Poultry enzyme/ probiotic combo

With pressure on the poultry industry to reduce production costs without compromising bird performance or gut health, a combination of enzymes and probiotics may offer opportunities to further unlock the nutritive value of feed.

By **JANET REMUS***

SINCE the 1990s, poultry numbers have grown at a similar rate as the human population, but the increase in poultry protein production has almost doubled, according to 2013 statistics from the U.N. Food & Agriculture Organization.

Producers are under pressure to increase the efficiency by which animals convert feed into protein and to shorten production cycles against a backdrop of market volatility, the main impact of which has been on the cost and quality of feed raw materials, which make up about 70% of overall production costs.

To achieve more high-quality poultry protein, attention should be paid to optimal nutrition as well as achieving a balanced gut microbiota as these two components go hand in hand with healthy performance. Enzymes and probiotics have a well-documented role to play in improving healthy performance. Enzyme benefits include enhanced digestion and absorption of nutrients as well as improvements in growth uniformity within flocks (Barletta, 2010).

The performance benefits delivered by probiotics can be linked to improved diversity and stability of the gut microbiota. This makes the gut environment less conducive to colonization by microorganisms that may have a negative impact on animal performance (Lee et al., 2010).

This article looks at the benefits of a multi-enzyme product and a bacillus probiotic as individual feed additives and examines the potential additional benefits seen when combining the two technologies.

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Gut microbiota balance

First introduced into the poultry industry in the 1980s, enzymes are now used in more than 90% of all broiler diets.

The penetration of carbohydrase and protease enzymes into poultry feed has been slower but is increasing. Volatility in feed ingredient costs has encouraged the use of multi-enzyme carbohydrase and protease combinations because these allow use of cheaper ingredients in feed formulation without having any detrimental effect on bird performance.

Although many factors cumulatively affect the microbial composition in the intestines and the number of non-beneficial bacteria there, the single biggest contributor has been the type, amount and availability of undigested nutrient substrate present in various segments in the gastrointestinal tract (Snel et al., 2002; Romero and Ravindran, 2011).

1. Improvements in broiler FCRc (feed conversion ratio - bodyweight converted) after addition of a three-strain Bacillus mix to the diet

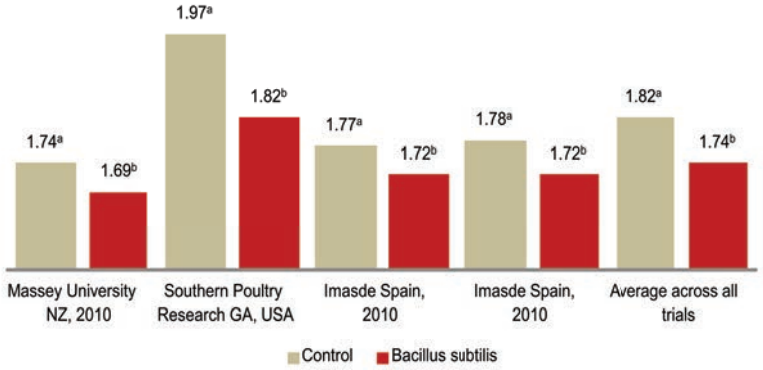
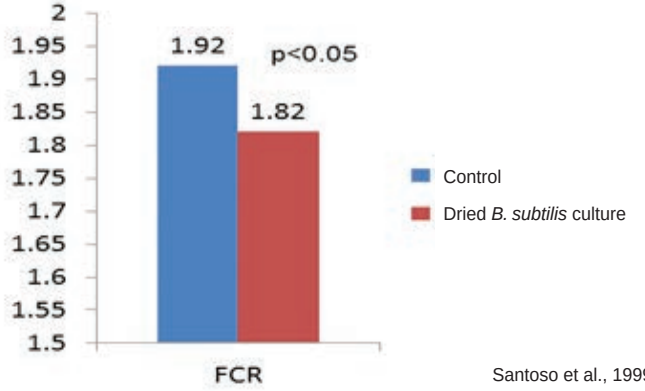


Figure shows number of kg of feed per kg gained (Danisco trials).
[ab]Significance of P < 0.05 within an individual trial.
FCRc: Corrected three points per 100g of liveweight difference.

2. FCR improvements in broilers after *B. subtilis* addition to the diet



Santoso et al., 1999.

Several studies have demonstrated incremental improvements in energy digestibility when dietary carbohydrases (xylanase and amylase) were used with or without protease in diets with or without dried distillers grains with solubles (DDGS) in corn-based diets (Cowieson and Ravindran, 2008; Romero et al., 2013a). What do these enzymes do?

- Xylanase breaks down non-starch polysaccharides (NSPs), specifically soluble and insoluble arabinoxylans, which, in turn, reduces digesta viscosity, releases trapped nutrients and improves feed passage rates (Choct, 2006; Mirzaie et al., 2012). The released arabino-oligosaccharides may also have a prebiotic effect in the gut (Cloetens et al., 2008; Courtin et al., 2008; Fernandez et al., 2000).
- Amylase increases the hydrolysis and digestibility of starch, resulting in improved energy release (Gracia et al., 2003; Barletta, 2010).
- Protease improves the digestibility of protein (Zanella et al., 1999; Romero et al., 2013a), disrupts interactions of proteins with starch and fiber in the diet (Yu et al., 2007; Cowieson and Adeola, 2005) and reduces anti-nutritional factors, e.g., residual trypsin inhibitors (Caine et al., 1998).

It appears that the activity of one type of feed enzyme can be facilitated by the other, possibly in a reciprocal fashion, by providing greater substrate access and also by reducing the anti-nutritive effects of the NSPs and phytate on nutrient utilization and by generating potentially prebiotic oligosaccharides.

The effect on ileal digestible energy and apparent metabolizable energy (AMEn) can be significantly different depending on the combination of enzymes used (Romero et al., 2013). In addition, a product with distinct xylanase, amylase and protease activities was shown to increase protein and amino acid digestibility — by 12-13% of the ileal undigested amino acid fraction, irrespective of the amino acid concerned (Romero et al., 2013).

Romero and Ravindran (2011) demonstrated significant improvements in crude protein as well as fat and starch digestibility with the xylanase, amylase and protease combination.

Microbial balance, gut health

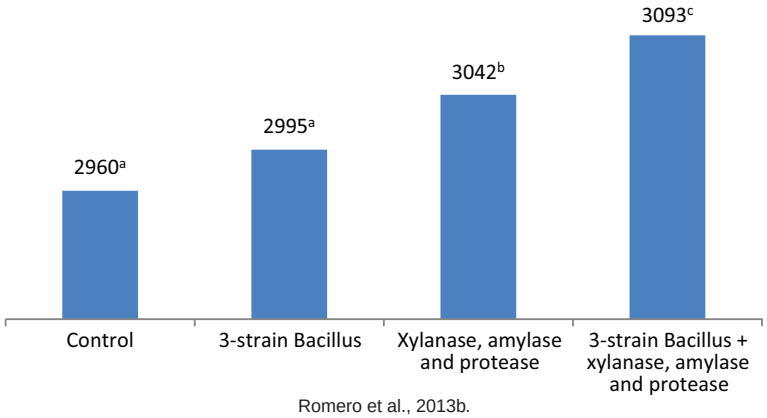
Probiotics have been defined as combinations of beneficial bacteria that maintain the gut microbiota and assist with natural defenses against pathogens (Patterson and Burkholder, 2009). Spore-forming bacillus strains — *Bacillus amyloliquefaciens*, *Bacillus licheniformis*, *Bacillus pumilis* and *Bacillus subtilis* — are particularly favored for animal feed use because of their stability in feed production and through digestion.

Bodyweight gain and FCR in unchallenged birds compared with birds challenged with *C. perfringens* on days 20-22 with or without a three-strain probiotic and a xylanase/amylase/protease enzyme combination

	Unchallenged control	Challenged control (CC)	CC + probiotics	CC + enzymes	CC + probiotics + enzymes
Experiment 1					
Weight gain (g, 1-42 days)	1,988^{ab}	1,790^{d}	1,935^{bc}	1,903^{c}	2,016^{a}
FCR (1-42 days)	1.75^{c}	1.97^{a}	1.82^{c}	1.87^{b}	1.76^{c}
Experiment 2					
Weight gain (g, 1-42 days)	2,095^{ab}	1,984^{b}	—	—	2,136^{a}
FCR (1-42 days)	1.93^{b}	2.13^{a}	—	—	1.87^{b}

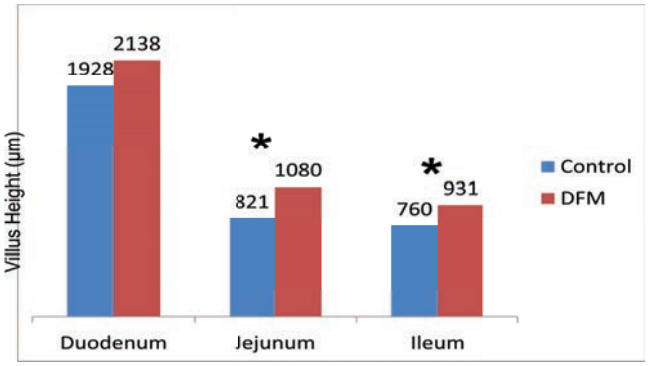
^{ab}Values without a common superscript are significantly different (P < 0.05).

4. Changes in AMEn of broilers supplemented with a distinct three-strain Bacillus probiotic, an enzyme combination (xylanase, amylase and protease) or a combination of both



Romero et al., 2013b.

3. Impact of Bacillus on villi height in key small intestine areas



Lee et al., 2010.

Their resistance to enzymatic digestion, acidity and their ability to be adherent helps them survive and colonize in the gastrointestinal tract (Alexpoulos et al., 2004; Duc et al., 2004; Jorgensen and Kurti, 2004; Jadamus et al., 2002; Hoa et al., 2001; Adami and Cavazzoni, 1998). Their presence in feed and the gastrointestinal tract means that they can establish in the gut when the birds are very young, stabilizing the gut at that time or later during stressful situations associated with feed changes, transportation, temperature, etc.

Bacillus strains also resist heat and high pressure, which helps them survive hostile steam conditioning and pelleting processes.

Trials with combined strains of bacillus have shown 4-5% improvements in

feed conversion ratio (FCR) corrected three points for each 100 g of liveweight difference of broilers raised to market age (Figure 1).

Research using a necrotic enteritis (NE) challenge model (Figure 2) also noted that broilers maintained good performance during the challenge when probiotics were added to their feed (Santosa et al., 1999).

The *B. subtilis* mode of action resulted in improved diversity and stability of the gut microbiota, optimum villi height maintenance and crypt depth. In a study using an eimeria vaccine challenge in broilers, Lee et al. (2010) showed that feeding a three-strain bacillus probiotic restored gut barrier structure, with treated birds showing significantly higher villi height compared to the control group (Figure 3).

Additional benefits

Given the different but potentially complementary modes-of-action of exogenous feed enzymes and probiotics, it seems logical that the two products could deliver additive benefits when used in combination.

Recent research studies have examined this concept under both "non-challenged" and "challenged" conditions. Romero et al. (2013b) measured AMEn at 21 days in non-challenged broilers fed a corn/soybean meal-based diet containing some fibrous cereal byproducts (as wheat middlings and DDGS). They observed significant ($P < 0.05$) incremental increases in AMEn of 35, 82 and 133 kcal/kg of dry matter with additions of a three-strain bacillus probiotic, xylanase/amylase/protease enzymes and the bacillus/enzyme combination, respectively (Figure 4).

The combination of the enzyme complex and bacillus probiotic appeared to exert its beneficial effects on AMEn via improved protein, fat and starch digestibility and reduced ileal insoluble NSP flow, the latter indicating enhanced fiber digestion.

Since NE, caused by *Clostridium perfringens*, is a major problem for the poultry industry that can affect up to 40% of flocks and cost producers about 5 cents per broiler in performance losses (McDevitt et al., 2006), the next step was to check whether the benefits could be seen within an NE challenge model.

In two experiments using an NE challenge model with *C. perfringens*, broilers offered feed with the combination of xylanase, amylase and protease and a probiotic product with three distinct strains of bacillus delivered an equivalent growth rate and FCR to the unchallenged control (Table).

The incremental recovery of bodyweight gain and FCR when using a combination solution (Mathis et al., 2013) suggested that the distinct modes of action of each product — the multi-enzyme and multi-strain probiotic — resulted in complementary and potentially additive effects in the bird. The improvements in bodyweight-corrected FCR in both experiments with the combination product gave a net benefit of 14% in relative cost per pound of liveweight gain versus the challenged control at current feed prices.

In another study using phytase in addition to a xylanase, amylase, protease and bacillus combination, a cost comparison with an antibiotic growth promoter (based on the current liveweight price of chickens and feed cost) showed that the enzyme and probiotic combination resulted in a 2.5% higher gross profit (DuPont internal data).

Combination

The research studies run to date in both challenged and non-challenged situations illustrate the opportunity for successfully using xylanase, amylase, protease and bacillus strains in combination due to their complementary modes of action.

With pressure on the poultry industry to reduce production costs without compromising bird performance or gut health, this combination of enzymes and probiotics appears to offer opportunities to unlock the potential nutritive value of feed.

References

References are available upon request from monica.hart@dupont.com. ■