Potential of Cranberry Extracts as Immuno-Modulatory Agent in Organic Broiler Chicken Production

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Abstract

*Cranberry (*Vaccinium macrocarpon *Ait.) has received considerable attention for its putative human health benefits. Most of the focus is on its phenolic compounds including phenolic acids, anthocyanins, flavonols, flavan 3 ols and the polymer classes of procyanidins and proanthocyanidins. Research in our laboratories has revealed that crude cranberry extracts can disrupt the cell envelope in Listeria, Escherichia coli, Salmonella, and S. aureus, activity which parallels that of antibiotics widely used as growth promoters in the poultry industry. The plant proanthocyanidins are well known to improve nitrogen nutrition in ruminant animals and as a powerful antioxidant with beneficial effects on human health and immunity. Limited laboratory research has examined the biological effect of cranberry extract using animal models. The purpose of the present work was to discuss progress being made in evaluating the potential for utilizing cranberry as an immune-modulatory agent in organic broiler chickens production.*

Introduction

Several antimicrobial agents are used in conventional broiler chicken feed for growth promotion and to prevent infectious diseases (Butaye et al. 2003). These antibiotics improve feed conversion and bodyweight gain presumably by altering the composition and activities of gut microflora, which may create a selective pressure in favor of resistant bacteria (Aarestrup 2006). Antibiotic use has long been forbidden in organic production. For organic poultry production to increase, suitable solutions must be available for disease prevention and control that meet organic standards.

Poultry utilized for commercial meat production are genetically very homogenous and their ability to build sufficient immune responses to bacteria during the rearing period is of concern (Koenen 2002). Nutritional methods including addition of probiotics or natural additives have been investigated to modulate chicken immunity (Rahmani and Speer 2005, Taheri et al. 2005). The impact of poultry production on food safety and environmental health is becoming an important public health issue. Methods that can improve chicken health and food safety under organic production will provide a good alternative to conventional antibiotic use.

Cranberry (*Vaccinium macrocarpon* Ait.) has received considerable attention for its putative human health benefits (Neto 2007, Wu et al. 2008). In past few years, we have made significant progress in the development of cranberry bioactives in animal production. The following is a review of this progress resulting from several studies.

Results

1) Non-dialyzable materials (NDMs) from cranberry fruit at 1 mg/ml increased phagocytosis and intracellular killing activity of chicken heterophils (which protect against bacterial infections). This has suggested that the infecting bacteria have become more susceptible to immuno-defense mechanisms against infections (Diarra and Rempel 2008).

2) Cranberry extracts induced growth inhibition and a decrease in viable cells of *Clostridium perfringens* isolates over 24 h of in vitro incubation, and significantly decreased expression of the necrotic enteritis causing toxin cpA gene of this bacterium, indicating that further examination of the antimicrobial potential of these compounds is warranted (Delaquis et al. 2010).

3) In vivo biological effects of cranberry extracts in a poultry feeding trial using a commercial whole cranberry fruit extract at 40 mg/kg of feed induced low early mortality rates (improvement by 40% compared to the control) in birds. Diet supplementation with such extracts caused a shift of the intestinal tract bacterial population while not altering any broiler meat properties (Leusink et al. 2010).

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4) The demonstration for the first time that a cranberry press cake (pomace) extract exerts vasodilatory effects (widening of blood vessels) by inducing 90-101% relaxation of rat aorta rings, which was similar to results achieved with aqueous *Prunus serotina* (Harrison et al., 2012).

5) Further studies on the effect of cranberry extracts against *E. coli*, a major cause of colibacillosis causing important economic losses to poultry industry worldwide, have been conducted using a DNA array-based approach in an attempt to correlate specific transcriptional signatures and bacterial cell damage. Treatment of *E. coli* with cranberry strongly down-regulated OmpF and overexpressed TolQ and Gad genes, all involved in membrane functions, maintenance of ionic balance and protection against high-proton-concentration environments, suggesting important membrane disturbances. In sum, the effects observed on the transcriptome of *E. coli* exposed to cranberry extracts correlated with known characteristics of cranberry constituents such as condensed tannins (flavonoids) and phenolics that could possibly act as iron chelators (González-Lamothe et al. 2009).

6) Demonstrated antimicrobial activity of cranberry fruit bioactives against several *Listeria* strains including *L. monocytogenes*, including clues about mode of action. Antimicrobial activity was related to disturbances in membrane integrity. To date, activity measured in vitro has exceeded that achieved in vivo (Block et al. 2012).

7) In *S. aureus*, the cranberry extracts were found to induce a transcriptional signature similar to that of peptidoglycan-acting antibiotics. We showed that pomace fractions induce membrane depolarization similar to daptomycin and are much better than vancomycin in interfering with bacterial cell-wall D-Ala-D-Ala synthesis (Diarra et al. 2013).

8) Recently, we demonstrated that cranberry extracts induce dose dependent bactericidal effect against *Salmonella* in broth and on cooked chicken meats as well as decreased the salt tolerance of this pathogen, indicating that that our cranberry extract could be developed for food preservation (Goubé et al. 2013).

9) In an exploratory study, we evaluated the high molecular weight NDMs of cranberry fruit extracts on the humoral response of broiler chicken. Our results showed no clear linear (dose dependence increase or decrease) effects on the immunoglobulin [IgA, IgG (IgY) or IgM] level. One of the explanations for this lack of effect could be the low concentration (0.5 to 2 mg of cranberry fruit extract per bird per day) and duration of treatments (1 wk at 7 to 14 days old). However, higher doses of cranberry extract might still be effective in promoting the antibodies levels in serum. This suggestion needs to be confirmed in a vaccination experiment using cranberry constituent as adjuvant. Further studies involving higher doses of cranberry extract administered for longer periods of time are warranted and are being conducted.

Discussion

Investigations on cranberry compounds could lead to the development of a feeding strategy for organic chicken production to improve bird health and immunity and on-farm food safety while reducing use of antibiotics (in conventional operations). Based on the above data, it is clear that additional research will unlock the full potential of cranberry and other fruits pomaces and how best to use them as feed ingredients for organic chicken producers.

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