feed conversion ratio (FCR) and body weight gain, as well as their benefits in assisting in disease prevention have been observed in recent trials.

Mode of action of phytogenics

A vast number of studies have been carried out regarding the screening of phytogenic compounds for their biological activities. Several plant extracts have shown antimicrobial, anticoccidial, fungicidal or antioxidant properties associated with their lipophylic character (Giannenas *et al.*, 2003; Helander *et al.*, 1998; Juven *et al.*, 1994). Phytogenic agents originating from oregano, thyme or cinnamon, for example, show broad antimicrobial activity against various pathogenic bacteria including *E. coli*, *Salmonella* and *Clostridium.* However, information about the mode of action of commercially available phytogenic feed additives is rather scarce. Assessment of biological effects is difficult if the composition of a test substance is unclear or variable. It is mandatory that phytogenic feed additives have a standardized composition which is based on carefully selected raw materials, undergoing strict quality control measures. A series of experiments was carried out using a synergistic combination of

selected essential oils from oregano, anise and citrus, and prebiotic substances (Biomin® P.E.P.).

Among these studies, recent data from a research project with swine (Kroismayr, 2008a,b) indicates that the mode of action of Biomin® P.E.P. is versatile and conclusive (Figure 1), finally assisting the animal to reach its genetic potential for growth performance better.

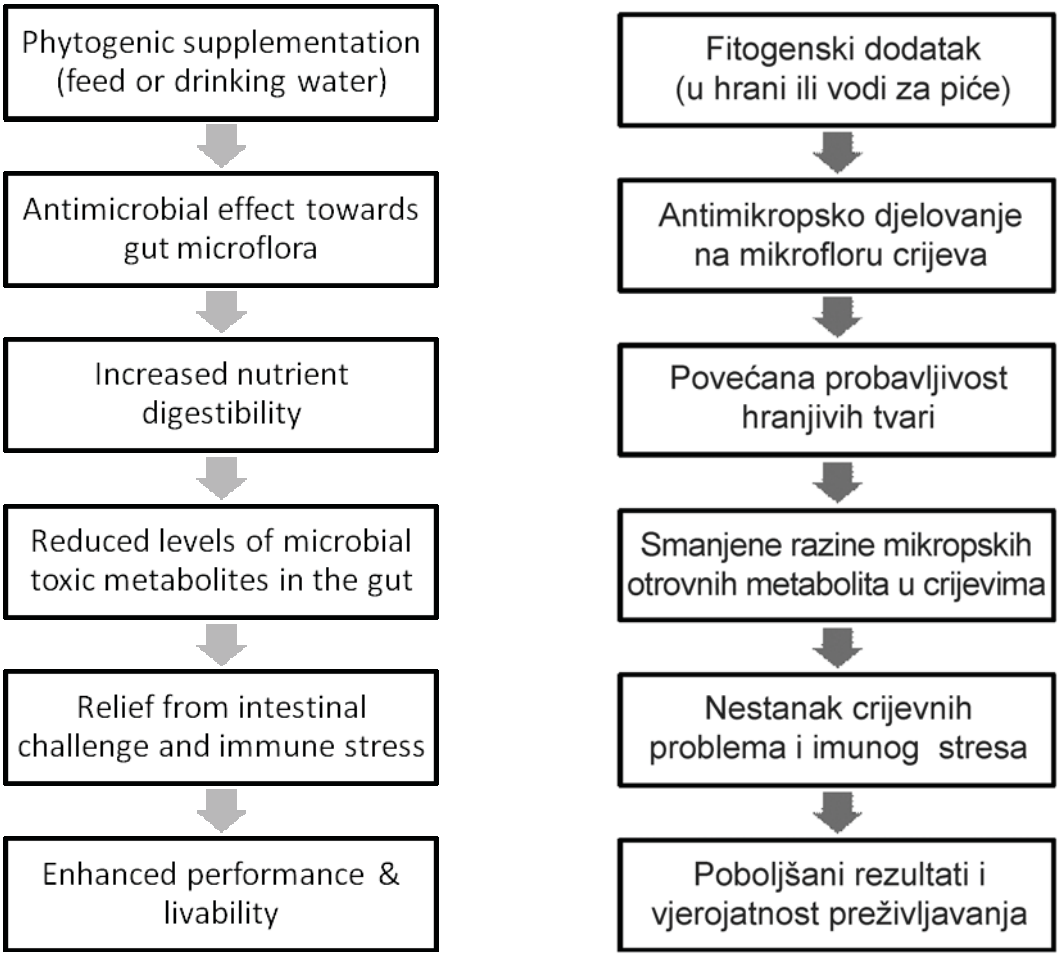

Figure 1. Principal mode of action of a phytogenic additive based on oregano, anise and citrus essential oils (Biomin® P.E.P.)

Graf. 1. Glavni način djelovanja fitogenskih dodataka temeljenih na esencijalnim uljima origana, anisa i limuna (Biomin® P.E.P.)

The study was initiated and lead by the University of Natural Resources and Applied Life Sciences, Vienna (Austria). Additionally, the University of Veterinary Medicine Vienna and the Technical University Munich–Weihenstephan (Germany) were involved in the project. Biomin® P.E.P. was tested in weaning piglets because these animals, and especially their gut environment, are representative for many nonruminant species. One-hundred-and-twenty weaning piglets were assigned to three trial groups: (1) negative control group, (2) group with Biomin® P.E.P. and (3) positive control group with a commonly used AGP (Avilamycin). On day 22 of the 50-day feeding trial, 12 piglets out of each trial group were sacrificed and samples of digesta and various tissues were collected. It was shown in this work that addition of the phytogenic feed additive to the basal diet resulted in a reduction of the total bacterial count in the intestinal tract,

concomitant with an increased nutrient digestibility (Stoni et al., 2005, Figure 2). Furthermore, decreased contents of ammonia and biogenic amines were an additional indicator for the beneficial impact of the phytogenic feed additive on gut microbiology. Finally, a down-regulation of the immune system was observed, as indicated by smaller Peyers Patches in the ileum and lower activity of specific primers (NFκB, Cyclin D1) of immune action. In conclusion, this indicates that more energy and nutrients are available for accretion of body mass rather than for microbial growth and immune action ("energy and nutrient sparing").

Phytogenics in broiler production

The main target in broiler production is to optimize feed conversion (FCR). Biomin® P.E.P. was tested in different dosages in a scientific trial at the Agricultural University of Athens, Greece (Mountzouris et al., 2008). Day-old, male Cobb broiler chicks were assigned to different treatments, comprising 3 replications per treatment and 105 birds per treatment. The Negative Control (NC) contained no growth promoters, whereas the Positive Control (PC) contained Avilamycin. In further treatments, Biomin® P.E.P. 125 poultry was

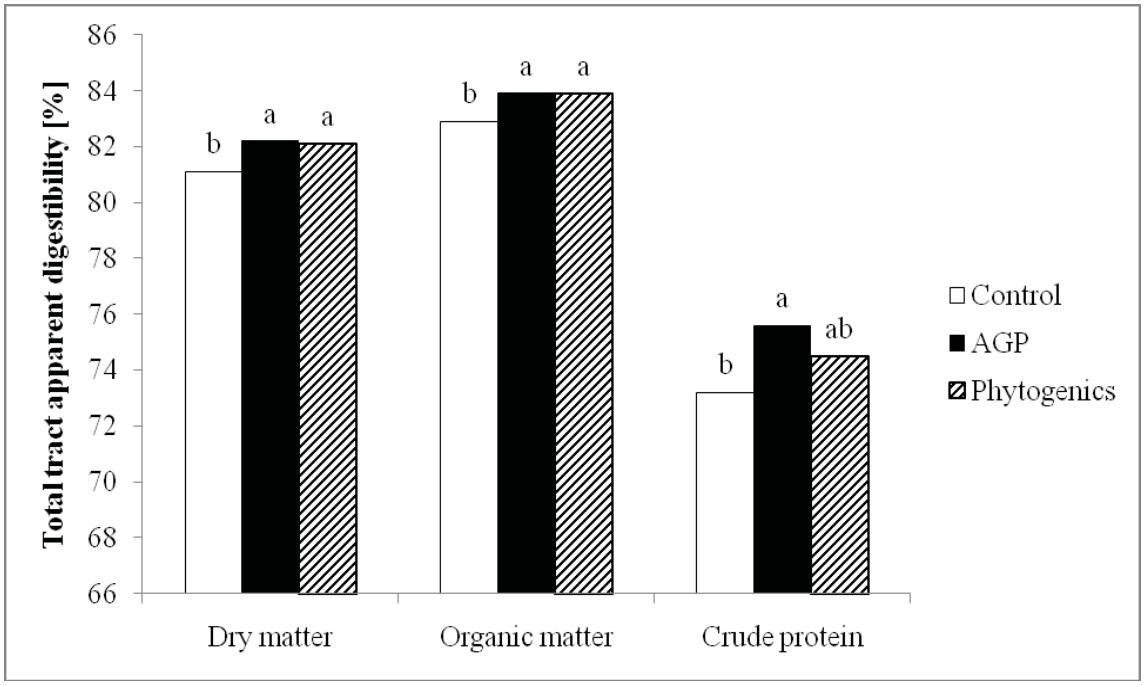

Figure 2. Effect of phytogenics (Biomin® P.E.P.) on nutrient digestibility in pigs (after Stoni et al., 2005). [a,b] Means with different letter differ (P<0.05).

Graf. 2. Djelovanje fitogenika (Biomin® P.E.P.) na probavljivost hranjivih tvari u svinja (after Stoni et al., 2005). [a,b]

Furthermore, there is evidence that phytogenics stimulate digestive secretions such as saliva or endogenous digestive enzymes (Williams and Losa, 2001; Platel and Srinivasan, 1996). In the meantime, additional studies are in progress to further identify potential mechanisms associated with the incorporation of phytogenics in diets for different animal species.

supplemented at 125 or 250 g/t, respectively. As shown in Figures 3 and 4, Biomin® P.E.P. increased body weight gain and significantly improved FCR. Differences between the dosages of Biomin® P.E.P. were minor, indicating that the regular inclusion level of 125 g/t was optimal under the experimental conditions herein.

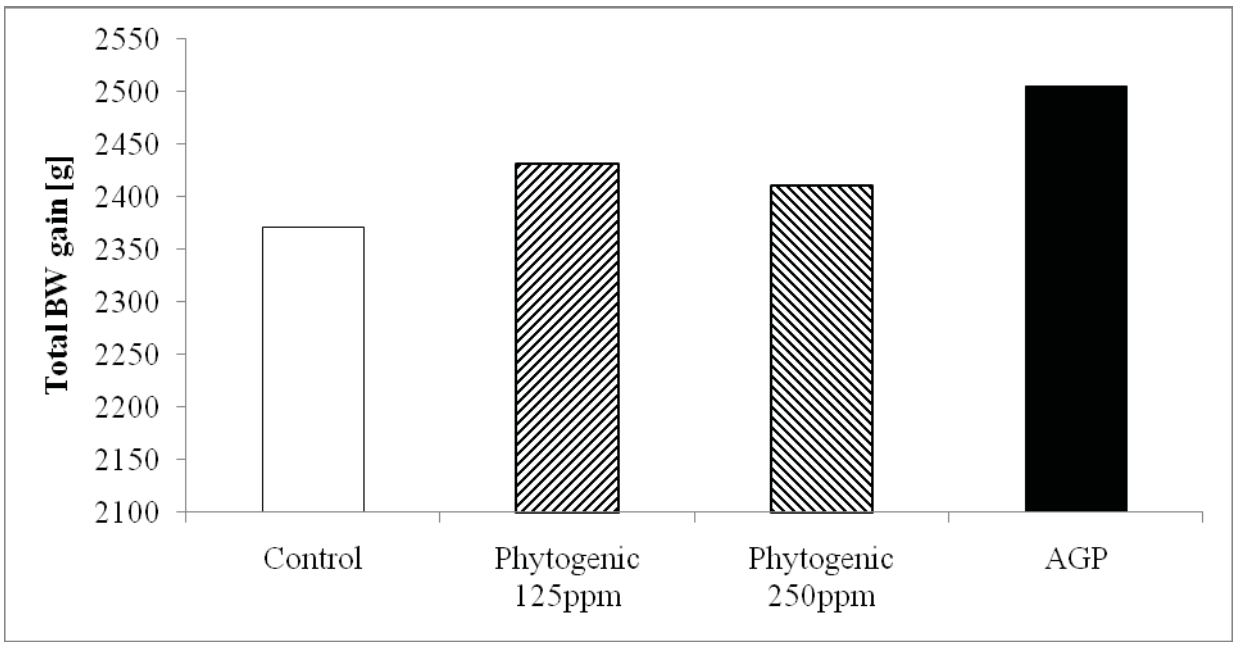

Figure 3. **Effect of phytogenics and an Antibiotic Growth Promoter on total body weight gain of broilers (Agricultural University of Athens, Greece)**

Graf. 3. **Djelovanje fitogenika i antibiotskog podupirača rasta na ukupni prirast tjelesne težine brojlera (Agricultural University of Athens, Greece)**

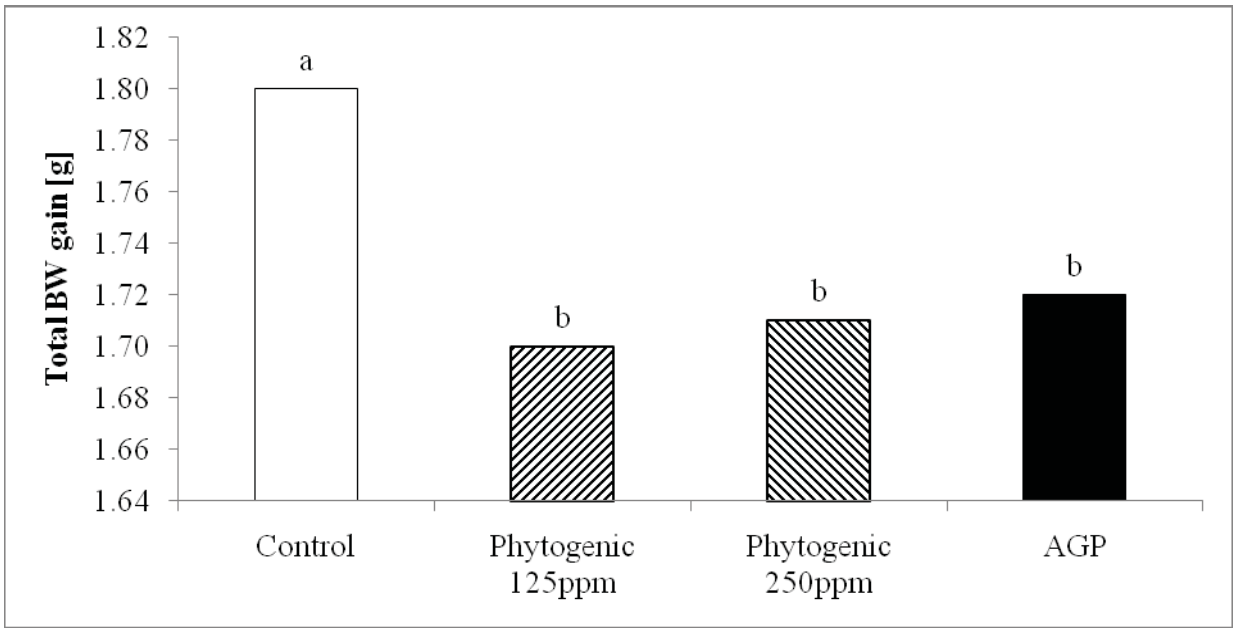

Figure 4. **Effect of phytogenics and an Antibiotic Growth Promoter on FCR of broilers (Agricultural University of Athens, Greece). [a,b] Means with different letter differ (P<0.05).**

Graf. 4. **Djelovanje fitogenika i antibiotskog podupirača rasta na FCR brojlera (Agricultural University of Athens, Greece)**

Table 2. Effects of phytogenics on average performance parameters (week 20 to 31) of layers
Tablica 2. Djelovanje fitogenika na prosječne radne parametre nesilica (20. do 31. tjedan)

	Control Kontrola	+ Phytogenics + Fitogenici	Difference (%) Razlika (%)
Daily feed intake per hen - Dnevni unos hrane po kokoši (g)	112	110	-1.8
Total feed intake per hen - Ukupni unos hrane po kokoši (kg)	9.42	9.26	-1.8
Egg production - Proizvodnja jaja (%)	92.6	93.5	+1.0
No. of eggs per hen - Broj jaja po kokoši	77.8	78.6	+1.0
FCR (kg feed/kg eggs) - FCR (kg hrane/kg jaja)	2.069	2.034	-1.7

Table 3. Effects of phytogenics on egg traits in layers
Tablica 3. Djelovanje fitogenika na značajke jaja nesilica

	Control - Kontrola	+ Phytogenics + Fitogenici
Shell thickness - Debljina ljuske (mm)	0.416^{b}	0.478^{a}
Albumen height - Visina bjelanjka (mm)	6.57	7.09
Haugh Units[1]	79	82

[a,b]Means with different superscript letters differ significantly (P<0.05)

[1]Haugh Unit is a correlation between egg weight and albumen height - Haugh Unit je korelacija između težine jajeta i visine bjelanjka.

Phytogenics in egg production

The effects on performance and economics of Biomin® P.E.P. were investigated in the early stages of the egg production cycle (Nichol and Steiner, 2008). A 12-week trial was carried out with high-performing, Lohmann Brown hens using six replications with 16 birds per replication in a randomized complete block design and resulting in 96 hens per treatment. The age of the birds at the beginning and conclusion of the trial was 20 and 32 weeks, respectively. The birds were assigned to two dietary treatments: (1) Control (no additives), (2) control + Biomin® P.E.P. All birds were vaccinated for Newcastle Disease and Infectious Bronchitis every six weeks. As shown in Table 2, hens fed phytogenics consumed less feed and had higher egg production as compared to the control group. Total and average daily feed intake was lower by 1.8% when the control diet was supplemented with phytogenics.

Hens offered phytogenics produced more eggs and had a better feed conversion in comparison to birds in the control group. Additionally, supplementation of the diets with phytogenics improved egg shell parameters (Table 3), i.e. shell thickness (P<0.05) and albumen height. As indicated by a higher Haugh Unit rating (82 vs. 79), the internal egg quality was higher in hens fed phytogenics.

Based on actual local prices, Biomin® P.E.P. improved productivity, resulting in a 1.74% cost saving (47.09 vs. 47.74 USD per 1000 eggs).

Phytogenics and Necrotic Enteritis

Necrotic Enteritis (NE) is an extremely costly disease in modern broiler production. It was estimated that the cost related to NE in commercial broiler flock is as high as 5 US-cents per bird (Choct, 2006). The main causative agent

of NE is *Clostridium perfringens*. *C. perfringens* is a gram-positive, anaerobic and spore-forming bacterium that is widely present in the environment. There are five types of *C. perfringens* (Type A, B, C, D and E), classified by their ability to produce different exotoxins (α-, β-, ε- and ι-toxin) as well as *Clostridium perfringens* Enteroxin. The severe disease pattern of NE is mainly related to α-toxin, a phospholipase which disintegrates cell membranes. Typical signs of NE are depressed growth performance and increased mortality, associated with severe lesions on the intestinal mucosa. It has been hypothesized that phytogenic agents might reduce the clinical signs of NE in broilers. A study conducted at the US Department of Agriculture (USDA) focused on this topic (Mc Reynolds et al., 2008). The results are very promising, showing that Biomin® P.E.P. had a highly beneficial impact by reducing NE symptoms in birds that had been challenged with *C. perfringens*.

Phytogenics in pig nutrition

Optimizing FCR is also crucial for efficiency in swine production. A trial was recently carried out at Kansas State University, United States, to evaluate the efficacy of phytogenics in comparison to AGPs in post-weaning piglets (Sulabo et al., 2007). 144 piglets (22 days of age) were assigned to three treatment groups: Group 1 was fed a negative control diet without growth-promoters. Group 2 received the negative control diet supplemented with Biomin® P.E.P. Group 3 was offered a positive control diet containing AGPs (140 g/t neomycin sulfate and 140 g/t oxytetracycline HCl). Growth performance was significantly improved over the negative control group when phytogenics or antibiotics were added to the feed. In terms of average daily gains, the pigs fed phytogenics were intermediate between the negative control and the AGPs (Figure 5). Feed conversion, however, was best in the group receiving Biomin® P.E.P. (Figure 6).

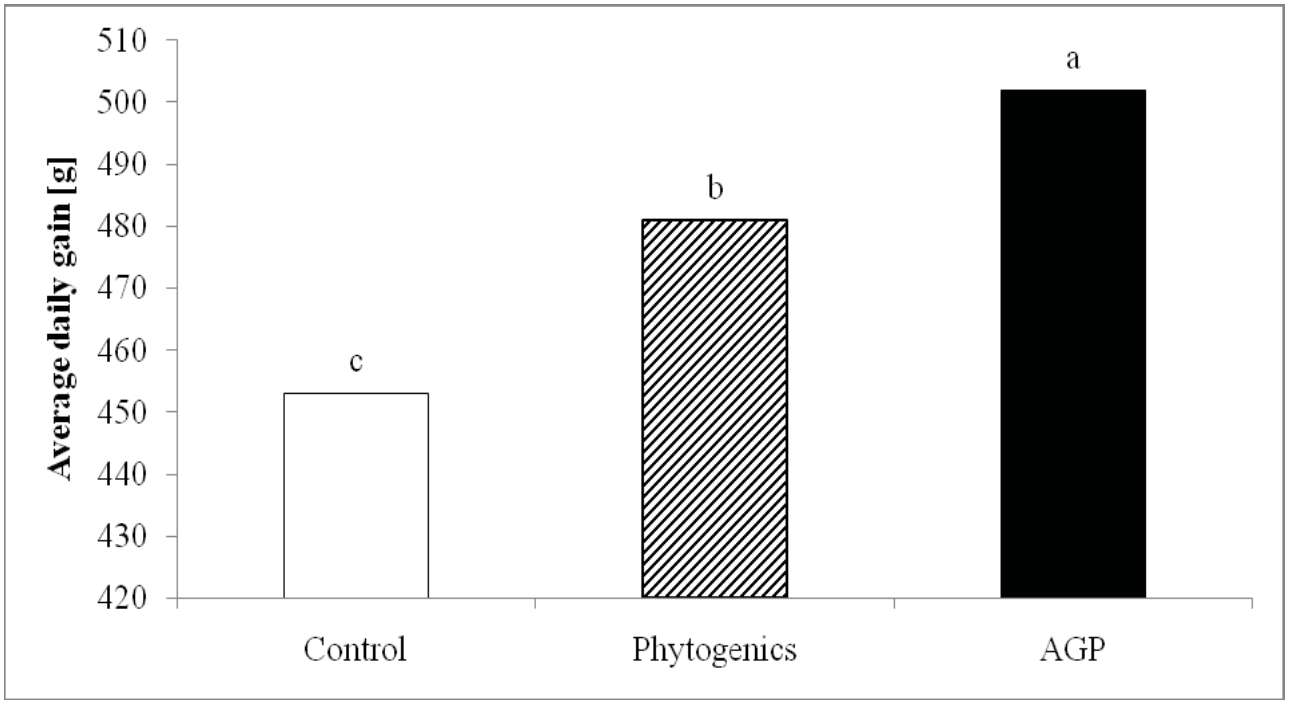

Figure 5. Effects of phytogenics on average daily gain (adapted from Sulabo et al., 2007). [a,b,c] Means with different letter differ (P<0.05)

Graf. 5. Djelovanje fitogenika na prosječni dnevni prirast (adapted from Sulabo et al., 2007)

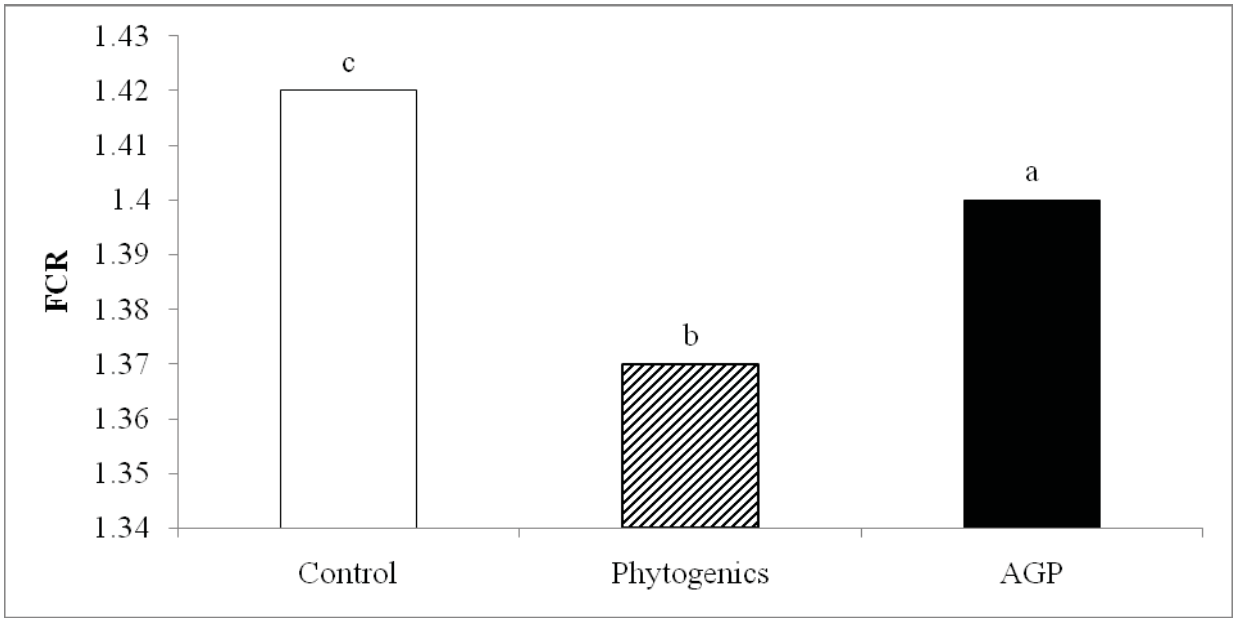

Figure 6. Effects of phytogenics on feed conversion ratio (adapted from Sulabo et al., 2007). [a,b] Means with different letter differ (P<0.05).

Graf. 6. Djelovanje fitogenika na omjer konverzije hrane (adapted from Sulabo et al., 2007)

The results from Kansas State University confirmed positive observations obtained in previous experiments. A trial conducted in Denmark by Danske Slagterier (Maribo, 2002) also showed an increase in performance when the feed was supplemented with phytogenics. In this trial, 384 pigs (5 weeks of age) were fed either a negative control diet or the negative control diet with supplemental Biomin® P.E.P. The feed was pelleted at a minimum temperature of 81 °C. Performance parameters, as recorded from weaning to 50 days post-weaning, are shown in Table 4.

Not only daily gain and FCR were improved by 5.2 and 4.5%, respectively. Also the Danish Production Value was increased by 10.3% through supplementation of the feed with phytogenics. The Danish Production Value represents an indicator of productivity and is calculated as follows: (kg gain × DKK/kg gain)–(no. of analyzed FUp × DKK/FUp), with figures being based on average local prices of 5 years.

Table 4. Piglet performance in response to phytogenics - data from Danske Slagterier (Maribo, 2002)

Tablica 4. Rezultati praščića u odgovoru na fitogenike - podaci iz Danske Slaghterier (Maribo, 2002)

	Negative control Negativna kontrola	Phytogenics Fitogenici	Difference - Razlika (%)
No. of pens - Broj obora	24	24	
No. of piglets - Broj praščića	192	192	
Daily weight gain - Dnevni prirast težine (g)	422	444	+5.2
Feed intake - Unos hrane (FUp[1])	0.84	0.85	+1.2
Feed conversion ratio - Omjer konverzije hrane	2.01	1.92	-4.5
Danish production value - Danska vrijednost proizvodnje	55.5	61.2	+10.3

[1]One FUp corresponds to 7.72 MJ net energy - [1]Jedan FUp odgovarA 7.72 mj NETO ENERGIJE

Phytogenics in sow nutrition

The high energy requirement of the sow in lactation is compensated for by the reduction of body mass. A reduction in body mass by 15 kg is commonly considered as tolerable (Jeroch et al., 1999). However, higher reductions can negatively affect the sow's fertility. There is a close correlation between litter size, feed intake and milk production, which indicates that feed intake of the sow has a substantial impact on litter performance. Sow's milk is the primary source of energy, nutrients and antibodies for new-born piglets. Therefore, adequate lactation performance is crucial to obtain healthy piglets with satisfying growth rates. Data presented in Figure 7 was obtained from a trial at Texas A&M University, United States (Miller et al., 2003). In this trial, sows were fed either a basal feed with or without supplemental phytogenics. Sows fed Biomin® P.E.P. consistently ingested more feed (on average 6.2 vs. 5.4 kg/d) as compared to the control sows. Furthermore, Biomin® P.E.P. reduced sow body weight losses in lactation (7.2 vs. 13.3 kg) in the above mentioned study.

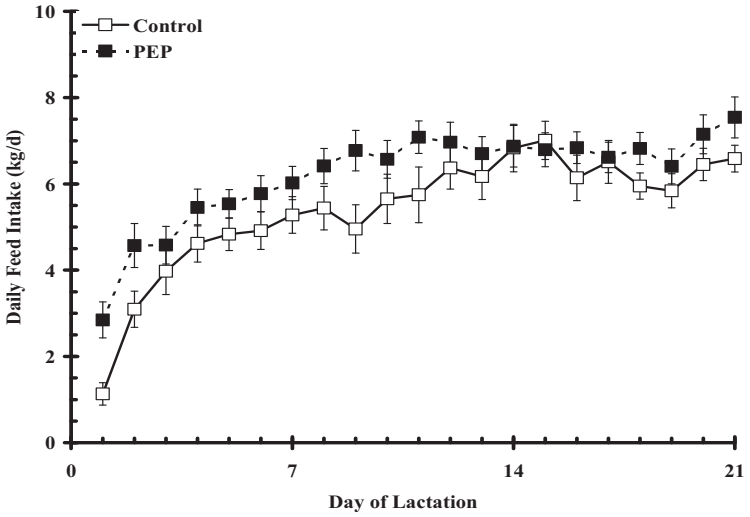

Figure 7. Effect of phytogenics on feed intake of sows in lactation (data from Texas A&M University, USA)

Graf. 7. Djelovanje fitogenika na unos hrane krmača u laktaciji (data from Texas A&M University, USA)

As a consequence of the increased sow feed intake in lactation, also piglet performance is usually substantially increased. The data from the Texas A&M University indicates the benefit of using Biomin® P.E.P. in sows (Table 5).

Table 5. The effect of supplementation of sows with Biomin® P.E.P. during late gestation through lactation on sow and pig performance (Miller et al., 2003)

Tablica 5. Djelovanje davanja Biomicina P.E.P. krmačama pri kraju trudnoće i za vrijeme laktacije na rezultate krmače i svinja

Measure - Mjera	Control sows Kontrolne krmače	Biomin® P.E.P. sows - krmače	Difference (%) Razlika (%)
Number of sows - Broj krmača	24	23	
Parity - Paritet	3.0	3.2	
Piglets born alive/litter - Živorođeni praščići/leglu	9.4	9.7	3.2
Piglets weaned/litter - Odbijeni praščići/leglu	8.1	8.6	6.2
Pre-weaning mortality - Smrtnost prije odbića (%)	13.7	10.8	21.2
Piglet birth weight (kg; n = 449 pigs) Težina praščića pri porođaju (kg; n = 449 svinja)	1.34	1.39	3.7
Piglet weaning weight at 21 days (kg; n=393 pigs) Težina odbijenih praščića 21. dana (kg; n=393 svinja)	5.82	6.42	10.3

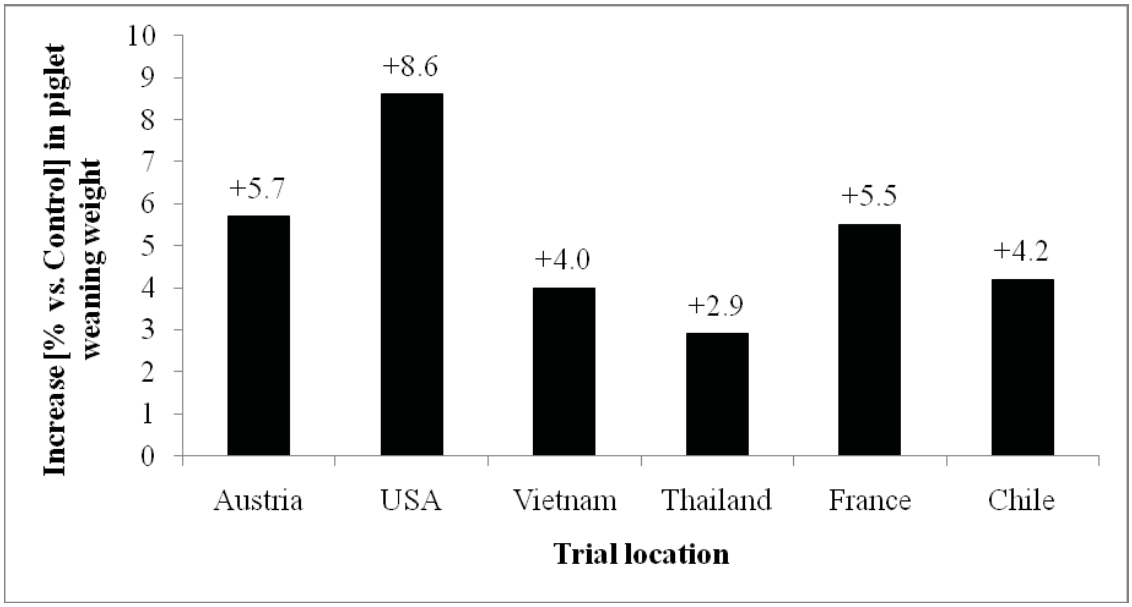

Figure 8. Effect of supplementation of diets for sows with phytogenics (Biomin® P.E.P.) on weaning weight of piglets

Graf. 8. Djelovanje dodavanja fitogenika (Biomin® P.E.P.) u obroke krmača na težinu praščića kod odbića

As shown above, positive effects of phytogenics in sow nutrition are usually reflected in increased litter performance. Results from different trial locations are summarized in Figure 8. In these trials, supplementation of diets for sows with phytogenics (Biomin® P.E.P.) increased average weaning weight of the piglets by 3 to 9%.

CONCLUSION

Phytogenics represent one of the most promising groups of feed additives. It should be kept in mind that only a well-balanced and scientifically developed combination of active ingredients with defined properties can be expected to function synergistically in order to bring about the desired benefits for the producer. Consistent beneficial effects on productivity in poultry, pigs and calves have been reported in scientific studies using a blend of oregano, anise and citrus essential oils. Furthermore, an overwhelming portion of livestock producers consider phytogenics as an outstanding solution to enhance performance and, therefore, profitability.

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SAŽETAK

Važnost zdravlja crijeva za optimiziranje djelotvornosti hrane sve je očitija danas u vrijeme nepostojanih cijena sastojaka hrane. Moguće je provesti nekoliko strategija hranidbe da bi se osiguralo zdravlje i rad crijeva domaćih životinja. Među mogućim alternativama fitogenici predstavljaju relativno novu i obećavajuću skupinu tvari što mogu pomoći životinjama u postizanju genetskih potencijala za bolji rast. Podrijetlom od biljnih materijala fitogenici posjeduju ukusna svojstva kao i biološke aktivnosti. Antimikrobne, antivirusne, antioksidantne i druge biološke aktivnosti nađene su u raznim fitogenskim spojevima. Međutim, način djelovanja fitogenika je mnogostran te zahtijeva dalju naučnu procjenu u mnogim slučajevima. Pozitivno djelovanje na crijevnu mikrofloru, razinu mikropskih otrova u crijevima i probavljivost hranjivih tvari izneseno je u novijem radu na svinjama. Osim toga, nagađa se da fitogenici mogu stimulirati izlučivanje sline i probavnih enzima. Nalazi mnogih istraživanja, dobiveni u pokusima s fitogenskim mješavinama esencijalnih ulja origana, anisa i limuna prikazani u ovom radu upućuju da ove tvari imaju izrazito djelovanje na rezultate i zdravlje peradi, svinja i teladi. Značajno poboljšanje dnevnog povećanja težine, omjera konverzije i unosa hrane dobiveni su dodavanjem fitogenika u hranu.

Ključne riječi: Fitogenici, aromatiziranje, rezultat, zdravlje crijeva