BOTANICALS AS FEED ADDITIVES TO IMPROVE HEALTH AND PRODUCTION IN PIGS

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Abstract

The need for natural alternatives to antibiotic growth promoters is an important issue in animal production following the European ban of antibiotic growth promoters in 2006. The high production level with still increasing demands as well as production sites that have to fulfil high quality standards at low costs result in high stress levels for the animals and will increase the demand for bioactive elements with effects on health and production.

The objective of this study was to examine the effect of different blends of botanicals rich in polyphenols on production parameters in piglets (Experiment 1 with additives based on a combination of citrus, grape and chestnut), in finishers (Experiment 2 with additives based on a combination of green tea, white willow bark, olive leaves and chestnut) and on mortality in piglets in herds with PMWS problems (Experiment 3 with additives based on a combination of green tea, white willow bark, olive leaves and chestnut).

Supplementing piglets with natural additives resulted in improved daily gain in the period following weaning of 29% ($P<0.01$), feed intake of 20% ($P<0.01$) and feed utilization by 13% ($P<0.01$) (Experiment 1). The number of outbreak of diarrhoea was reduced when supplementing weaned piglets with the natural feed additive. Supplementing finisher pigs with a natural additive resulted in increased daily gain of 8 % ($P< 0.01$) and an improved feed utilization of 10% (Experiment 2). Supplementing piglets from herds with PMWS problems with a natural additive resulted in reduced mortality from 5.8% to 3.1% (Experiment 3).

Trial results suggest positive effects of including selected botanical additives on production parameters like daily gain and feed utilization of piglets and finishers as well as on several health parameters.

Keywords: Botanicals, food animals, health, natural feed additives, PMWS, production

The focus on plant secondary metabolites in the alternative medicine is not new and medicinal herbs have been used for human for decades. In the animal industry the use of natural bioactives is quite new and reliable trials and scientific results in this area are still scarce. The prohibition of antibiotic growth promoters in 2006 in the EU (EC, 2003) resulted in a need for natural alternatives with effect not only on health but also on production. Concern has been given to the high usage of antibiotic growth promoters in farm animals and the risk of resistant bacteria giving serious health concern to human as well as farm animals (Kroismayr, 2007). Attention was given to feed additives as botanicals, essential oils, yeast, pre- and probiotics and their effects on productivity and health.

Botanicals contain secondary metabolites with known health properties and there is evidence that already Neanderthals used botanicals as medicine (Cowan, 1999). Known plant secondary metabolites can be classified as phenols and polyphenos, alkaloids, lectins, polypeptides, terpenes, saponins, polyacetylenes and glycosides (Acamovic and Brooker, 2005; Cowan, 1999). Thus plant metabolites are a huge group of natural chemicals. In the present paper focus will be primarily on whole plants and plant extracts rich in phenols and polyphenos.

It is well known and well documented that polyphenols have health promoting properties in general, like anticancer, antiviral, antimicrobial and anti-inflammatory effects among others due to the antioxidative capacity (Bocco et al., 1998; Cowan, 1999; Schubert & Lansky 1999). Flavonoids are a broad class of polyphenolic compounds which are hypothesized to be important in wine-promoted vascular protection (Sauro-Calixto, 1998). These botanicals with health promoting properties may have effect on production reducing subclinical infections and oxidative stress and have the potential to improve productivity in farm animals.

The objective of this study was to examine the effect of different blends of botanicals rich in polyphenols on production parameters in general in piglets (Experiment 1 with an additive based on a combination of citrus, grape and chestnut) and in finishers (Experiment 2 with an additive based on a combination of green tea, white willow bark, olive leaves and chestnut) and on mortality in piglets in PMWS herds (Experiment 3 with an additive based on a combination of green tea, white willow bark, olive leaves and chestnut).

Material and Methods

Experiment 1

The feeding trial was carried out in April and May 2007, starting on April 26, 2007 on a trial farm at the Swiss College of Agriculture at Zollikofen. A total of 60 crossbred piglets (Edelschwein, Edelschwein * Landrasse), 35 days of age, half castrates and half gilts were randomly allocated to 2 treatments (no addition (group CONTROL) or 2000 ppm of a blend of citrus extract (*Citrus limon*), sweet chestnut wood (*Castanea sativa*), and grape pomace (*Vitis vinifera*) (Cabanin CS Powder from NOR-FEED A/S) (group CABANIN CS) balanced for liveweight and sex. There were 6 replications per treatment and 5 piglets per pen. All pigs were fed with a standard feed ration based on barley, corn, soy bean, potato protein, vegetable oil, minerals and sugar beet containing 14 MJ/kg digestible energy, 18.5% crude protein and 12.5 g/kg lysine.

Piglets were weighed individually and feed consumption was registered by replicate at 35 days of age (start of trial), after 20 and after 35 (end of trial) days after trial start. The data was analyzed using the ANOVA procedure of SAS (SAS Institute Inc., 1999). A P-value of ≤ 0.05 was considered significant. The trial was carried out in cooperation with the feed company Haefliger (member of the Fenaco group) and Ceracom Ltd. Observations of outbreak of diarrhoea were performed daily.

Experiment 2

The trial was performed at "E.-A. Geweke" in Northern Germany. The farm has a yearly production of 3000 slaughter pigs and manages 80 ha land. Piglets are delivered from a directly neighbouring piglet producer (closed system). The trial was organised and supervised by Pulte GmbH & Co. KG.

A total of 116 finisher pigs (80-88 kg liveweight) approximately 4 weeks before the pigs were expected slaughtered from the German BHZP sire were part of the trial. The pigs remained in the pens/groups, where they were placed when taken to the grower unit. The pigs were housed in pens with approximately 15 in each. Two pens shared a feed dispenser. Feed and water was freely available (ad libitum) for the pigs. The pens were randomly allocated to 2 treatments: CONTROL and addition of 500 ppm of a blend of green tea extract (*Camellia sinensis*), sweet chestnut wood (*Castanea sativa*), white willow bark (*Salix alba*) and olive leaves (*Olea europaea*) (Nor-Guard AV Powder from NOR-FEED A/S) (group Nor-Guard AV).

Pigs were individually weighed on the day of trial start (June 23rd, 2007), on the 14th day of the trial (July 6th, 2007) and on day 21 of the trial (July 13th, 2007). Furthermore, feed intake per group was measured at the same days.

All pigs were fed with a standard feed ration based on 32% barley, 20% wheat, 15% triticale, 15% rye, 10% soy bean meal, 4% rapeseed cake, 1% vegetable oil and fat, 1% molasses, 0.8% calciumcarbonate, 0.4% calcium–sodium-phosphate, 0.3% sodiumchloride. Nutrient contents were 13.4 MJ ME/kg, 13.5 % crude protein, 3.3 % crude fat, 4.2 % crude fibers, 5.0 % crude ash, 0.9 % Lysine, 8000 I.E./kg Vitamin A, 1000 I.E./kg vitamin D3, 50 mg/kg vitamin E, 12 mg/kg Copper (Copper (II) – sulfat, Pentahydrat).

The results are given as means and standard deviation (STDV). Statistical analyses were done by an analysis of variance with start weight as covariate using proc glm in SAS, version 9.1 (SAS Institute Inc., 1999).

It was not possible to have any replications in the trial, this should be kept in mind concerning the results of the statistical analysis. A P-value of ≤ 0.05 was considered significant.

Experiment 3

The trial was carried out in March to October 2004 on a Danish commercial farm with PMWS problems. A total of 960 newly weaned crossbred piglets, 28 days of age were allocated to 2 treatments (no addition (group CONTROL) or 500 ppm of a blend of green tea extract (*Camellia sinensis*), sweet chestnut wood (*Castanea sativa*), white willow bark (*Salix alba*) and olive leaves (*Olea europaea*) (Nor-Guard AV Powder from NOR-FEED A/S) (group Nor-Guard AV).

It was not possible to have 2 different feeding groups at the same time, therefore all weaned piglets in week 1, 3, 5 and 7 were allocated to the control group and all weaned piglets in week 2, 4, 6 and 8 were allocated to the group Nor-Guard AV. The trial lasted for 28 days. All piglets were fed with a standard feed ration based on barley, corn and soy bean meal. Mortality was registered continuously.

Results

Experiment 1

Supplementing piglets with natural additives based on citrus, chestnut and grape resulted in improved daily gain in the period following weaning of 29% (P<0.01) and an improvement of feed intake of 20% (P<0.01) (Table 1). The feed conversion rate was improved by 13% (P<0.01). The number of outbreak of diarrhoea was reduced when supplementing weaned piglets with the natural feed additive.

Experiment 2

Supplementing finisher pigs with natural additives based on green tea extract, sweet chestnut wood, white willow bark and olive leaves resulted in increased daily gain of 8 % (P= 0.004) (Table 2). Feed utilization was improved by 10%. Gilts improved daily gain by 9% (P=0.022) (Table 3). Barrows did not show any significant improvement in weight gain (Table 4).

Experiment 3

Supplementing piglets with natural additives based on green tea extract, sweet chestnut wood, white willow bark and olive leaves resulted in reduced average mortality from 5.8% to 3.1% (Table 5). Mortality rate was reduced to 2-4% (Figure 1).

Discussion

Experiment 1

Trial results suggest positive effects of including a botanical additive based on selected elements from citrus, grape pomace and chestnut on production parameters like daily gain and feed conversion rate of piglets. These results confirm findings by Nielsen et al. (2006). No physiological analyses were part of the trial to examine the mode of action however several trials and analyses have been done concerning health promoting activities from citrus, grape and chestnut.

The citrus part contains polyphenols, primarily flavonoids. Polyphenols have health promoting effects in general, like anticancer, antiviral and anti-inflammatory effects among others due to the antioxidative capacity of citrus (Bocco et al., 1998). Citrus flavonoids are also supposed to have antimicrobial activities probably by complexing with virus and trials have shown that dialysis nor centrifugation could dissociate quercetin-virus complex (Benavente-Garcia et al., 1997). Antibacterial effect of citrus flavonoids has been explained by a reduction of DNA-synthesis in the bacteria (Bernard et al., 1997). E. coli contains two types of: enzymes necessary for the DNA replication in the bacterial cell (DNA-topoisomerase IV). Flavones in citrus inhibit theses enzymes (Bernhard et al., 1997). Citrus flavonoids have also the ability to provide a bitter or a sweet taste and to inhibit bitterness (Benavente-Garcia et al., 1997).

Citrus has also prebiotic effects supporting the growth of beneficial bacteria as Bifidobacterium spp. in the large intestine and Lactobaccili in the small intestine and thereby suppress the growth of pathogenic bacteria (Berg, 2001). Lactobaccili inhibits the pathogenic flora by production of antibiotic substances resulting in inhibition of pathogens as E.coli and Salmonella species (Kocher, 2005). Lactobaccili also produce lactic acid that will inhibit especially pathogenic gram-negative bacteria. Production of acid lowers the pH, changing the acids oxidation potential, making them antimicrobial. Lactobaccili also can inhibit adhesion of E.coli to the intestine by successfully dominating other bacteria the attachment sites (Ewing and Cole, 1994).

Chestnut contains a high amount of polyphenols including hydrolysable tannins. These tannins possess an astringent and an antimicrobial effect. Tannins complex with proteins and coats the intestinal wall and in this way protecting the animal against toxins resulting in a diarrhoea controlling effect (Basile et al., 2000).

Grape pomace, a by-product from wine production from Vitis vinifera, consists of pressed skins, seeds and stems, and represents as much as 20% of the weight of grapes processed (Larrauri et al., 1996). Grape pomace contains phenolic compounds, primarily tannins, that play an important role in determining the colour, taste and body of wine (Bombardelli and Morazzoni, 1995). Flavonoids from grape has shown to be antioxidative and antimicrobial (Saura-Calixto 1998), cancer protective and anti-inflammatory (Bombardelli & Morazzoni 1995; Schubert et al. 1999), gastric protecting activity in rats (Saito et al. 1998) and they have been found that phenols from red grapes are more effective than vitamin C and E (Lachman et al. 2004).

Although the presented trial did not include experiments of mode of action, it is probable that the improved production in the Cabanin CS group may be explained by antioxidative, antimicrobial and gastric protecting activities from the botanicals rich in polyphenols. It should me mentioned that active elements may vary in botanicals with varieties, country of origin and harvest time and standardization of the active elements in the final products are essential.

Experiment 2 and 3

Trial results showed positive effects on production in finishers as well as reduced mortality in PMWS herds when including a botanical additive based on green tea, chestnut, white willow bark and olive leaves.

The postweaning multisystemic wasting syndrome (PMWS) has first been identified in 1991 and has since become an economically important disease in pig production worldwide. The porcine circovirus type II (PCV2) is central for the development of the disease and both direct losses as increased mortality, reduced growth and poor feed conversion as well as secondary infections is typical for the disease. PMWS is thus characterized by the virus infection as well as secondary infections in general.

The botanicals used in Exp. 2 and 3 were green tea, olive leaves, white willow bark and chestnut. Olive leaves have shown antiviral activity by reducing the viral infectivity of viral haemorrhagic septicaemia rhabdovirus (VHSV) from 100 to 10 - 30% when VHSV was preincubated with olive leaves prior to infection of fish cell lines (EPC cells) (Micol et al., 2005).

Another botanical with possible effect on general health and that has been used in traditional medicine is white willow, a tree native to Europe, and western and central Asia. Hippocrates, a Greek physician, wrote already in the 5th century BC about a bitter powder extracted from willow bark that could ease aches and pains and reduce fevers. White willow bark contains salicin that is converted to acetylsalicylic acid, the active element found in analgesic drugs, in the body. Thus white willow bark is known to have pain-relieving and anti-inflammatory activities (Chrubasik, 2003).

It is well known that olives have a number of health promoting effects, such as lower risk of developing cardiovascular diseases and cancer, which partly has been dedicated the high content of antioxidants of the olives. Among the isolated antioxidants from olive oil are phenol components like simple phenols (hydroxytyrosol ((3.4-dihydroxyphenyl)ethanol), tyrosol (p-hydroxyphenylethanol)), secoiridoids (oleuropein) and lignans (pinoresinol) and other polyphenols (Owen et al., 2000). These active substances have shown biological activity, among these inhibition of cell growth of cancer cells and antiviral and antioxidative activity (eg. inhibition of oxidation of low-density lipoproteins (LDL) and inhibition of oxidative stress). The antioxidative activity from the active substances found in olive is far more effective than a synthetic form of vitamin E (Owen et al., 2000). There has been found in vitro anti-microbial activity in olive leaves (Markin et al. 2003).

Thus green tea, white willow bark and olive leaves are known for their antioxidative capacity (Chrubasik, 2003; Ishihara et al., 2003). Oxidative stress is an unbalance between produced radicals and the amount of antioxidants available. In a modern pig production the stress level will typical be high and antioxidants has to be given through the diet to counteract the increased production of radicals. Reactive oxygen species are involved in various gastrointestinal pathologies.

Oxidative stress may cause cell injury and induce cell death (Karczewski, 1999) thus the intestinal epithelium can be damaged with effect on the utilization of nutrients and the protection against foreign toxic substances (Holthausen, 2005). The right balance between oxidants and antioxidants prevents these unfortunate consequences. Some cases of antioxidant-inhibited apoptosis (programmed cell death) have even been described in which reactive oxygen species play a role in the mechanism that leads to apoptosis (Karczewski, 1999). Thus the improved production results and health parameters observed in Exp. 2 and Exp. 3 might be explained by a higher supply of antioxidants from the botanicals.

At the beginning of the trial in Exp. 3 the start weight was different in the two groups being highest in the control group which could have an influence on the results of this trial. As start weight was included in the analyses as covariate this difference should be eliminated.

Table 1. Effects on weight gain and feed conversion rate of supplementing piglets with the natural additive Cabanin CS Powder (Exp. 1)

Parameters	**Control group**	**Cabanin CS Powder**	**Diff. %**
Start weight, kg	9.16	9.15	
Feed intake (day 1-20), g	286	340**	*19*
Feed intake (day 21-35),g	699	892**	*28*
Feed intake (day 1-35),g	463	577**	*25*
Average daily weight gain (day 1-20), g	188	266**	*41*
Average daily weight gain (day 21-35), g	439	617**	*41*
Average daily weight gain (day 1-35), g	296	416**	*41*
Feed conversion (day 1-20)	1.53	1.28**	*-16*
Feed conversion (day 21-35)	1.60	1.45**	*-9*
Feed conversion (day 1-35)	1.57	1.39**	*-11*
Piglets with diarrhoea	10	5	*-50*

** P < 0.01

Table 2. Effects on weight gain and feed conversion rate of supplementing piglets with the natural additive Nor-Guard AV Powder, all pigs (Exp. 2)

	Control group		**Trial group**		**Index**	**P-value**	
	Mean	**STDV**	**Mean**	**STDV**		**Group**	**Gender**
No. of pigs	59	---	57	---	---	---	---
Av. start weight, kg	86.3	7.2	83.2***	6.4	96	0.0001	0.0005
Av. end weight, kg	101.9	9.1	100.1	7.8	98	0.155	0.454
Total gain/pig, kg	15.6	3.3	16.9	3.2	108	0.004	NS
Gain/pig/day, gram	745	156	807**	153	108		
Feed intake/pig/day, kg	2.89	---	2.81	---	97	---	---
Feed utilization, kg feed/ kg gain	3.88	---	3.48	---	90	---	---
Mortality, no. of pigs	0	---	0	---	---	---	---

P≤0.01 **, P≤0.001***

Table 3. Effects on weight gain and feed conversion rate of supplementing piglets with the natural additive Nor-Guard AV Powder, gilts (Exp. 2)

	Control group		Trial group		Index	P-value
	Mean	STDV	Mean	STDV		Group
No. of pigs	45	---	14	---	---	---
Av. start weight, kg	84.8	6.6	80.1	4.6	94	0.017
Av. end weight, kg	100.2	8.4	95.6	5.9	95	0.135
Total gain/pig, kg	15.4	3.3	16.8	2.3	109	0.022
Gain/pig/day, gram	733	158	799*	109	109	
Mortality, no. of pigs	0	---	0	---	---	---

P≤0.05 *

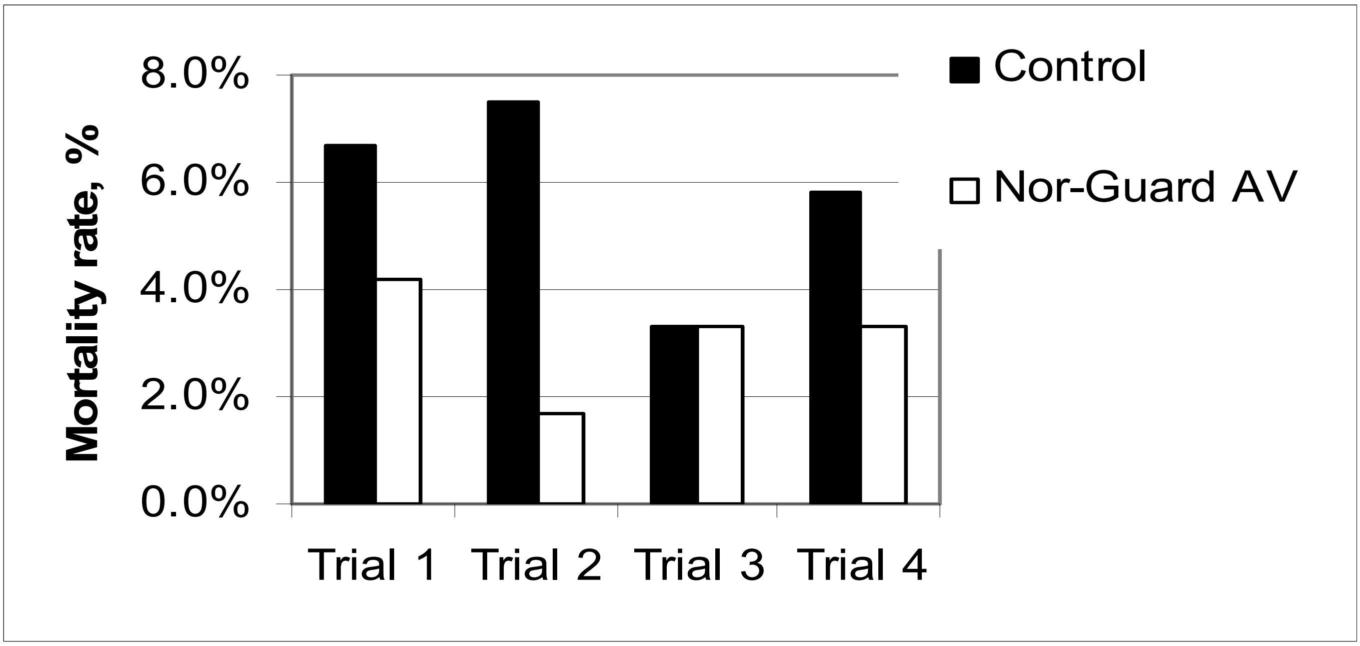
Table 4. Effects on weight gain and feed conversion rate of supplementing piglets with the natural additive Nor-Guard AV Powder, barrows (Exp. 2)

	Control group		Trial group		Index	P-value
	Mean	STDV	Mean	STDV		Group
No. of pigs	14	---	43	---	---	---
Av. start weight, kg	90.9	7.4	84.2	6.7	93	0.0022
Av. end weight, kg	107.4	9.3	101.2	8.1	94	0.747
Total gain/pig, kg	16.4	3.2	17.0	3.5	104	0.589
Gain/pig/day, gram	782	150	810	166	104	
Mortality, no. of pigs	0	---	0	---	---	---

Table 5. Effects on mortality of supplementing piglets from a farm with PMWS-problems with the natural additive Nor-Guard AV Powder (s.d. = standard deviation) (Exp. 2)

	Control	Nor-Guard AV	Diff, %
Pigs at start, No.	480	480	
Pigs after 28 days, No.	452	475	+ 5
Mortality rate	5.8 (s.d. 1.8)	3.1 (s.d.1.1)	- 46

Figure 1. The effect of supplementing piglets with the natural product Nor-Guard AV Powder (green tea, olive leaves, sweet chestnut bark and white willow bark) on the mortality on a farm with PMWS problems. (Exp. 3)



Conclusion

It can be concluded that both natural feed additives based on either a blend of selected elements from citrus, chestnut and grape (Experiment 1) or selected elements from green tea extract, sweet chestnut wood, white willow bark and olive leaves (Experiment 2) resulted in improved daily gain and feed utilization in both piglets and finishers. Also health could be improved by reducing the number of outbreak of diarrhoea (Experiment 1) as well as reducing mortality from 5.8% to 3.1% in piglets from herds with PMWS problems. A patent and a utility model have been granted on Cabanin CS Powder and Nor-Guard Powder respectively.

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