J. E. Sullivan Enterprise, LLC

The Potential Use of Dried Dairy Permeate in Poultry Feed to Reduce the Incidence of *Salmonella*

Conducted for the American Dairy Products Institute

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OBJECTIVES

1. To review literature and report on published scientific research on this topic.

2. To summarize published research results.

3. To draw conclusions and make recommendations based on the research summary.

4. To learn if any of the poultry associations are interested in supporting research trials on this topic.

5. To learn if CP Intertrade in Bangkok has conducted research on this subject and to learn if they are willing to share their results.

6. Recommend a university poultry researcher who may be the best candidate to conduct research trials with dried dairy permeate to reduce *Salmonella* in chicken meat and eggs.

7. Estimate the potential market size for dried dairy permeate use in poultry feed.

8. Offer opinion on the effect of changes in antibiotic usage in US poultry feeds could have on the use of dried dairy permeate in poultry feeds

METHODOLOGY

This study will be conducted through the use of literature searches, personal conversations and interviews with poultry researchers, communications with US poultry associations and direct communications with CP in Thailand.

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1. REVIEW OF SCIENTIFIC LITERATURE

Review of the Effects of Dairy Products on the Concentration and Incidence of *Salmonella* in Broilers

Introduction and Importance

Salmonella is a pathogenic type of bacteria that is commonly found in the gastro-intestinal tract of broilers and frequently contaminates poultry carcasses during processing (Oyofo et al., 1989). Humans can be infected with *Salmonella* by consuming undercooked poultry products, thus making control of *Salmonella* in broiler chickens an integral part in reducing the impact of *Salmonella* on human health (Totton et al., 2012). The CDC estimates that about 1.2 million people become ill with Salmonellosis each year in the United States (Scallan et al., 2011).

Young chickens are known to be highly susceptible to *Salmonella,* with as few as 2 to 10 *Salmonella* bacteria being able to cause infection (Ziprin et al., 1990). The young chick is believed to be particularly sensitive until normal beneficial microbial populations are established (Bilgili & Moran, 1990). Thus, it has been hypothesized that the susceptibility of young chicks to *Salmonella* infection may be reduced by accelerating the growth of normal microbes through the use of probiotics and prebiotics (Nurmi & Rantala, 1973). These methods are of particular interest currently as some *Salmonella* strains have developed substantial antimicrobial resistance (Diarra et al., 2014). Additionally, traditional methods of ensuring gut health, such as low level antibiotic use, are being faced with considerable opposition from consumers and legislative bodies (Douglas et al., 2003; Lee et al., 2011). This review will focus on the use of dairy products as prebiotics with and without the use of probiotics, and the consequent effects on *Salmonella* prevalence and incidence in broiler chickens.

Mode of Action of Prebiotics and Probiotics

Providing dairy products in low levels to poultry may be beneficial due to lactose acting as a prebiotic. Prebiotics are simply ingredients that are not digested by the broilers, and are rather designed to aid the growth of specific bacteria or groups of bacteria in the digestive tract (Vicente et al., 2007). Dairy products are effective

prebiotics because while lactose is not digested well by poultry (Hume et al., 1992) it is a preferred fermentation substrate of many types of bacteria that are believed to be beneficial to gut health (Chambers et al., 1997).

There are several theories that attempt to explain how providing dairy products to poultry enhances gut health and protects against *Salmonella.* Perhaps the oldest theory is that growth of normal intestinal bacteria crowds out undesirable bacteria via the mechanism of competitive exclusion (DeLoach et al., 1990; NurmiI & Rantala, 1973). This competition is most often believed to be for bacterial attachment sites on the mucosal surface (Bilgili & Moran, 1990). An additional theory is that normal microbes secrete substances that are bactericidal towards *Salmonella* or otherwise make the intestinal tract unsuitable for *Salmonella* growth. The primary sites of fermentation in the chicken are the ceca, and are also known to be the primary sites of *Salmonella* colonization (Nurimi & Rantala, 1973). The fermentation products that are most likely responsible for protection against *Salmonella* in the ceca are volatile fatty acids (Bilgili & Moran, 1990), particularly in their undissociated forms (Corrier et al., 1990a; Hinton Jr. et al., 1990). As lactose is fermented by anaerobic bacteria in the ceca to form various acids (Hume et al., 1992), the pH of the ceca drops resulting in an increase in the concentration of undissociated volatile fatty acids (Corrier et al., 1990a; Hinton Jr. et al., 1990). The undissociated volatile fatty acids are thought to be bactericidal by being able to penetrate the bacterial cell wall and disrupt the acid/base balance inside the cell by dissociating (Hinton Jr. et al., 1990).

Probiotics may be necessary to allow dairy-based prebiotics to be effective at controlling *Salmonella* colonization in young chicks. Probiotics are also known as direct-fed microbial products and are cultures of live bacteria such as *Lactobacillus, Pediococcus,*and *Bifidobacterium* (Vicente et al., 2007). Since broiler chicks are hatched in environments that are believed to be abnormally devoid of normal bacteria, probiotics may be needed to inoculate the gut of the young chick (Nurmi & Rantala, 1973). The introduced bacteria are then able to quickly colonize the digestive tract with the aid of the dairy-based prebiotic. Once the digestive tract is colonized, the protective mechanisms discussed above come into play.

Ability to Reduce Salmonella Concentration and Incidence - Dairy Products Without Probiotics

Various dairy products including whey, milk, lactose, and various lactose derivatives have been evaluated as potential prebiotics to reduce *Salmonella* colonization of broiler chickens. Results have been variable and inconsistent. Inconsistency in infection dose, dairy inclusion rate, treatment length, and other factors have likely contributed to the variability of the data. The variables of significance are the number of *Salmonella* in the ceca (concentration), and the number of birds that tested positive for *Salmonella* (incidence). For ease of discussion, the results will be broken down into three categories: young broilers (0-21 days), older broilers (>21 days), and feed withdrawal treatments.

In young broilers, the majority of studies infected the chicks at 3 days of age and quantified *Salmonella* infection at 10 days of age. Dairy products were most often included in the feed from 0-10 days of age. Due to the large number of studies, a summary of the data is displayed in Table 1. In brief, 64% of the studies showed a significant decrease in the cecal concentration of *Salmonella,* and 29% showed a significant decrease in the number of birds that tested positive for *Salmonella* (note that studies not reporting concentration or incidence were counted as non-significant for calculation purposes). Thus, it seems that dairy product inclusion in young broilers may be somewhat effective in reducing cecal concentrations of *Salmonella,* but not in a reliable manner, and is not generally effective at reducing the incidence of *Salmonella.*

Three studies were found that evaluated the effect of dairy supplementation on *Salmonella* concentration and incidence in older broilers. The first study was conducted by Waldroup et al., (1992). Lactose was fed at 0, 2.5, 5, and 7.5% to broilers from 0-49 days of age. The broilers were slaughtered on day 50 and were evaluated for the incidence and concentration of *Salmonella* prechill. There were no significant differences in incidence of *Salmonella* between treatments. There were also no significant differences in *Salmonella* concentration for the 0, 2.5, and 5% lactose treatments, however, there was a significant increase in *Salmonella* concentration for the 7.5% lactose treatment. The second study was done in association with the US Dairy

Export Council (2002). Broilers were fed control, 7.5% whey, 5% whey, 3.5% whey, and 3.5% lactose diets from 0 to 49 days. There was no introduced *Salmonella* infection. The only birds that tested positive for *Salmonella* were on the control diet, but the incidence was so low in the control birds that meaningful conclusions on the efficacy of the treatments for controlling *Salmonella* cannot be made. The third study was conducted by Chambers et al., (1997). Broilers were split into two groups: Group 1 was fed 5% lactose derivatives for 0-6 weeks of age, and Group 2 was fed 5% lactose derivatives for 0-5 weeks of age followed by no lactose derivative inclusion from 5-6 weeks of age. The results of the study were inconsistent overall, and the only definitive conclusion made by the authors was that any protective effect of lactose derivatives was lost when lactose derivatives were removed at 5 weeks of age. The results of these three studies are inconclusive, and there is not currently enough published literature in this area to form significant conclusions.

Table 1. Effect of Dairy Supplementation on *Salmonella* in Young Broilers

Author	**Dairy Product**	**Dairy Inclusion Rate**	**Effect on *Salmonella* Concentration**	**Effect on *Salmonella* Incidence**
(Oyofo et al., 1989)	Lactose, 2.5% in water	2.5% (wt:vol in drinking water)	Decreased	Decreased
(DeLoach et al., 1990)	Whey	5% in diet	Decreased	Decreased
(DeLoach et al., 1990)	Lactose	2.5% (wt:vol in drinking water)	Decreased	Decreased
(DeLoach et al., 1990)	Nonfat dried milk	5% in diet	Non-significant	Non-significant
(DeLoach et al., 1990)	Nonfat dried milk	5% (wt:vol in drinking water)	Decreased	Decreased
(Hinton Jr. et al., 1990)	Lactose	2.5% (wt:vol in drinking	Decreased	Non-significant

		water)		
(Hinton Jr. et al., 1991)	Lactose	2.5% (wt:vol in drinking water)	Decreased	Not reported
(Corrier et al., 1993)	Lactose	5% in diet	Decreased	Non-significant
(Ziprin & Deloach, 1993)	Lactose	5% in diet	Non-significant	Not reported
(Nisbet et al., 1993)	Lactose	5% in diet	Decreased	Non-significant
(Hollister et al., 1994a)	Lactose	5% in diet	Non-significant	Non-significant
(Hollister et al., 1994b)	Lactose	2% in diet	Non-significant	Non-significant
(Nisbet et al., 1994)	Lactose	2-4% in diet	Non-significant	Non-significant
(Chambers et al., 1997)	Lactose derivatives	5% in diet	Decreased	Non-significant

Since contamination of broiler carcasses with *Salmonella* during processing is believed to be a major source of Salmonellosis in humans, there has been some research on using dairy products to decrease the concentration and incidence of *Salmonella* in market-age broilers. Bilgili and Moran (1990) supplemented withdrawal diets for six-week-old broilers with 5% whey for one week post *Salmonella* infection. Results were inconclusive, as *Salmonella* recovery was low in all treatments including the control, and no differences between treatments were evident. An additional study consisting of seven similar experiments was conducted on *Salmonella*-infected seven-week-old broilers that were treated with 2.5% lactose in the drinking water for 5-11 days prior to slaughter (Barnhart et al., 1999). The treatment period included an 18 to 24 hour fast directly prior to slaughter. Crops and ceca were evaluated for the presence of *Salmonella;* no consistent significant differences between the treatment and control were found. Thus, it seems that there is no evidence to show that lactose administration

immediately prior to slaughter has any protective effects against *Salmonella*.

Dairy product inclusion alone does not seem to be able to give consistent and reliable protection against *Salmonella;* this is a conclusion reached by more than one author (Waldroup et al., 1992; Ziprin et al., 1990). Research with other species and strains of poultry tend to support this conclusion, as results with turkeys and quail are variable and inconsistent (Corrier et al., 1991; Corrier et al., 1992; Opitz et al., 1993; Tellez et al., 1993).

Ability to reduce *Salmonella* - Dairy Products in Combination with Probiotics

A wealth of literature is available on the use of probiotics in broiler chickens, however, this review will only include studies that included dairy products along with probiotics. Including probiotics along with dairy product administration tends to give much more consistent and meaningful results than providing dairy products alone (Totton et al., 2012). It is still worth noting that many of the same factors that contributed to high variation in the research reviewed earlier apply here as well. Variables such as *Salmonella* infection dose and unknown strains of probiotics used contribute to the variation in results. As before, the variables of significance are the number of *Salmonella* in the ceca (concentration), and the number of birds that tested positive for *Salmonella* (incidence). The results will be broken down into three categories, also as before: young broilers (0-21 days), older broilers (>21 days), and feed withdrawal treatments.

In young broilers, the majority of studies infected the chicks at 3 days of age and quantified *Salmonella* infection at 10 days of age. Dairy products were generally included in the diet from 0 to 10 days of age. Probiotic administration tended to be via crop gavage on day of hatch, though there was some variation in technique. Due to the large number of studies, a summary of the data is displayed in Table 2. In brief, 100% of the studies showed a significant decrease in the cecal concentration of *Salmonella,* though some of the studies only showed a significant decrease at low to moderate infection doses. Also, 69% of studies showed significant reductions in the number of birds that tested positive for *Salmonella* (note that studies not reporting incidence were

counted as non-significant for calculation purposes). Thus, it appears that lactose (the only dairy product tested) plus probiotic inclusion reduces concentration of *Salmonella* and generally reduces incidence of *Salmonella.* Results from studies with turkeys tend to support this conclusion (Corrier et al., 1991; Vicente et al., 2007)

Table 2. Effect of Dairy and Probiotic Supplementation on *Salmonella* in Young Broilers

Author	**Dairy Product**	**Dairy Inclusion Rate**	**Effect on *Salmonella* Concentration**	**Effect on *Salmonella* Incidence**
(Corrier et al., 1990a)	Lactose	2.5% (wt:vol in drinking water)	Decreased	Decreased*
(Corrier et al., 1990a)	Lactose	5% in diet	Decreased*	Decreased*
(Corrier et al., 1990a)	Lactose	10% in diet	Decreased	Decreased*
(Corrier et al., 1990b)	Lactose	7% in diet	Decreased	Not reported
(Hinton Jr. et al., 1990)	Lactose	2.5% (wt:vol in drinking water)	Decreased†	Non-significant
(Ziprin et al., 1990)	Lactose	7% in diet	Decreased†	Decreased*
(Hinton et al., 1991)	Lactose	2.5% (wt:vol in drinking water)	Decreased	Not reported
(Corrier et al., 1993)	Lactose	5% in diet	Decreased	Decreased
(Ziprin & DeLoach, 1993)	Lactose	5% in diet	Decreased	Not reported
(Nisbet et al., 1993)	Lactose	5% in diet	Decreased	Decreased
(Hollister	Lactose	5% in diet	Decreased	Decreased

et al., 1994a)				
(Hollister et al., 1994b)	Lactose	2% in diet	Decreased	Decreased
(Nisbet et al., 1994)	Lactose	2, 3, and 4% in diet	Decreased	Decreased

*Results only significant for lower infection dose. Inconsistent or non-significant for higher infection dose(s).
†Results significant regardless of infection dose.

There was only one study found that focused on older broilers (Corrier et al., 1990b). Broiler chicks were inoculated with a probiotic on day of hatch and grown to 40 days of age. There were two treatment groups: Group 1 received 7% lactose from day 0 to day 40, and Group 2 received 7% lactose from day 0 to day 10, and then no lactose treatment from day 11 to day 40. All birds were infected with *Salmonella* on day 3 and day 33. Chicks receiving lactose throughout the 40-day period had significantly decreased *Salmonella* concentrations and incidence compared to the control. Chicks only receiving lactose through day 10 showed significant differences in concentration and incidence at day 10, but there were no significant differences in concentration or incidence as compared to the control at day 40. Thus, lactose administration may reduce the concentration and incidence of *Salmonella* in older broilers, but only if administered throughout the entire growing period.

There was only one study found that focused on feed withdrawal treatments (Bilgili & Moran, 1990). Six-week-old female broilers were fed a withdrawal feed containing 5% whey and a probiotic for 24 hours pre and post infection with *Salmonella*. High levels of *Salmonella* were found in the ceca of all treatments, and there were no significant differences in concentration as compared to the control. Thus, it seems that administration of dairy products plus a probiotic in withdrawal feed shortly before the time of slaughter is not effective at reducing the concentration or incidence of *Salmonella.*

Timing and Duration of Administration of Dairy Products

The majority of work that has been done has looked at the young chick, which makes intuitive sense based on the concept of competitive exclusion (Nurmi & Rantala, 1973). The data reviewed above seem to indicate that for young broilers, *Salmonella* concentration and incidence in the ceca can be reduced by the inclusion of dairy products, especially with the addition of probiotic cultures. However, the few studies that looked at older broilers seem to show that if the dairy product administration is stopped significantly before slaughter, protection against *Salmonella* is reduced or removed (Chambers et al., 1997; Corrier et al., 1990b). Thus it seems that dairy products would need to be included until directly before slaughter, which is supported by research with broilers up to 40 days old (Corrier et al., 1990b) but is not supported by the work of Waldroup et al., (1992), who failed to see a significant reduction in concentration or incidence of *Salmonella* of carcasses of broilers fed 2.5, 5, or 7.5% lactose. It has been postulated that the ceca of broilers fed dairy products may be more prone to rupture during processing due to distention with gas (Bilgili & Moran, 1990). Thus, the findings of Waldroup et al. may be confounded by increased ceca rupture rates, especially considering that the broilers were taken off feed for only eight hours before slaughter. It may be that a more normal 12 to 24 hour fasting time would allow the ceca to empty and show more favorable results, but there were no studies found that tested this theory. Thus, it seems that dairy inclusion is likely most helpful for young chicks, but that positive effects will likely only be maintained by inclusion until directly before slaughter.

Method of Delivery and Concentration of Dairy Products

Water was the initial medium that was used to deliver dairy products to broiler chickens, and this method seemed to have some advantages because day-old chicks will drink more water than they will eat feed. However, it has been shown that dietary inclusion of dairy is just as effective as inclusion in water if the percentage inclusion in feed is increased over that of the water to equalize intake (Corrier et al., 1990a). In addition, the water containing the dairy was mixed daily; this seems impractical for wide-spread use.

Feed seems to be the most practical carrier for dairy products. There is no consensus as to the best level of inclusion of dairy products, however, inclusion should be based on the amount of lactose in the product (Bilgili & Moran, 1990), as lactose is believed to be the principle prebiotic agent in dairy products (DeLoach et al., 1990). Lactose fed at 6% showed numerical reductions in growth in broiler chicks (Douglas et al., 2003), and lactose fed at 7.5% resulted in significantly reduced body weights in male broilers (Waldroup et al., 1992). Thus, 6% dietary lactose seems a reasonable maximum inclusion rate. Based on the reviewed literature above, an inclusion rate of 2-5% seems to provide adequate prebiotic effect, particularly in the presence of probiotics. It can be postulated that since broilers are increasingly resistant to *Salmonella* as they age (Nurmi & Rantala, 1973), lactose inclusion rate should be highest in the starter phase diet, intermediate in the grower phase diet, and lowest in the finisher phase diet. This type of step-down program might also help decrease ceca distention and consequent rupture during processing, however, data is not available to support either of these hypotheses.

Considerations Before Large Scale Application

Dairy products seem to hold substantial promise as prebiotic agents to reduce *Salmonella* in broilers, but there are a number of factors that weaken the significance of the evidence presented thus far. These factors are well reviewed by Totton et al., (2012); they include lack of adequate blinding of study researchers, lack of adequate randomization, and poorly applicable study settings (*i.e.* studies not performed in commercial conditions). In addition, there is a lack of evidence showing that dairy product inclusion and its consequent effects on *Salmonella* in the intestine translate into safer poultry products for human consumption. Such a theory was postulated by Oyofo et al., (1989), but there has been little research to test this, and what research has been done has not been positive (Waldroup et al., 1992). For example, if dairy product inclusion does lead to an increase in ceca rupture as has been postulated (Bilgili & Moran, 1990), then any positive effect of reduced concentrations of cecal *Salmonella* may be nullified by increased incidence of *Salmonella*-contaminated carcasses caused by ceca rupture.

An additional concern with the studies reviewed is that the majority of the diets did not contain any type of anticoccidial drugs or treatments. Coccidiosis is known to be an extremely costly disease to the broiler industry, and commercial broiler diets commonly contain anticoccidial drugs to combat the effects of this disease (Lee et al., 2011). Thus, in order for the use of dairy products to be applicable to the commercial broiler industry, it must first be demonstrated that the positive prebiotic effects of dairy product inclusion are compatible with anticoccidial use.

Thus, although dairy products show significantly more promise as prebiotics to control *Salmonella* than many other feed additives (Totton et al., 2012), there are still significant gaps in the data that should be taken into account before wide-spread application of dairy products as prebiotics for broiler chickens.

2. SUMMARY OF LITERATURE REVIEW

As the search for alternative methods for controlling *Salmonella* continues, the use of dairy products as prebiotics will likely grow in importance. Though there are considerable questions left unanswered by the currently available data, there are some conclusions that can be drawn: (1) dietary lactose inclusion of 2 to 5% in young broilers may decrease cecal concentrations of *Salmonella,* though not reliably, (2) dietary lactose inclusion of 2 to 5% in young broilers in conjunction with probiotic use affords considerable protection from *Salmonella* by reducing cecal concentrations and incidence of *Salmonella,* and (3) there may be protective effects of dairy product and probiotic inclusion in older broilers if fed dairy from the time of hatch up to the time of slaughter.

3. CONCLUSIONS AND RECOMMENDATIONS BASED ON THE LITERATURE REVIEW FINDINGS

The limited scientific data appears to indicate that feeding a lactose source can reduce the incidence of *Salmonella* some of the time.

The CDC (Centers for Disease Control) reports that 48 million Americans get sick from foodborne illnesses each year. Of course not all

are from *Salmonella* and poultry is only one source of potentially dangerous contaminated food. Food safety is a major issue in this country.

According to the CDC the top five pathogens contributing to foodborne illness in the US are:

Salmonella	35%
Norovirus	26%
Campylobacter spp.	15%
Toxoplasma gondii	8%
E. coli STEC	4%
Subtotal	88%

Since it has been proven scientifically that the feeding of lactose containing ingredients to chickens may reduce *Salmonella,* it would appear that more work should be done in order to help protect the health of the US public.

4. TO LEARN IF ANY US POULTRY ASSOCIATION IS INTERESTED IN SUPPORTING RESEARCH ON THIS TOPIC.

The US Poultry and Egg Association is the poultry association that actively supports research .

John Starkey is the President of the US Poultry and Egg Association.

John indicated that he would be very interested in discussing research that may reduce *Salmonella* with the ADPI. He said that they may support part or all of such a trial.

The US Poultry and Egg Association has a process for submitting research proposals.

They have a university researcher help them develop a list of priorities for research.

They then invite researchers to submit one-page pre-proposals. These are due in by May 1 or November 1 each year.

The pre-proposals will go before their panel of 15 industry experts who will decide which pre-proposals to be declined and which to request full proposals.

The full proposals will go before their Research Advisory Committee and selected proposals will be sent to the board of directors.

Dr. John Glisson is their science expert.

I recommend that the ADPI open dialogue with the US Poultry and Egg Association.

5. TO LEARN IF CP INTERTRADE IN BANGKOK HAS CONDUCTED RESEARCH TRIALS ON THIS SUBJECT AND TO LEARN IF THEY ARE WILLING TO SHARE THEIR RESULTS.

Supaporn Sooncharernying, a manager at the CP Group, was contacted and reported that all of their research data is confidential. The research data or results are not available.

6. RECOMMEND A UNIVERSITY POULTRY RESEARCHER WHO MAY BE THE BEST CANDIDATE TO CONDUCT RESEARCH TRIALS TO DETERMINE IF DRY DAIRY PERMEATE IN THE DIET CAN REDUCE *Salmonella* IN CHICKEN MEAT OR EGGS.

Poultry nutritionists recommend that the best person would be Dr. Ryan Dilger and his colleagues at the University of Illinois. His laboratory is set up to do this type of research. There is a microbiologist on his team and they have experience with *Salmonella.*

If the ADPI decides to participate in funding research on the efficacy of feeding dried dairy permeate to chickens to reduce *Salmonella,* it is recommended that a research proposal should be requested from Dr. Dilger.

7. ESTIMATE THE POTENTIAL MARKET SIZE FOR DRIED DAIRY PERMEATE USE IN POULTRY FEED.

According to the National Chicken Council, approximately 9 billion broilers are produced per year in the US.

If the broilers are fed for six weeks prior to slaughter they will consume approximately 8.15 pounds of mixed feed per bird.

If permeate is included at the rate of 3.5 % of the diet for this six weeks, then each broiler would consume 0.2842 pounds of dried dairy permeate.

When permeate is added to the diet it will most likely replace corn.

At this time the value of corn is approximately $3.75/bushel. At 56 pounds per bushel corn is worth $0.67/pound. About 1.9 cents worth of corn would be replaced by permeate.

If dried dairy permeate is $0.30/lb then the cost of permeate per bird would be about 8.5 cents per bird from hatch until market.

If 10% of the broilers are fed this level of dried dairy permeate, they would consume 255,780,000 pounds (127,890 tons) of dried dairy permeate.

Obviously these are very large numbers and depending on what assumptions are made it becomes immediately clear that the potential for dried dairy permeate usage is very great.

8. OFFER OPINION ON THE EFFECT THAT CHANGES IN THE USAGE OF ANTIBIOTICS IN POULTRY FEEDS WOULD HAVE ON THE POTENTIAL USE OF DRIED DAIRY PERMEATE IN POULTRY FEEDS.

It has been estimated that approximately 65-80% of US broilers are fed subtherapeutic levels of antibiotics in their feed. The majority of this antibiotic use is to increase growth rate and improve feed efficiency of the birds.

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The antibiotics are not being fed to reduce the incidence of *Salmonella* in the birds.

Given that the current use of antibiotics in poultry feeds is for growth promotion, it is doubtful if the outlawing of antibiotic feeding would have any effect on potential dried permeate use in poultry feeds.

The two antibiotics that are used the most in broiler feed are Bacitracin MD and Virginiamycin.

The approximate cost of the antibiotic is about $2.50/ton of feed. This equates to an antibiotic cost of from 1.8 to 2.5 cents per bird from hatching all the way to market.

Poultry growers have no direct financial incentive to reduce the incidence of *Salmonella* and therefore may be hesitant to increase feed cost by the addition of dried permeate.

Of course the growers have very strong incentive of to reduce the number of poultry caused cases of *Salmonella* food poisoning. The cost of feeding subtherapeutic levels of antibiotics is much lower than the cost of adding dried permeate to the feed.

While costs vary depending on a number of factors, it is estimated that the cost of feeding a probiotic is similar to the cost of feeding subtherapeutic levels of antibiotics.

Perhaps the dairy industry should look at dried DLP as a feed ingredient for poultry. It is a very good source of lactose as well as a great source of nutritionally important minerals. DLP is difficult to dry but the cost of the dry product could be much lower than dried dairy permeate and therefore more attractive to the poultry industry.

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