Stability of Secondary Plant Compound based Products in Feed Processing

R. Aschenbroich  
EW Nutrition GmbH; Hogenbögen 1, 49429 Visbek, Germany

Introduction

Secondary plant compounds are incorporated into diets to improve productivity of livestock by ameliorating feed properties, promoting the animals' production performance and improving the quality of food derived from these animals. The commonly used SPC products are offered as free flowing and granulated products. On farm, this standard use of SPCs has a pleasant side effect namely the smell. However, the economic sense has to be questioned, since substances that reach our nose are no longer available in the product to find their way into the digestive tract of the animal.

To prevent these losses many products containing SPCs are encapsulated and have entered the market over the last few years. These products and the processes that generate them differ greatly in design, technology, and unfortunately, in terms of performance. The question is if the product is stable enough to overcome production steps like grinding, pelleting or extrusion.

Encapsulation is a method of enclosing the active components within a carrier material in order to protect them from harmful environmental influences. With this innovation developed more than 50 years ago the delivery of veterinary and medical drugs has largely improved (Avgenaki, 2002). As the structure of the carrier material determines the degree of protection against volatilization, aspects like good film formation, emulsion stability, low viscosity, hygroscopicity, lack of an own taste or smell, and the possibility of release have to be considered (Salzer and Siewek, 2014; Avgenaki, 2002).

For many applications utilizing the physical methods of spray drying, spray granulation or extrusion, the commonly used techniques are involving core-shell encapsulation (Coating) or matrix/micro droplet encapsulation. In this study, we demonstrate the superior stability of secondary plant compounds after feed processing, when protected via matrix/micro droplet encapsulation.

Technology

Core shell encapsulation (Coating)

Core shell encapsulation applies a layered coating around the outside of the active ingredient e.g. essential oils to form a protective barrier. The most commonly used substances to form such a barrier or shell are ethyl cellulose, polyvinyl alcohol, gelatin or sodium alginate.

One of the major disadvantages of core shell encapsulation is the limited stability it provides during feed processing like pelleting, grinding, extruding. The high temperature and pressure applied through such processing technologies can lead to the damage of the outer shell and thus the release of liquid and easily volatile secondary plant compounds into the environment. This significantly reduces the content of active compounds in final feed but also changes odor and taste.

Matrix/Micro Droplet Encapsulation

Matrix encapsulation allows enclosing minute droplets of a complete mixture in different matrices like hydrocolloids, proteins or fat. Micro droplet encapsulation with fat emerged as an effective and economical method to protect secondary plant compounds. One of its major advantages compared to core shell encapsulation is the increased protective capacity during feed processing. In the event of damage, only smallest amounts of active substance leak out. Losses in active compounds can be reduced and a negative influence on odor and taste is minimized. The use of a combination of different sources of fats can optimize enzymatic degradation of the matrix through lipases. This allows the slow release of secondary plant compounds to exert their full potential in promoting digestion, reducing pathogenic load and inflammatory processes, and acting as antioxidants along the gastrointestinal tract.

Evaluation

Material and Methods

In this experiment feed processing stability of a defined blend of secondary plant compounds (Activo®), in comparison to 4 competitors was analysed. The total recovery of the lead substance (marker) was taken as a measure of processing stability. The analysis was conducted by a certified laboratory in Germany. For each product the recommended dosage was added to a standardized feed (the ingredients of this feed formulation are characteristic for pig feed as well as for poultry feed). After mixing, pellets were produced in a feed press using different temperature conditions (70°C and 90°C) with 3 min incubation time. In the process, steam was added into the conditioner before the feed entered the shaping die. Subsequently, the pellets were cooled down with a belt cooler and for each temperature 10 samples were collected and analyzed.

To measure the recovery rate in the finished feed the recovery of the lead substance (marker) was taken as a measure of processing stability. The analysis was conducted by a certified laboratory in Germany. For each product the recommended dosage was added to a standardized feed (the ingredients of this feed formulation are characteristic for pig feed as well as for poultry feed). After mixing, pellets were produced in a feed press using different temperature conditions (70°C and 90°C) with 3 min incubation time. In the process, steam was added into the conditioner before the feed entered the shaping die. Subsequently, the pellets were cooled down with a belt cooler and for each temperature 10 samples were collected and analyzed.

Results

The loss of the markers is influenced by heat and steam applied during processing. Heating at 70°C decreases the content in the non-encapsulated products B and C by more than 40%, whereas encapsulation via core shell (Product A) and matrix encapsulation (Activo®) preserve more marker within feed under those conditions. At 90°C, the protective effect of core shell encapsulation is diminished, whilst markers in Activo® are still preserved to more than 82%. Competitor D, a non-encapsulated product, also shows a very high recovery rate. This might be explained by the protective effect of the plant material storing the active substances. However, this product has to be applied in feed at 7 fold higher inclusion than Activo®.

Thus matrix encapsulation provides the best and most economic protection independent of the processing conditions.

Conclusion

Encapsulation is a good tool to protect the often volatile secondary plant compounds from evaporating. The kind of encapsulation, however, is very important. Core-shell encapsulation only is protecting, if the product is not damaged by milling. The more sophisticated method of micro-droplet encapsulation shields the mixtures in case of heating but also of milling. If damaged, only smallest amounts of the active components can lack, but the main part is ingested. If a fat matrix out of different fats is used, release in the gastrointestinal tract can be regulated up to a certain degree.

For the use of secondary plant compounds in animal nutrition, an adequate method of encapsulation should be implemented to tap the full potential of these useful substances.

References:

Secondary plant compounds and their antimicrobial properties to inhibit the growth of antibiotic resistant bacteria

T. Rothstein, I. Heinzl and Thilo Borchardt
EW Nutrition GmbH; Hogenbögen 1, 49429 Visbek, Germany

Introduction
Antibiotics were and still remain the method of choice against bacterial diseases. Due to their additional positive effect on growth performance they increasingly have been used in animal husbandry. But every use of antibiotics imposes positive selection pressure towards resistant bacteria and especially this prophylactic use at low dosage provides bacteria a better chance to adapt. For this very prophylactic and metaphylactic use secondary plant compounds could be an alternative: they are generally recognized as safe (GRAS) and for a number of them antimicrobial efficacy has been demonstrated, e.g. Carvacrol and Cinnamon aldehyde. They effectively act against Salmonella, E. coli, Pseudomonas aeruginosa, Klebsiella pneumoniae, Enteroto- and Staphylococcus and Candida albicans (1,2,3) but also against multi drug resistant strains of Escherichia coli, Klebsiella pneumoniae and Candida albicans (2).

In this study, we demonstrate, that defined blends of secondary plant compounds are as effective in their antimicrobial efficacy towards antibiotic resistant E.coli (ESBL) and Staphylococcus aureus (MRSA) as they are against non-resistant strains of the same genus.

Trial 1 Minimal Inhibitory Concentration Test against ESBL and AmpC E. coli

Material and Methods
Two Extended-Spectrum Beta-Lactamase producing Escherichia coli (ESBL) field isolates and two aminopenicillin and cephalosporin resistant strains (AmpC), were used and compared to one nonresistant reference strain of the same species with respect to their sensitivity against Activo® Liquid. In a Minimal Inhibitory Concentration Assay (MIC) under approved experimental conditions (Poultry Microbiology Laboratory, Edinburgh, Scotland) the antimicrobial efficacy of Activo® Liquid in different concentrations was evaluated.

Results
The antimicrobial efficacy of the defined blend of secondary plant compounds (Activo® Liquid) could be demonstrated in a concentration dependant manner with antimicrobial impact at higher concentrations and bacteriostatic efficacy in dilutions up to 0,1% (ESBL).

Table 1: Efficacy of secondary plant compounds (Activo® Liquid) against ESBL and AmpC E. coli

<table>
<thead>
<tr>
<th>Laboratory:</th>
<th>Cefotaxim 30 µg / ml</th>
<th>Secondary Plant Compounds (Activo® Liquid)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1%</td>
<td>0.2%</td>
</tr>
<tr>
<td>E. coli ESBL 1 Poultry</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>E. coli ESBL 2 Poultry</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>E. coli AmpC 1 Poultry</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>E. coli AmpC 2 Poultry</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>E. coli non-resistant</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

- no effect          +   growth inhibiting          ++ bactericide

Trial 2 Minimal Inhibitory Concentration Test against ESBL and MRSA

Material and Methods
Farm isolates of four ESBL producing E. coli and two Methicillin resistant Staphylococcus aureus strains were compared to nonresistant reference strains of the same species with respect to their sensitivity against Activo® Liquid. In a Minimal Inhibitory Concentration Assay (MIC) under approved experimental conditions (Vaxxinova Diagnostic, Muenster, Germany) the antimicrobial efficacy of Activo® Liquid in different concentrations was evaluated.

Results
The antimicrobial efficacy of the defined blend of secondary plant compounds (Activo® Liquid) could be demonstrated in a concentration dependant manner with antimicrobial impact at higher concentrations and bacteriostatic efficacy in dilutions up to 0,1% (ESBL) and 0,2% (MRSA).

Table 2: Efficacy of secondary plant compounds (Activo® Liquid) against ESBL producing E. coli and MRSA

<table>
<thead>
<tr>
<th>Laboratory:</th>
<th>Secondary Plant Compounds (Activo® Liquid)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1%</td>
</tr>
<tr>
<td>E. coli/Reference ATCC25922</td>
<td>+</td>
</tr>
<tr>
<td>ESBL 1 (Pig)</td>
<td>-</td>
</tr>
<tr>
<td>ESBL 2 (Pig)</td>
<td>+</td>
</tr>
<tr>
<td>ESBL 3 (Poultry)</td>
<td>+</td>
</tr>
<tr>
<td>ESBL 4 (Poultry)</td>
<td>-</td>
</tr>
<tr>
<td>S. aureus Reference ATCC29213</td>
<td>-</td>
</tr>
<tr>
<td>MRSA 1 (Pig)</td>
<td>-</td>
</tr>
<tr>
<td>MRSA 2 (Pig)</td>
<td>-</td>
</tr>
</tbody>
</table>

- no effect          +   growth inhibiting          ++ bactericide

Conclusion
In order to contain the emergence and spread of newly formed resistance mechanisms it is of vital importance to reduce the use of antibiotics. A general rethinking is necessary to accept the challenge and give new approaches a chance. These approaches however, will only be successful in combination with good management practices. Antibiotics must not be used for growth promotion or metaphylactic treatment, but only as a pure curative instrument. In in-vitro trials the liquid blend of secondary plant compounds and organic acids (Activo® Liquid) showed strong antimicrobial effects against prevalent livestock pathogens. This gives reason for further investigations with secondary plant compounds in animal production in order to use them for pro- and metaphylaxis and therefore to reduce the use of antibiotics in the future. The positive influence on performance parameters, as shown in many other trials, is an additional incentive for farmers to use flavoring substances as part of innovative health management.

The high efficacy of secondary plant compounds against ESBL producing and AmpC Escherichia coli and Methicillin resistant Staphylococcus aureus (MRSA) could be a further step towards the reduction of antibiotic use. Due to the specific mode of action of antibiotics, resistance mechanisms are more likely to emerge. To support antibiotic treatment, Activo® Liquid, a blend of natural compounds with broad spectrum efficacy, probably could be a safe supplement for the control of pathogenic organisms.

References:
1) BAIU, N., S.M. MOOKA, 2007: Broad-spectrum disinfectant composition containing a synergistic combination of cinnamon oil and citric acid. International Journal of Essential Oil Therapeutics 1, pp. 117-121