Alternatives to Dietary Antibiotics: The Potential of Essential Oils

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Background

The emergence of super bugs (drug resistant bacteria) and drug residues in food are the two major food safety and human health concerns associated with drug use in agricultural production. The use of antimicrobials as growth promoters (AGPs) has completely been banned in EU countries starting from January of 2006. Swine and other livestock industries in Canada are also under publics' pressure to reduce or even stop the use of AGPs in livestock production. Consequently, developing alternative products to replace AGPs has become urgent for both the livestock industry and scientific research community.

Essential oils (EOs) are volatile components of plants. Many EOs are generally recognized as safe by the FDA of the United Sates for use as ingredients of perfumes, cosmetic, and food. Some EOs have demonstrated strong antimicrobial activities, against both bacteria and fungi. Previous studies on EOs have mainly focused on seeking natural and safer means for food hygiene or preservation, with limited effort in investigating their potential to control both human and animal pathogens and reduce the use of dietary antibiotics in livestock production. We recently completed a research project on EOs and structurally related compounds and their potentials for being developed into AGPs for swine production. The research showed some positive and promising results. Following is a brief summary of the outcomes from the project.

Experimental Results

To identify effective EOs, a total of sixty-six EOs/compounds were tested for their ability to inhibit the growth of *Salmonella* Typhimurium DT104 and *Escherichia coli* O157:H7. Sixteen out of the sixty-six EOs/compounds tested were found to have strong antimicrobial activity (over 80% inhibition) and nine of them were further studied. The majority of nine EOs/compounds demonstrated high efficacy against *S.* Typhimurium DT104, *E. coli* O157:H7, and *E. coli* K88 (Table 1) with little inhibition towards lactobacilli and bifidobacteria. They were also tolerant to the low pH. When mixed with pig cecal digesta, these EOs/compounds retained their efficacy against *E. coli* O157:H7. In addition, they significantly inhibited *E. coli* and coliform bacteria in the digesta, but had little effect on the total number of lactobacilli and anaerobic bacteria. When mixed with pig diets, all the tested EOs/compounds except for one lost their antimicrobial activity. This EO reduced *Salmonella* counts in the diets by approximately 2-log units (Fig. 1) and required emulsification in hydrocolloid solutions to retain its antimicrobial activity during storage. Pig infection experiments demonstrated a promise of this EO for future application. Further investigation, however, is required to determine the level of treatment, delivery, and other issues regarding its on-farm use.

Take-home Messages

1. Some essential oils can be developed into the substitutes for dietary antibiotics because of their strong antimicrobial activity, tolerance to low pH, and selectivity towards bacterial pathogens over beneficial gut bacteria.

2. Pig diets are a significant factor limiting the antimicrobial activity of essential oils. An effective and practical delivery of essential oils to the animal guts is critical in maximizing their antimicrobial effect.
3. An essential oil has been identified that retained its antimicrobial activity in the presence of diets, in addition to its strong antimicrobial activity, tolerance to low pH, and selectivity towards pathogens. Pig infection experiments have also demonstrated a promise of this EO for future application although further investigation is required.

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Table 1. Minimum Bactericidal Concentrations of essential oils/compounds against *E. coli* and *S.* Typhimurium DT104*

Oil/compound	MBC ($\mu g\ ml^{-1}$)		
	E. coli K88	*E. coli* O157:H7	*S.* Typhimurium DT104
m-Anisaldehyde	700^{a}	933^{a}	933^{a}
Geraniol	300^{b}	283^{bd}	367^{b}
(*DL*)-Mandelonitrile	833^{c}	766^{a}	767^{c}
Clove oil	233^{be}	283^{bd}	300^{bdf}
Carvacrol	100^{d}	283^{bd}	167^{de}
Cinnamon oil	133^{bg}	133^{b}	100^{e}
Eugenol	300^{b}	466^{c}	400^{b}
Thymol	100^{d}	166^{b}	233^{ef}
2-*tert*-Butyl-4-methylphenol	200^{e}	433^{cd}	333^{bf}

* [a,b,c,d,e,f]Values in the same column with different superscript letters differ ($p<0.05$); n = 3.

Reference: Si, W. J. Gong, R. Tsao, T. Zhou, H. Yu, C. Poppe, R. Johnson, and Z. Du. 2005. Antimicrobial activity of essential oils and structurally related synthetic food additives towards selected pathogenic and beneficial gut bacteria. J. Appl. Microbiol. (in press).

Figure 1. Antimicrobial activity toward *Salmonella* Typhimurium DT104 in the presence of diets of essential oil compounds emulsified or suspended in water. The final concentrations of the emulsifiers and essential oil compounds were 0.1% (1 ml l^{-1} or 1 g l^{-1}). The ration of diets to the solution of essential oil compound was 2:1.