Comparison of using label instructions vs. extended intramammary therapy to improve mastitis cure rates and lower somatic cell counts in lactating dairy cows.

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Abstract

Objectives: Determine whether extended intramammary antibiotic therapy results in greater cure rates for IMI caused by common mastitis-causing bacteria compared with conventional label instructions, resulting in lower somatic cell counts (SCC) and increased production.

Materials and Methods: 158 quarters of 87 lactating Holsteins and Jerseys with confirmed IMI were treated intramammarily per label instructions with one of 5 commercial products or via extended therapy by administering a total of 6 intramammary infusions at 6 consecutive milkings. Quarter milk samples were collected aseptically prior to treatment, daily for 1 week after treatment was initiated, and weekly through Day 36. A quarter was deemed cured if it tested negative for microbial infection on Day 36 after treatment was initiated.

Results and Discussion: Generally, extended therapy resulted in higher cure rates, and rates were highest for the coagulase-negative staphylococci (CNS), followed by environmental streptococci, and lowest for *Staphylococcus aureus*. Label therapy resulted in a 42.42% cure rate for *Staph. aureus*, 50% cure rate for environmental streptococci, and 72.22% cure rate for CNS. Extended therapy resulted in a 43.59% cure rate for *Staph. aureus*, a 67.86% cure rate for the environmental streptococci, and a 94.44% cure rate for CNS. Generally, cure rates by antibiotic type were similar. Infected quarters destined to cure exhibited an average SCC of 1,320,000/ml just prior to antibiotic treatment, whereas the average SCC of quarters destined to fail was 3,249,000/ml. The only antibiotic to significantly lower SCC regardless of type of IMI was extended therapy with ToDAY®. Similarly, ToDAY extended therapy significantly reduced SCC in quarters with *Staph. aureus* IMI, while SPECTRAMAST® LC extended therapy significantly reduced SCC in quarters with environmental streptococcal IMI. Total costs due to discarded milk and antibiotics were highest for treating *Staph. aureus*, followed by environmental streptococci, and lowest for CNS; total costs were highest when treating with ToDAY extended therapy. There were no differences in milk production before and after therapy using label or extended therapy.

Implications and Applications: Overall antibiotic cure rate was low (57.6%), and there was a slight advantage of using extended therapy. However, expedient treatment when SCC were lower (e.g., < ~1,500,000/ml vs. >~3,000,000/ml) resulted in a higher probability of curing an infected quarter whether label or extended therapy was used.

Introduction

For the milk producer, it is imperative that milk somatic cell counts (SCC) be kept low (goal: less than 200,000/ml) in order to yield a premium from their co-op. To do so, producers must follow recommended mastitis control programs, which include antimicrobial therapy of clinical cases of mastitis. But, what about the subclinical cases that go undetected? This form of mastitis increases the herd bulk tank SCC and decreases milk quality as well as milk production, and may be spread from one animal to the next, such as in cases of *Staphylococcus aureus*. Such cows with subclinical mastitis have elevated SCC, which leads to elevated bulk tank SCC, lowered milk quality, and decreased quality premiums (Ruegg, 2004). Therefore, mastitis in all forms (subclinical and clinical) should be monitored and potentially treated with antibiotics, after factoring in the chances for a successful cure, spread to herd mates, individual cow and bulk tank SCC, cow age and history, level of production, severity of infection, costs due to therapy and discarded milk, and stage of lactation.

Gram-positive infections (mainly staphylococci and streptococci) are more likely to respond to antibiotic therapy than gram-negative (mainly coliform) infections. Coliform mastitis cases have high spontaneous cure rates, which questions the need for antibiotics (Erskine et al., 2003, Hogan and Smith, 2003). However, treatment of staphylococcal and streptococcal infections is viewed as beneficial for enhancing cure rates, preventing chronic mastitis, and maintaining milk production for the remainder of the lactation (Wilson et al.; Oliver et al., 2004). Failure to treat infected quarters may allow the infecting bacteria to spread to other quarters and cows, establish chronic infections that are less likely to respond to antimicrobial therapy, and result in elevated SCC and lowered milk production.

SCC are a useful means to determine udder health. These white blood cells, if elevated greater than 200,000/ml in individual quarters, are, in all likelihood, defending the mammary gland against pathogenic bacteria or injury. The Dairy Herd Improvement Association (DHIA) monitors SCC on composite samples monthly, and the California Mastitis Test (CMT) is a good tool to check the status of individual cow quarters in animals with elevated SCC. Culturing will then identify those organisms responsible for the mastitis and whether antimicrobial treatment with mastitis tubes should be advised. In fact, this disease – mastitis – is the main reason that dairy cows are treated with antibiotics (Pol and Ruegg, 2007; Saini et al., 2012).

Unfortunately, cure rates for subclinical and clinical mastitis resulting from lactating cow intramammary antibiotics following label instructions can be quite low (<50%), even with expedient treatment. It is believed that by following label instructions, the amount of antimicrobial used and the duration of therapy are insufficient to kill all infecting bacteria and effect a true cure. Thus, is off-label extended use of lactating cow therapy under veterinary supervision a viable alternative as suggested by Erskine et al. (2003)? In addition, is it worth the extra labor, treatment cost, and additional loss of milk?

The purpose of this trial was to determine whether extended antibiotic therapy would result in a greater cure rate for the mastitis-causing bacteria: *Staph. aureus*, the environmental streptococci, and the coagulase-negative staphylococci (CNS) compared with conventional label instructions. For example, does label therapy over a shorter treatment period provide enough antibiotics to successfully kill the bacteria in the infected quarter resulting in a successful cure, or is lengthening the therapeutic period (extended therapy) required to ultimately clear the quarter, thereby reducing SCC, increasing production, and enhancing milk quality?

Materials and Methods

Animals:

To compare the two treatment regimens (label vs. extended therapy), 158 infected quarters, (41 clinical and 117 subclinical mastitis cases) from 87 lactating Holsteins and Jerseys were analyzed. All animals were housed at the University of Georgia (UGA) Teaching Dairy and fed a total mixed ration (TMR) according to stage of lactation. All husbandry procedures were carried out according to the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 2010).

Cows were selected to be on the trial if the microbial infection status of a quarter was confirmed. This was determined if, after procuring quarter samples on day 3 and day 10 postpartum, an infection was verified by the isolation of the same bacterial species from both 3- and 10-day samples. In addition, clinical cases of mastitis diagnosed throughout lactation based on presence of clots, flakes, or blood in milk or secretions of watery consistency in addition to a microbial infection were treated. Lastly, cows exhibiting high SCC >500,000/ml for 3 consecutive mo based on DHIA testing were monitored for mastitis-causing bacteria, and if bacteria were isolated, the infected quarters were placed on the trial. In all cases, a milk sample was collected prior to antibiotic infusion and processed to confirm presence of infection and to determine SCC.

Intramammary Treatments:

After confirmation of microbial infection, quarters were treated with one of 5 lactating cow antibiotic products by either 1) following label instructions or 2) via extended therapy by administering a total of 6 intramammary infusions at 6 consecutive milkings. For the purposes of this study, subclinical and clinical infections were not distinguished, and both considered to be cases of IMI to receive antimicrobial therapy. The 5 lactating cow products were Hetacin-K, subsequently sold as PolyMast® (hetacillin potassium, Boehringer Ingelheim, Ridgefield, CT; ToDAY® (cephapirin sodium, Boehringer Ingelheim); Amox-Mast® (amoxicillin, Merck, Kenilworth, NJ); SPECTRAMAST® LC (cetiofur, Zoetis, Parsippany, NJ); and PIRSUE® (pirlimycin hydrochloride, Zoetis). Treatments were randomly allotted as the cows with infected quarters entered the trial. Prior to dispensing treatment, the teat end orifice was sanitized with a cotton swab immersed in 70% isopropyl alcohol. The treatment was then administered by inserting only the distal end of the syringe cannula into the teat orifice, infusing the syringe contents, and immersing each teat into a post milking teat germicide. There were no untreated quarters that were diagnosed as infected.

Milk Sample Collection and Processing for Microbiological and SCC Analyses and to Determine Cure Rate:

Quarter milk samples were collected aseptically prior to treatment and daily for one week after treatment was initiated and then weekly thereafter through Day 36 after treatment was initiated. A quarter was determined to be cured if it tested negative for microbial infection on the last 3 consecutive milk samples including Day 36 after treatment was initiated.

Prior to machine milking, teats were predipped, wiped clean with paper towels, and sanitized using a 70% isopropyl alcohol immersed cotton swab, which was used to scrub the teat ends until visibly clean. Upon collection into 12-cc sterile vials, samples were stored in the refrigerator, awaiting transport to the UGA Mastitis Lab to be processed for SCC and bacteriological culture.

Milk samples collected were dispersed onto trypicase soy agar plate containing 5% sheep blood plates using sterile, flamed 10-µl loops. Plates were incubated for 48 h at 37 C and visually inspected for microbial growth. Presumptive identification of colony forming units was performed following procedures outlined in the National Mastitis Council (2004). After presumptive identification, bacteria were further identified as follows: Staphylococci were differentiated from streptococci by means of the catalase test. Staphylococci were differentiated as coagulase positive or negative by conducting the coagulase test, and mannitol positive or negative by plating on mannitol-salt agar. Final identification of the staphylococcal species was performed using the API Staph test (bioMerieux, Inc., Marcy l'Etoile, France). Identification of *Streptococcus* spp. was verified by means of the Slidex test and the API Strep Test (bioMerieux, Inc.).

The Direct Cell Counter (DeLaval, Tumba, Sweden) was utilized to determine SCC of the quarter milk samples collected on days 3 and 10 postpartum, at time of antibiotic infusion (day 1) and on days 7, 15, and 36 after treatment. The difference in SCC just prior to antibiotic infusion (Pre-SCC) and on day 36 after therapy (Post-SCC) was designated as Diff SCC. The association of SCC prior to treatment in quarters destined to cure or fail after therapy was also determined.

Quarter samples were categorized as either clinical (clots, flakes, watery or blood in the milk) or subclinical (normal in appearance). Antibiotic residues were monitored by use of the Delvotest® (Royal Gist-brocades NV, Delft, The Netherlands), and days to return to bulk tank and milk production were recorded during this time period as described below.

Milk Production; Discarded Milk Losses in Number of Milkings, Volume of Milk, and Dollar Costs; and Cost of Antibiotic Treatment:

Cows were milked twice daily in a double-6 herringbone parlor using a DeLaval system equipped with automatic milking unit takeoffs, milk volume meters, and electronic cow identification. Daily milk production was recorded on the day prior to antibiotic therapy (Pre-milk), during therapy, and on the day after antibiotic therapy (Post-milk). The difference in production before (Pre-milk) and after therapy (Post-milk) was determined and was designated as Diff milk.

Discarded milk volume as well as the number of milkings that milk was discarded during and after therapy were monitored. Dollar losses were then determined based on volume of milk discarded at $17/cwt (Milk:$17), which was the lowest average value of milk during the trial, and at $21/cwt (Milk:$21), which was the highest average value. Cost of antibiotic therapy (Trt$cost) was figured at an average of $6/tube, and number of infusions ranged from 2 to 3 for label instructions and was 6 infusions for extended therapy. Total cost of discarded milk @ $17/cwt plus antibiotic therapy was designated as Tot.$cost @17 and total cost of discarded milk @ $21/cwt plus antibiotic therapy was designated as Tot.$cost @21.

Statistical Analyses:

The individual mammary quarter was the experimental unit and considered an independent variable. After antibiotic therapy, quarter infection data collected through Day 36 after treatment was initiated were compared with quarter infection data collected prior treatment as described above. Results were used to determine the overall percentage cure of existing IMI at time of treatment as well as to compare cure rates between label and extended therapy, and for each antibiotic tested using label and extended therapy. Cure rate (%) was determined by dividing the number of quarters cured by the number of quarters treated for each set of variables tested.

The SCC means were calculated for quarter secretions collected prior to treatment and compared with SCC collected post treatment for overall SCC differences (Diff SCC), for label vs. extended therapy, and for each antibiotic tested using label and extended therapy.

Means for cure rate, SCC, number of milkings that milk was discarded, discarded milk losses in volume (lb) and dollar costs, and cost of antibiotic treatment were separated using SAS 9.3 Proc GLM for Windows (SAS Institute, Inc., Cary, NC).

Results and Discussion

Cure Rates across Antibiotics:

Overall cure rate across bacterial species and treatment regimens (label or extended) was 57.6% (Table 1), which is lower than that found in a retrospective study by Wilson et al. (1999), who observed that cure rate of antibiotic treated quarters was 75%.

Across all microbes, cows receiving label therapy were infused an average of 2.43 times, and cows receiving extended therapy were infused 6 times (Table 2). These numbers of infusions were similar regardless of type of IMI treated (Tables 3, 4, and 5). Treatment per label was assigned to 73 of 158 quarters, providing an overall cure rate of 52.05%, whereas extended therapy resulted in an overall cure rate of 62.35% ($P < 0.194$, Table 2). This latter figure is similar to the 68% cure rate observed by Wilson et al. (1999) in a retrospective study of mastitis pathogens that included antibiotic and untreated control quarters (spontaneous cure rate was 65%).

For the different bacterial groups, label therapy resulted in a 42.42% cure rate for *Staph. aureus* (Table 3), a 50% cure rate for the environmental streptococci (Table 4) and a 72.22% cure rate for the CNS (Table 5). Extended therapy resulted in a 43.59% cure rate for *Staph. aureus* (Table 3), a 67.86% cure rate for the environmental streptococci (Table 4), and a 94.44% cure rate for the CNS (Table 5). Thus, with the exception of *Staph. aureus*, extended therapy resulted in higher but not significantly different cure rates. Similarly, use of extended therapy for up to 6 days was shown to increase cures against environmental streptococci by over 90% (Hillerton and Kleim, 2002). Although a recent review concluded that extended therapy for 5 to 8 days was the best therapeutic option for treating *Staph. aureus* (Roy and Keefe, 2012 review), in our study, extended therapy was no better than label therapy; 42.42% vs. 43.59%, respectively.

Among bacterial groups, cure rates for label and extended therapies were lowest for *Staph. aureus* (42.42% and 43.59%, Table 3), higher for environmental streptococci (50.0% and 67.86%, Table 4), and highest for CNS (72.22% and 94.44%, Table 5). Similarly, Pyörälä (2009) observed that the best therapeutic response to antibiotic therapy was found for streptococci and CNS. Sadly, the overall cure rate of 43.1% for *Staph. aureus* in the current study for label and extended therapies combined (Table 6) is the same as it was 50 years ago as summarized by Philpot (1969). Sol et al. (2000) and Barkema et al. (2006) also found low cure rates for *Staph. aureus* ranging from 30 to 50%.

Cure Rates by Antibiotic across All Bacterial Groups:

For Amoxi-Mast, Hetacin K, and Pirsue, we observed no differences between treatment regimens. However, extended treatment with Spectamast LC resulted in greater cure rates than label therapy (23.1% vs. 66.7%, $P = 0.03$, Table 1), which is similar to that observed by Oliver et al. (2004), who observed overall efficacies of 38.8% for 2-day and 65.8% for 8-day treatments. Although cure rate for extended therapy with ToDAY was greater than label therapy (61.5% vs. 90%, Table 1), the difference was not significant.

Cure Rates for Label and Extended Therapies by Antibiotic for Each Bacterial Group:

Staph. aureus (Table 6): For Amoximast, there was no difference between label and extended therapies (33.3% vs. 16.7%), although label therapy was twice as effective. Label use of Hetacin-K was better than extended therapy (57.1 vs. 0%, $P < 0.001$). Likewise, label use of Pirsue was superior to extended therapy (50% vs. 16.7%) but the difference was not significant. The higher cure rate using label therapy is opposite of what was expected, and the opposite of what was reported previously. For example, Deluyker et al. (2001) observed a 34% cure rate for Pirsue 2X, and a 60% for 8X therapy across all bacterial species. Similarly, Hallberg et al. (2000) reported *Staph. aureus* cure rates of 54% and 71% using Pirsue 2X and 8X, respectively, when quarters were treated within 1 mo after experimental infection. The reason for label therapy resulting in greater cure rates for Amoxi-Mast, Hetacin-K, and Pirsue was most likely due to the severity of infection, which may have been greater in quarters treated with extended therapy, hence the lower cure rates.

For Spectramast LC, extended therapy (50%) was more effective than label therapy (14.3%), but the difference was not significant. The extended therapy cure rate of 50% is higher than the 8-day therapy observed by Oliver et al. (2004), which was 36%. Similarly, for ToDAY, extended therapy (91.67%) was more effective than label therapy (60%), but the difference was not significant.

Environmental streptococci (Table 7): For all antibiotics, there was no difference between label and extended therapies. Highest cure rates were observed for Pirsue (80 and 75%) and lowest for Amoximast (50 and 40%). Our cure rate against the environmental streps was 0% using Spectramast label therapy, but was 71.4% with extended therapy; the later cure rate is similar to findings of Oliver et al. (2004), who observed cure rates of 67 to 80%.

Coagulase-negative staphylococci (Table 8): For all antibiotics, there was no difference between label and extended therapies. However, for all antibiotics except for Pirsue and Spectramast, cure rates were numerically higher for extended therapy. Although numbers were small, Spectramast was 100% effective in curing CNS by label and extended therapy. Likewise, Oliver et al., (2004) observed a high cure rate (86%) for CNS after 8 days of treatment.

SCC Before and After Treatment Overall and for Label and Extended Therapies Across Bacterial Species for Each Antibiotic Used (Table 1):

Overall, SCC decreased from 1,925,000 prior to therapy to 1,336,000; a decrease of 583,000/ml (Table 1).

Amoximast: SCC prior to beginning antibiotic therapy following label instructions was 2,831,000/ml, and decreased by 1,056,000 to 1,775,000/ml after treatment. SCC prior to beginning antibiotic therapy following extended therapy was 1,560,000/ml, but increased by 798,000 to 2,358,000/ml after treatment, which was a greater difference than label therapy ($P < 0.005$, See Diff SCC, Table 1).

Hetacin-K: SCC prior to beginning antibiotic therapy following label instructions was 2,233,000/ml /ml, and decreased by 1,110,000 to 1,123,000/ml after treatment. SCC prior to beginning antibiotic therapy following extended therapy was 2,346,000/ml, and decreased by 852,000 to 1,494,000/ml after treatment. The SCC decrease between label and extended therapy was not significant.

Pirsue: SCC prior to beginning antibiotic therapy following label instructions was 951,000/ml /ml, and decreased by 283,000 to 668,000/ml after treatment. SCC prior to beginning antibiotic therapy following extended therapy was 1,384,000/ml, and decreased by 194,000 to 1,190,000/ml after treatment. The SCC decrease between label and extended therapy was not significantly different.

Spectramast LC: SCC prior to beginning antibiotic therapy following label instructions was 2,066,000/ml, and increased slightly by 284,000 to 2,350,000/ml after treatment. SCC prior to beginning antibiotic therapy following extended therapy was 2,035,000/ml, and decreased by 808,000 to 1,227,000/ml after treatment. The SCC decrease between label and extended therapy was not significantly different.

ToDAY: SCC prior to beginning antibiotic therapy following label instructions was 1,793,000/ml, and decreased slightly by 231,000 to 1,562,000/ml after treatment. SCC prior to beginning antibiotic therapy following extended therapy was 2,101,000/ml, and decreased by 1,761,000 to 340,000/ml after treatment, which was a greater reduction compared with label therapy ($P < 0.005$). Thus, the only antibiotic treatment to significanly lower SCC across microbes was extended therapy with ToDAY.

SCC Before and After Treatment for Label and Extended Therapies Across Antibiotics Used and Bacterial Species (Table 2):

SCC prior to beginning antibiotic therapy following label instructions was 1,941,000/ml, and decreased by 502,000 to 1,439,000/ml after treatment. SCC prior to beginning antibiotic therapy following extended therapy was 1,900,000/ml, and decreased by 654,000 to 1,247,000/ml after treatment; the decreases between label and extended therapies were not different ($P = 0.611$).

SCC Before and After Treatment for Label and Extended Therapies Across Antibiotics Used for Each Bacterial Species (Tables 3, 4, and 5):

Staph. aureus (Table 3): SCC prior to beginning antibiotic therapy following label instructions was 1,935,000/ml, and decreased by 724,000 to 1,210,000/ml after treatment. SCC prior to beginning antibiotic therapy following extended therapy was 2,228,000/ml, and decreased by 390,000 to 1,837,000/ml after treatment; the decreases between label and extended therapies (See Diff SCC, Table 3) were not different (P = 0.494). The pre-SCC and post-SCC between label and extended therapies were not different.

Environmental streptococci (Table 4): SCC prior to beginning antibiotic therapy following label instructions was 2,120,000/ml, and remained the same (2,198,000/ml) after treatment. SCC prior to beginning antibiotic therapy following extended therapy was 2,174,000/ml, and decreased by 1,109,000 to 1,045,000/ml after treatment. This difference (See Diff SCC, Table 4) was a greater reduction (P = 0.029) than SCC in quarters treated with label therapy, which increased by 77,000. The pre-SCC between label and extended therapies were not different, but the post-SCC were significantly lower for extended therapy (P = 0.033).

Coagulase-negative staphylococci (Table 5): SCC prior to beginning antibiotic therapy following label instructions was 1,733,000/ml, and decreased by 802,000 to 931,000/ml after treatment. SCC prior to beginning antibiotic therapy following extended therapy was 830,000/ml, and decreased by 544,000 to 286,000/ml. This difference (See Diff SCC, Table 5) between label and extended therapy was not significant (P = 0.599). The pre-SCC and post-SCC between lable and extended therapies were not different.

SCC Before and After Treatment of Staph. aureus Using Label and Extended Therapies for Each Antibacterial Therapeutic Used (Table 6):

Amoximast: Average SCC prior to beginning therapy following label instructions was 2,878,000/ml, and decreased by 749,000 to 2,129,000/ml after therapy, whereas SCC prior to extended therapy was 1,826,000/ml, and actually increased by 1,930,000 to 3,756,000/ml after therapy, which was a greater difference than that found with label therapy (P = 0.004).

Hetacin-K: Average SCC prior to beginning therapy following label instructions was 2,346,000/ml, and decreased by 1,441,000 to 905,000/ml after therapy, whereas SCC prior to extended therapy was 2,806,000/ml, and decreased only slightly by 136,000 to 2,670,000/ml after therapy.

Pirsue: Average SCC prior to beginning therapy following label instructions was 762,000/ml, and decreased by 376,000 to 385,000/ml after therapy, whereas SCC prior to extended therapy was 978,000/ml, and increased by 828,000 to 1,806,000/ml after therapy.

Spectramast LC: Average SCC prior to beginning therapy following label instructions was 2,384,000/ml, and decreased by 719,000 to 1,665,000/ml after therapy, while SCC prior to extended therapy was 2,257,000/ml, and decreased by 477,000 to 1,779,000/ml after therapy.

ToDAY: Average SCC prior to beginning therapy following label instructions was 1,475,000/ml, and decreased slightly by 258,000 to 1,217,000/ml after therapy, whereas SCC prior to extended therapy was 2,698,000/ml, and decreased markedly by 2,253,000 to 445,000/ml after therapy, which was a greater difference than that found with label therapy (P < 0.004). Thus, the only antibiotic treatment to significanly lower SCC for *Staph. aureus* IMI was extended therapy with ToDAY.

SCC Before and After Treatment of Environmental Streptococci Using Label and Extended Therapies for Each Antibacterial Therapeutic Used (Table 7):

Amoximast: Average SCC prior to beginning therapy following label instructions was 2,843,000/ml, and decreased by 784,000 to 2,058,000/ml after therapy, whereas SCC prior to extended therapy was 1,978,000/ml, and decreased only slightly by 48,000 to 1,899,000/ml after therapy. The differences in SCC (Diff SCC) pre and post treatment for label and extended therapies were not significant.

Hetacin-K: Average SCC prior to beginning therapy following label instructions was 2,255,000/ml, and decreased by 1,404,000 to 851,000/ml after therapy, whereas SCC prior to extended therapy was 3,483,000/ml, and decreased by 2,355,000 to 1,128,000/ml after therapy, but the difference was not significant.

Pirsue: Average SCC prior to beginning therapy following label instructions was 1,575,000/ml, and decreased by 119,000 to 1,456,000/ml after therapy, whereas SCC prior to extended therapy was 2,235,000/ml, and decreased by 1,219,000 to 1,016,000/ml after therapy, but the difference was not significant.

Spectramast LC: Average SCC prior to beginning therapy following label instructions was 2,192,000/ml, and increased by 2,399,000 to 4,592,000/ml after therapy, while SCC prior to extended therapy was 1,686,000/ml, and decreased by 816,000 to 870,000/ml after therapy, which was a greater difference than that observed for label therapy (P < 0.014).

ToDAY: Average SCC prior to beginning therapy following label instructions was 1,837,000/ml, and increased by 717,000 to 2,554,000/ml after therapy, whereas SCC prior to extended therapy was 1,896,000/ml, and decreased markedly by 1,637,000 to 259,000/ml after therapy, but the reduction was not statistically different compared with label therapy.

Thus, the only antibiotic treatment to significanly lower SCC for streptococcal IMI was extended therapy with Spectramast.

SCC Before and After Treatment of CNS Using Label and Extended Therapies for Each Antibacterial Therapeutic Used (Table 8):

Amoximast: Average SCC prior to beginning therapy following label instructions was 2,747,000/ml, and decreased by 1,785,000 to 962,000/ml after therapy, whereas SCC prior to extended therapy was 381,000/ml, and decreased only slightly by 52,000 to 329,000/ml after therapy. No significant differences were observed.

Hetacin-K: Average SCC prior to beginning therapy following label instructions was 2,008,000/ml, and decreased by 165,000 to 1,843,000/ml after therapy; no significant differences were observed. SCC prior to extended therapy was 791,000/ml, and decreased markedly by 625,000 to 140,000/ml after therapy, but the difference was not significant.

Pirsue: Average SCC prior to beginning therapy following label instructions was 550,000/ml, and decreased by 299,000 to 250,000/ml after therapy, whereas SCC prior to extended therapy was 337,000/ml, and increased by 84,000 to 422,000/ml after therapy. No significant differences were observed.

Spectramast LC: Average SCC prior to beginning therapy following label instructions was 698,000/ml, and decreased by 433,000 to 265,000/ml after therapy, while SCC prior to extended therapy was 2,258,000/ml, and decreased by 1,667,000 to 590,000/ml after therapy. No significant differences were observed.

ToDAY: Average SCC prior to beginning therapy following label instructions was 2,145,000/ml, and decreased by 1,143,000 to 1,001,000/ml after therapy, whereas SCC prior to extended therapy was 513,000/ml, and decreased markedly by 407,000 to 105,000/ml after therapy, but the differences were not different.

Association of Cure Rates with SCC: Across all bacterial species, infected quarters destined to cure exhibited an average SCC of 1,320,000/ml just prior to antibiotic treatment, whereas the average SCC of quarters destined to fail was over 2-fold higher at 3,249,000/ml (Figure 1) just prior to antibiotic treatment. The respective SCC for individual bacterial species followed the same trend for *Staph. aureus* (1,237,000 vs. 2,648,000/ml), the environmental streptococci (1,266,000 vs. 3,570,000), and CNS (1,458,000 vs. 3,530,000) for quarters destined to cure and fail, respectively. While these counts are excessive, it does indicate that expedient treatment when SCC are lower (e.g., < 1,500,000/ml) may result in a higher probability of curing an infected quarter than when SCC are >3,000,000/ml.

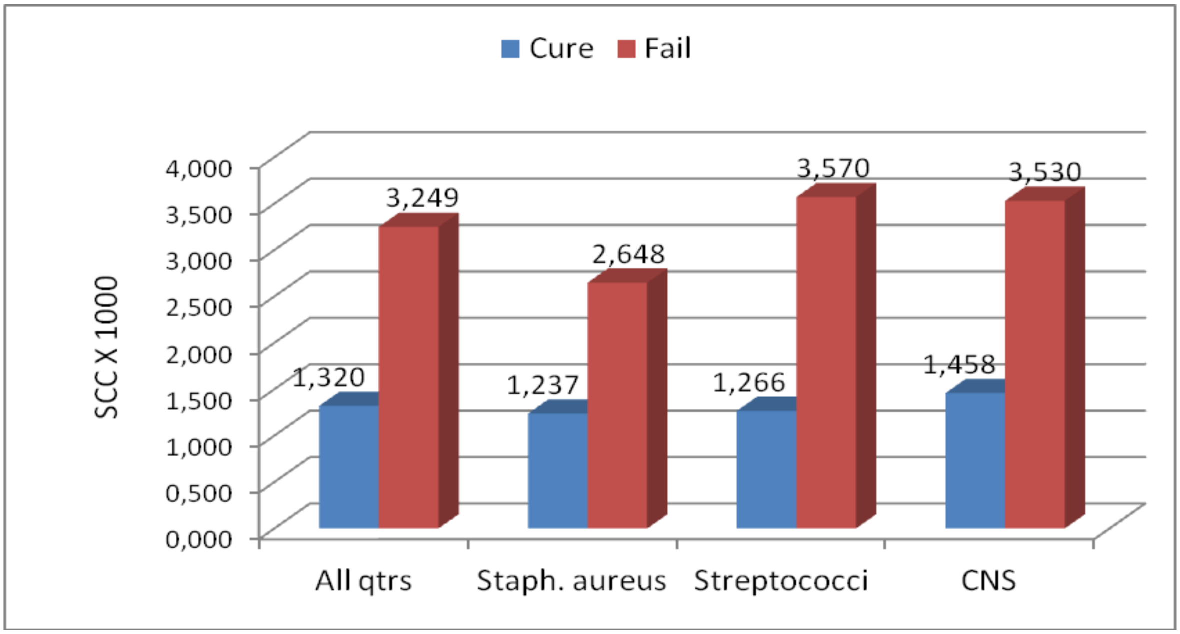

Figure 1. SCC at the start of treatment for quarters destined to cure or destined to fail.

Milk Production Before and After Antibiotic Therapy, Number of Milkings That Milk Was Discarded, and Pounds of Abnormal Milk Discarded:

Overall, milk production averaged 60.2 lb/cow prior to therapy regardless of label or extended treatment, and remained about the same after therapy (61.6 lb), a difference of +1.1 lb (See Diff milk, Table 1). During therapy, regardless of label or extended treatment, milk was discarded for an average of 14.9 milkings, and an average of 455.9 lb of milk were discarded. See Table 1.

For cows treated with label therapy across microbes, average production was 61.33 lb prior to therapy, and similar (61.23 lb) after therapy, a difference of -0.10 lb (See Diff milk, Table 2) and for cows treated with extended therapy, average production was 59.30 lb prior to and 61.98 lb after therapy, a difference of +2.71 lb. See Table 2.

The average number of discarded milkings was lower for label therapy compared with extended therapy, which was expected (12.62 vs.16.93, $P < 0.001$), and less milk was discarded for label therapy (376.23 vs. 523.76, $P < 0.001$). See Table 2.

For cows treated for *Staph. aureus* IMI with label therapy, average production was 65.79 lb prior to therapy, and similar (65.77 lb) after therapy, a difference of -0.02 lb (Table 3). For cows treated with extended therapy, average production was 62.80 lb prior to and 64.88 lb after therapy, an increase of 2.08 lb. The average number of discarded milkings was lower for label therapy compared with extended therapy, which was expected (12.78 vs.18.13, $P < 0.005$), and less milk was discarded for label therapy (415.70 vs. 596.46, $P = 0.019$). See Table 3.

For cows treated for environmental streptococcal IMI with label therapy, average production was 59.67 lb prior to therapy, and similar (61.33 lb) after therapy, a difference of +1.66 lb (Table 4). For cows treated with extended therapy, average production was 54.00 lb prior to and 59.25 lb after therapy, an increase of 5.25 lb. The average number of discarded milkings was lower for label therapy compared with extended therapy, which was expected (12.86 vs.16.64, $P < 0.036$), and less milk was discarded for label therapy (375.49 vs. 479.61, $P = 0.093$). See Table 4.

For cows treated for CNS IMI with label therapy, average production was 54.83 lb prior to therapy, and similar (52.83 lb) after therapy, a decrease of 2 lb (Table 5). For cows treated with extended therapy, average production was 60.72 lb prior to and 60.56 lb after therapy, a decrease of 0.16 lb. The average number of discarded milkings was lower for label therapy compared with extended therapy, which was expected (12.00 vs.14.78, $P = 0.113$), and less milk was discarded for label therapy (304.62 vs. 451.08, $P = 0.014$). See Table 5.

Discarded Milk Costs Overall, by Label or Extended Therapy, and by Type of IMI:

Overall, the average discarded milk cost for product valued at $17/cwt was $77.50, and for $21-milk, the cost was $95.70 regardless of label or extended treatment (Table 1).

For cows treated with label therapy, average costs for discarded milk were $63.96 for $17-milk, and $79.01 for $21-milk (Table 2); and for cows treated with extended therapy, average costs were $89.04 and $109.99, respectively. At both milk prices, costs were significantly higher ($P < 0.001$) for extended therapy. See Table 2.

For cows treated for *Staph. aureus* IMI with label therapy, average costs for discarded milk were $70.67 for $17-milk, and $87.30 for $21-milk (Table 3), and for cows treated with extended therapy, average costs were $101.40 and $125.26, respectively. At both milk prices, costs of discarded milk were significantly higher ($P < 0.019$) for extended therapy. See Table 3.

For cows treated for environmental strep IMI with label therapy, average costs for discarded milk were $63.83 for $17-milk, and $78.85 for $21-milk (Table 4), and for cows treated with extended therapy, average costs were $81.53 and $100.72, respectively. At both milk prices, costs tended to be higher ($P = 0.093$) for extended therapy. See Table 4. The cost of dicarding milk from cows treated for environmental strep IMI (Table 4) was lower than that for *S. aureus*; compare with Table 3.

For cows treated for CNS IMI with label therapy, average costs for discarded milk were $51.79 for $17-milk, and $63.97 for $21-milk (Table 5), and for cows treated with extended therapy, average costs were $76.68 and $94.73, respectively. At both milk prices, costs were higher ($P < 0.014$) for extended therapy. See Table 5. The cost of dicarding milk from cows treated for CNS IMI (Table 5) was lower than that for *S. aureus* and the environmental streps; compare with Tables 3 and 4.

Discarded milk costs were greatest for *Staph. aureus*, followed by the environmental streptococci, and lowest for CNS.

Discarded Milk Costs for Each Each Type of Antibiotic for Quarters Treated by Label or Extended Therapy Across All Microbes (Table 1):

Regardless of antibiotic used and $ value/cwt, average discarded milk costs after extended therapy were higher than label therapy except for Hetacin K, which was most likely due to prolonged presence of antibiotic residues or abnormal milk, both of which would have increased the amount of time that milk was discarded and its cost.

For costs figured at $17 milk, cost for treating with SPECTRAMAST using label therapy ($44.80) was lower (P < 0.001) than SPECTRAMAST extended therapy ($82.70), Amoxi-Mast using extended therapy ($88.20), and ToDAY extended therapy ($130). Also, cost for treating with ToDAY using extended therapy ($130) was higher (P < 0.001) than ToDAY label therapy ($76.70), and all other antibiotics whether using label or extended therapy.

For costs figured at $21 milk, cost for treating with Pirsue using label therapy ($65.70) was lower (P < 0.001) than Amoxi-Mast using extended therapy ($108.90), Spectramast using extended therapy ($102.20), and ToDAY using extended therapy ($160.60). The most costly treatment was with ToDAY extended therapy when a cost of $21/cwt for milk was considered ($196.60, P < 0.001).

Discarded Milk Costs for Each Each Type of Antibiotic for Quarters Treated by Label or Extended Therapy for Staph. aureus IMI (Table 6):

Overall, the average discarded milk cost for product valued at $17/cwt was $86.50, and for $21-milk, the cost was $106.80 regardless of label or extended treatment.

As observed above, regardless of antibiotic used and $ value/cwt, average costs after extended therapy were higher than label therapy except for Hetacin K, which was most likely due to prolonged presence of antibiotic residues or abnormal milk in treated quarters.

For costs figured at $17 milk, costs for treating with Pirsue using label therapy ($53) and SPECTRAMAST label therapy ($50.80), were lower than ToDAY using label ($115) or extended therapy ($147.80, P < 0.001).

For costs figured at $21 milk, costs for treating with Pirsue using label therapy ($65.40) and SPECTRAMAST label therapy ($62.70), were lower than ToDAY using label ($142) or extended therapy ($182.60, P < 0.001).

Discarded Milk Costs for Each Each Type of Antibiotic for Quarters Treated by Label or Extended Therapy for Environmental Streptococcal IMI (Table 7):

Overall, the average discarded milk cost for product valued at $17/cwt was $74.60, and for $21-milk, the cost was $92.20 regardless of label or extended treatment.

Regardless of antibiotic used and $ value/cwt, average costs after extended therapy were higher than label therapy except for Amoxi-Mast, which was most likely due to prolonged presence of antibiotic residues or abnormal milk in treated quarters.

For costs figured at $17 milk or $21 milk, there were no differences (P = 0.40) among antibiotics used.

Discarded Milk Costs for Each Each Type of Antibiotic for Quarters Treated by Label or Extended Therapy for CNS IMI (Table 8):

Overall, the average discarded milk cost for product valued at $17/cwt was $64.20, and for $21-milk, the cost was $79.40 regardless of label or extended treatment. This cost was less than that for the streptococci ($92.20), which was less than that for *Staph. aureus* ($106.80); compare with Tables 6 and 7.

As observed above, regardless of antibiotic used and $ value/cwt, average costs after extended therapy were higher than label therapy except for Hetacin K, which was most likely due to prolonged presence of antibiotic residues or abnormal milk in treated quarters.

For costs figured at $17 milk, costs for treating with Amoxi-Mast using extended therapy ($119.90) and ToDAY extended therapy ($100.50), were higher than all other antibiotics. Treatment with Spectramast label resulted in a lower cost ($24.20, P = 0.001) compared with Amoxi-Mast label therapy ($64.40) and extended therapy ($119.90), and ToDAY extended therapy ($100.50).

For costs figured at $21 milk, costs for treating with Amoxi-Mast using extended therapy ($148.10) and ToDAY extended therapy ($124.20), were higher than all other treatments. Use of Specramast label was less costly ($29.90, P = 0.001) than Amoxi-Mast label ($80.80) and extended therapies ($148.10), and ToDAY extended therapy ($124.20).

Costs of Antibiotic Therapy Overall, by Label or Extended Therapy, and by Type of IMI:

Overall, the average cost of antibiotic used to treat a case of mastitis was $26.10 regardless of label or extended treatment (See Trt $ cost, Table 1).

For cows treated with label therapy, average cost of antibiotic used to treat a case of mastitis was $14.38, and for cows treated with extended therapy, average cost was significantly higher (P < 0.001) at $36 (Table 2).

For cows treated for *Staph. aureus* IMI with label therapy, average cost of antibiotic used to treat a case of mastitis was $14.54, and for cows treated with extended therapy, average cost was significantly higher (P < 0.001) at $36 (Table 3).

For cows treated for environmental strep IMI with label therapy, average cost of antibiotic used to treat a case of mastitis was $14.45, and for cows treated with extended therapy, average cost was significantly higher (P < 0.001) at $36 (Table 4).

For cows treated for CNS IMI with label therapy, average cost of antibiotic used to treat a case of mastitis was $14.67, and for cows treated with extended therapy, average cost was significantly higher (P < 0.001) at $36 (Table 5).

Treatment Costs for Each Each Type of Antibiotic for Quarters Treated by Label or Extended Therapy Across All Microbes and for Each Type of IMI Treated.

Regardless of antibiotic used, average costs after extended therapy were higher than label therapy. Lowest costs were found for Pirsue ($12.40), Spectramast ($12.00), and ToDAY ($12.00) label therapy (Table 1). Likewise, for *Staph. aureus*, environmental strep, and CNS IMI, lowest costs (P < 0.001) were found for Pirsue, Spectramast, and ToDAY label therapy (Tables 6, 7, and 8).

Total Costs of Discarded Milk Plus Antibiotics Overall, by Label or Extended Therapy, and by Type of IMI:

Overall, the average total cost of treatment when $17 milk plus antibiotic costs were added was $103.50, and for $21 milk, the total cost was $121.80 regardless of label or extended treatment, or type of microbe causing the IMI (Table 1).

For cows treated with label therapy, average total cost based on $17 milk was $78.31, and based on $21 milk, the total cost was $98.36 (Table 2). For cows treated with extended therapy, average total costs for $17 milk and $21 milk were $125.04 and $145.99. At both milk prices, total costs were significantly higher (P < 0.001) for extended therapy. See Table 2.

For cows treated for *Staph. aureus* IMI with label therapy, average total cost at $17 milk was $84.85 and at $21 milk cost was $101.48 (Table 3). For cows treated with extended therapy, average total cost at $17 milk was $137.40, and at $21 milk, cost was $161.26. At both milk prices, total costs were significantly higher (P < 0.001) for extended therapy. See Table 3.

For cows treated for environmental strep IMI with label therapy, average total cost at $17 milk was $78.16 and at $21 milk cost was $93.18 (Table 4). For cows treated with extended therapy, average total cost at $17 milk was $117.53 and at $21 milk, cost was $136.72. At both milk prices, total costs were significantly higher (P < 0.001) for extended therapy. See Table 4.

For cows treated for CNS IMI with label therapy, average total cost at \$17 milk was \$66.45 and at \$21 milk cost was \$78.64 (Table 5). For cows treated with extended therapy, average total cost at \$17 milk was \$112.84 and at \$21 milk, cost was \$130.73. At both milk prices, total costs were significantly higher ($P < 0.001$) for extended therapy. See Table 5.

The total costs were greatest for cows treated for *S. aureus* IMI, followed by the environmental streps, and lowest for CNS; compare Tables 3, 4, and 5.

Total Costs of Discarded Milk Plus Antibiotics for Each Each Type of Antibiotic for Quarters Treated by Label or Extended Therapy Across All Microbes (Table 1):

Regardless of antibiotic used and \$ value/cwt, average total costs after extended therapy were higher than label therapy as expected.

For total costs figured at \$17 milk using label therapy, costs were lowest for Pirsue and Spectramast but not significantly different from other antibiotics. For total costs figured at \$17 milk using extended therapy, cost for treating with ToDAY (\$166) was higher than all other antibiotics ($P < 0.001$).

For total costs figured at \$21 milk using label therapy, cost for treating with Spectramast (\$67.30) was lowest but not significantly different from other antibiotics. For total costs figured at \$21 milk using extended therapy, cost for treating with ToDAY (\$196.60) was higher than all other antibiotics ($P < 0.001$).

Total Costs of Discarded Milk Plus Antibiotics for Each Each Type of Antibiotic for Quarters Treated by Label or Extended Therapy for Staph. aureus IMI (Table 6):

Regardless of antibiotic used and \$ value/cwt, average total costs after extended therapy were higher than label therapy except for Hetacin K label (\$117.20), which was higher than extended (\$112.60) therapy; this was most likely due to longer milk withdrawal times due to antibiotic residues or abnormal milk.

For total costs figured at \$17 milk using label therapy, costs were highest for ToDAY (\$124.60, $P < 0.01$) compared with Pirsue (\$65.70) and Spectramast (\$62.80) but not significantly different from other antibiotics. For total costs figured at \$17 milk using extended therapy, cost for treating with ToDAY (\$183.80) was higher than all other antibiotics ($P < 0.001$) except Amoxi-Mast (\$149.20).

For total costs figured at \$21 milk using label therapy, cost for treating with ToDAY (\$151.60) was highest but not significantly different from other antibiotics. For total costs figured at \$21 milk using extended therapy, cost for treating with ToDAY (\$218.60) was higher than all other antibiotics ($P < 0.001$) except Amoxycillin (\$175.90).

Total Costs of Discarded Milk Plus Antibiotics for Each Each Type of Antibiotic for Quarters Treated by Label or Extended Therapy for Environmental Streptococcal IMI (Table 7):

Regardless of antibiotic used and $ value/cwt, average total costs after extended therapy were higher than label therapy except for Amoxi-Mast label ($99.60 @$17 and $118.80 @$21), which were higher than extended ($95.20 @$17 and $109.80 @$21) therapy.

For total costs figured at $17 milk using label therapy, costs were lowest for Spectramast ($56), which was different (P < 0.001) from all other antibiotics except ToDAY ($72.80). For total costs figured at $17 milk using extended therapy, costs for treating with all antibiotics were similar.

For total costs figured at $21 milk using label therapy, cost for treating with Spectramast ($66.70) was lower (P < 0.001) than all other antibiotics except ToDAY ($87.20). For total costs figured at $21 milk using extended therapy, costs for treating with all antibiotics were similar.

Total Costs of Discarded Milk Plus Antibiotics for Each Each Type of Antibiotic for Quarters Treated by Label or Extended Therapy for CNS IMI (Table 8):

Regardless of antibiotic used and $ value/cwt, average total costs after extended therapy were higher than label therapy.

For total costs figured at $17 milk using label therapy, costs were lowest for Spectramast ($36.20, which was different (P < 0.001) only from Amoxi-Mast ($83.40). For total costs figured at $17 milk using extended therapy, costs for treating with Amoxi-Mast ($155.90) and ToDAY ($136,50) were higher (P < 0.001) than all other antibiotics.

For total costs figured at $21 milk using label therapy, cost for treating with Spectramast ($41.90) was lower (P < 0.001) than Amoxi-Mast ($98.90), but similar to all other antibiotics. For total costs figured at $21 milk using extended therapy, costs for treating with Amoxi-Mast ($184.10) and ToDAY ($160.20) were higher (P < 0.001) than all other antibiotics.

Conclusions

Use of antibiotic therapy to control mastitis is usually viewed as a last resort, as current control programs are based on preventing this disease. However, to maintain the herd bulk tank SCC below 200,000/ml, it may be necessary to treat those infected cows that are contributing to elevated SCC if drying off and culling are not viable options.

Results of antibiotic therapy are generally poor, and unfortunately, producers have at best, a 50:50 chance of successfully curing an infected quarter (50% cure rate). However, findings of this study show that use of extended therapy does improve the overall cure rate to 62.4% and enhances cure rates for the environmental streptococci (67.9%) and CNS (94.4%).

Use of extended therapy resulted slightly lower SCC (-654,000/ml) and greater milk production (+2.71 lb), but drug costs ($36 vs. $14.38), discarded milk (16.93 vs. 12.62 milkings), and overall total losses at $21 milk ($145.99 vs. $93.36) were greater using extended therapy compared with label therapy. Across all microbes, extended treatment with Spectamast LC resulted in greater cure rates than label therapy; likewise, the only antibiotic treatment to significanly lower SCC (including *Staph. aureus* IMI) was extended therapy with ToDAY.

The improved cure rate against environmental streptococci and CNS, and lower SCC and slight increase in production at the end of therapy compared with label therapy may justify using this treatment regimen when treating mastitis in attempts to lower herd SCC, depending on market demands.

Regardless of the treatment regimen used, infected quarters that cured had an initial average SCC of 1,320,000/ml, while those that failed had an initial average SCC of 3,250,000/ml, suggesting that if SCC are available, the infected quarters with SCC <1,500,000/ml are more likely to cure than those with SCC of 3,000,000/ml or higher.

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Table 1. Comparison of labeled versus extended treatment of IMI by antibiotics across all mastitis-causing bacteria.

Treatment	n[1]	Cure %[2]	Pre-SCC[3]	Post-SCC[4]	Diff SCC[5]	Pre-milk[6]	Post-milk[7]	Diff milk[8]	Milkings discard[9]	Lb milk discard[10]	Milk: $17[11]	Milk: $21[12]	Trt $ cost[13]	Tot. cost @ $17[14]	Tot. cost @ $21[15]
Amoxiext	14	45.9[bc]	1560	2358[a]	798[a]	76.4[a]	64.9[a]	-11.5[d]	13.7[c]	518.7[b]	88.2[b]	108.9[b]	36[a]	124.2[b]	144.9[b]
Amoxlab	14	50.0[bc]	2831	1775[abc]	-1056[cd]	69.2[ab]	62.3[bc]	-6.9[cd]	12.7[c]	412.0[bc]	70.0[bc]	88.5[bc]	18[b]	88.04[cd]	104.5[bcd]
Heta-Kext	16	50.0[bc]	2346	1494[abc]	-852[bcd]	54.7[bc]	58.8[bc]	4.1[ab]	13.4[c]	378.1[bc]	64.4[bc]	79.5[bc]	36[a]	100.4[bc]	115.5[b]
Heta-Klab	16	56.3[bc]	2233	1123[bc]	-1110[cd]	62.1[ab]	62.9[bc]	0.81[bc]	14.8[bc]	433.5[bc]	73.7[bc]	91.0[bc]	18[b]	91.7[c]	109.0[bc]
Pirsueext	17	53.9[bc]	1384	1190[abc]	-194[abc]	54.8[bc]	61.9[bc]	7.1[ab]	14.5[bc]	419.3[bc]	71.3[bc]	88.1[bc]	36[a]	107.3[b]	124.0[b]
Pirsuelab	17	64.7[ab]	951	668[c]	-283[abc]	71.3[a]	77.1[a]	5.8[a]	8.4[d]	312.9[c]	53.2[b]	65.7[c]	12.4[c]	65.6[cd]	78.0[cd]
Spectraext	18	66.7[ab]	2035	1227[abc]	-808[bcd]	49.1[c]	59.6[bc]	11.1[a]	17.4[b]	486.4[b]	82.7[b]	102.2[b]	36[a]	118.0[b]	138.1[b]
Spectralab	13	23.1[c]	2066	2350[a]	284[ab]	50.4[c]	48.0[c]	-2.4[bcd]	10.2[cd]	263.3[c]	44.8[c]	55.3[c]	12[c]	56.8[d]	67.3[d]
ToDAYext	20	90.0[a]	2101	340[c]	-1761[d]	67.4[a]	65.3[ab]	-2.1[bcd]	23.7[a]	764.7[a]	130.0[a]	160.6[a]	36[a]	166.0[a]	196.6[a]
ToDAYlab	13	61.5[ab]	1793	1562[abc]	-231[ab]	49.4[c]	48.7[c]	-0.7[bc]	17.8[b]	451.2[bc]	76.7[bc]	94.7[bc]	12[c]	88.7[cd]	106.7[bcd]
SEM		13.0	512	455	493	5.3	5.07	3.6	1.6	64.6	10.9	13.6	0.29	11.0	13.6
P		0.03	0.2	0.01	0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Overall	158	57.6	1925	1336	-583	60.2	61.6	1.1	14.9	455.9	77.5	95.7	26.1	103.5	121.8

[1] Number of quarters treated.
[2] The percentage of quarters treated with antibiotics that cured.
[3] Average SCC x 10^3 prior to treatment.
[4] Average SCC x 10^3 after treatment.
[5] Difference between pre-SCC and post-SCC x 10^3.
[6] Average daily milk production prior to treatment.
[7] Average daily milk production after to treatment.
[8] Difference between milk production pre- and post-treatment.
[9] Number of milkings that milk was discarded.
[10] Total pounds of milk discarded.
[11] Cost of milk discarded at $17/cwt.
[12] Cost of milk discarded at $21/cwt.
[13] Cost of antibiotic therapy.
[14] Total cost of milk discarded at $17/cwt + antibiotic therapy.
[15] Total cost of milk discarded at $21/cwt + antibiotic therapy.

Table 2. Comparison of labeled versus extended treatment for all mastitis-causing bacteria.

All microbes	n	Labeled	n	Extended	SEM	P
No. times treated[1]	73	2.43	85	6.00	0.04	0.001
Cure %[2]	73	52.05	85	62.35	5.36	0.194
Pre-SCC[3]	73	1941	85	1900	202	0.892
Post-SCC[4]	73	1439	85	1247	185	0.485
Diff SCC[5]	73	-502	84	-654	204	0.611
Pre-milk[6]	69	61.33	81	59.30	2.31	0.551
Post-milk[7]	39	61.23	81	61.98	2.15	0.815
Diff Milk[8]	69	-0.10	80	2.71	1.55	0.219
Milkings discard[9]	73	12.62	85	16.93	0.73	0.001
Lb milk discard[10]	69	376.23	81	523.76	28.36	0.001
Milk @ $17[11]	69	63.96	81	89.04	4.82	0.001
Milk @ $21[12]	69	79.01	81	109.99	5.96	0.001
Trt. $ cost[13]	73	14.38	85	36.00	0.25	0.001
Tot. cost @ $17[14]	39	78.31	81	125.04	4.85	0.001
Tot. cost @ $21[15]	39	93.36	81	145.99	5.99	0.001

[1] Average number of times quarters were treated.
[2] The percentage of quarters treated with antibiotics that cured.
[3] Average SCC x 10^3 prior to treatment.
[4] Average SCC x 10^3 after treatment.
[5] Difference between pre-SCC and post-SCC x 10^3.
[6] Average daily milk production prior to treatment.
[7] Average daily milk production after to treatment.
[8] Difference between milk production pre- and post-treatment.
[9] Number of milkings that milk was discarded.
[10] Total pounds of milk discarded.
[11] Cost of milk discarded at $17/cwt.
[12] Cost of milk discarded at $21/cwt.
[13] Cost of antibiotic therapy.
[14] Total cost of milk discarded at $17/cwt + antibiotic therapy.
[15] Total cost of milk discarded at $21/cwt + antibiotic therapy.

Table 3. Comparison of labeled versus extended treatment for IMI caused by *Staph. aureus*.

Staph. aureus	n	Labeled	n	Extended	SEM	P
No. times treated[1]	33	2.42	39	6	0.05	0.001
Cure %[2]	33	42.42	39	43.59	8.04	0.922
Pre-SCC[3]	33	1935	39	2228	329	0.549
Post-SCC[4]	33	1210	39	1837	272	0.124
Diff SCC[5]	33	-724.00	39	-390.00	328.00	0.494
Pre-milk[6]	33	65.79	35	62.80	3.41	0.543
Post-milk[7]	33	65.77	35	64.88	3.53	0.864
Diff Milk[8]	33	-0.02	34	2.08	2.41	0.528
Milkings discard[9]	33	12.78	39	18.13	1.25	0.005
Lb milk discard[10]	33	415.70	35	596.46	52.74	0.019
Milk @ $17[11]	33	70.67	39	101.40	8.97	0.019
Milk @ $21[12]	33	87.30	39	125.26	11.08	0.019
Trt. $ cost[13]	33	14.54	39	36.00	0.33	0.001
Tot. cost @ $17[14]	33	84.85	35	137.40	9.01	0.001
Tot. cost @ $21[15]	33	101.48	35	161.26	11.11	0.001

[1] Average number of times quarters were treated.
[2] The percentage of quarters treated with antibiotics that cured.
[3] Average SCC x 10^3 prior to treatment.
[4] Average SCC x 10^3 after treatment.
[5] Difference between pre-SCC and post-SCC x 10^3.
[6] Average daily milk production prior to treatment.
[7] Average daily milk production after to treatment.
[8] Difference between milk production pre- and post-treatment.
[9] Number of milkings that milk was discarded.
[10] Total pounds of milk discarded.
[11] Cost of milk discarded at $17/cwt.
[12] Cost of milk discarded at $21/cwt.
[13] Cost of antibiotic therapy.
[14] Total cost of milk discarded at $17/cwt + antibiotic therapy.
[15] Total cost of milk discarded at $21/cwt + antibiotic therapy.

Table 4. Comparison of labeled versus extended treatment for IMI caused by environmental streptococci.

Env. streptococci	n	Labeled	n	Extended	SEM	P
No. times treated[1]	22	2.41	28	6.00	0.06	0.001
Cure %[2]	22	50.00	28	67.86	9.29	0.209
Pre-SCC[3]	22	2120	27	2174	352	0.918
Post-SCC[4]	22	2198	28	1045	348	0.033
Diff SCC[5]	22	77	27	-1109	353	0.029
Pre-milk[6]	22	59.67	28	54.00	3.97	0.377
Post-milk[7]	22	61.33	28	59.25	3.38	0.702
Diff Milk[8]	22	1.66	28	5.25	2.51	0.377
Milkings discard[9]	22	12.86	28	16.64	1.16	0.036
Lb milk discard[10]	22	375.49	28	479.61	37.92	0.093
Milk @ $17[11]	22	63.83	28	81.53	6.44	0.093
Milk @ $21[12]	22	78.85	28	100.72	7.56	0.093
Trt. $ cost[13]	22	14.45	28	36.00	0.38	0.001
Tot. cost @ $17[14]	22	78.16	28	117.53	6.54	0.001
Tot. cost @ $21[15]	22	93.18	28	136.72	8.05	0.002

[1] Average number of times quarters were treated.
[2] The percentage of quarters treated with antibiotics that cured.
[3] Average SCC x 10^3 prior to treatment.
[4] Average SCC x 10^3 after treatment.
[5] Difference between pre-SCC and post-SCC x 10^3.
[6] Average daily milk production prior to treatment.
[7] Average daily milk production after to treatment.
[8] Difference between milk production pre- and post-treatment.
[9] Number of milkings that milk was discarded.
[10] Total pounds of milk discarded.
[11] Cost of milk discarded at $17/cwt.
[12] Cost of milk discarded at $21/cwt.
[13] Cost of antibiotic therapy.
[14] Total cost of milk discarded at $17/cwt + antibiotic therapy.
[15] Total cost of milk discarded at $21/cwt + antibiotic therapy.

Table 5. Comparison of labeled versus extended treatment for IMI caused by CNS.

CNS	n	Labeled	n	Extended	SEM	P
No. times treated[1]	18	2.44	18	6.00	0.08	0.001
Cure %[2]	18	72.22	18	94.44	8.63	0.077
Pre-SCC[3]	18	1733	18	830	317	0.052
Post-SCC[4]	18	931	18	286	262	0.092
Diff SCC[5]	18	-802	18	-544	304	0.599
Pre-milk[6]	18	54.83	18	60.72	4.96	0.409
Post-milk[7]	18	52.83	18	60.56	4.09	0.191
Diff Milk[8]	18	-2.00	18	-0.16	3.42	0.708
Milkings discard[9]	18	12.00	18	14.78	1.21	0.113
Lb milk discard[10]	18	304.62	18	451.08	39.75	0.014
Milk @ $17[11]	18	51.79	18	76.68	6.76	0.014
Milk @ $21[12]	18	63.97	18	94.73	8.35	0.014
Trt. $ cost[13]	18	14.67	18	36.00	0.51	0.001
Tot. cost @ $17[14]	18	66.45	18	112.84	6.89	0.001
Tot. cost @ $21[15]	18	78.64	18	130.73	8.48	0.001

[1] Average number of times quarters were treated.
[2] The percentage of quarters treated with antibiotics that cured.
[3] Average SCC x 10^3 prior to treatment.
[4] Average SCC x 10^3 after treatment.
[5] Difference between pre-SCC and post-SCC x 10^3.
[6] Average daily milk production prior to treatment.
[7] Average daily milk production after to treatment.
[8] Difference between milk production pre- and post-treatment.
[9] Number of milkings that milk was discarded.
[10] Total pounds of milk discarded.
[11] Cost of milk discarded at $17/cwt.
[12] Cost of milk discarded at $21/cwt.
[13] Cost of antibiotic therapy.
[14] Total cost of milk discarded at $17/cwt + antibiotic therapy.
[15] Total cost of milk discarded at $21/cwt + antibiotic therapy.

Table 6. Comparison of labeled versus extended treatment by antibiotics for IMI caused by *Staph. aureus*.

Treatment	n[1]	Cure %[2]	Pre-SCC[3]	Post-SCC[4]	Diff SCC[5]	Pre-milk[6]	Post-milk[7]	Diff milk[8]	Milkings discard[9]	Lb milk discard[10]	Milk: $17[11]	Milk: $21[12]	Trt $ cost[13]	Tot. cost @ $17[14]	Tot. cost @ $21[15]
Amoxiext	6	16.7[bc]	1826	3756[a]	1930[a]	88.5	77.5	-11.0	13.3[bc]	999.0[abc]	113.3[abc]	139.9[abc]	36.0[a]	149.2[abc]	175.9[abc]
Amoxilab	6	33.3[bc]	2878	2129[abc]	-749[bcd]	78.0	72.7	-5.3	11.7[bc]	407.7[bc]	69.3[bc]	85.6[bc]	18.0[b]	87.3[bc]	103.1[bc]
Heta-Kext	7	0.0[c]	2806	2670[ab]	-136[bc]	52.6	60.3	7.7	13.1[bc]	364.6[bc]	62.0[bc]	76.6[bc]	36.0[a]	98.0[bc]	112.6[bc]
Heta-Klab	7	57.1[ab]	2346	905[cd]	-1441[cd]	67.4	71.0	3.6	13.6[bc]	472.5[bc]	80.3[bc]	99.2[bc]	18.0[b]	98.3[bc]	117.2[bc]
Pirsueext	6	16.7[bc]	978	1806[bcd]	828[ab]	64.8	69.0	4.2	12.2[bc]	402.7[bc]	68.5[bc]	84.6[bc]	36.0[a]	104.5[bc]	120.6[bc]
Pirsuelab	8	50.0[b]	762	385[d]	-376[bc]	69.9	72.3	2.4	8.8[c]	311.5[c]	53.0[c]	65.4[c]	12.0[c]	65.7[c]	78.2[c]
Spectraext	8	50.0[b]	2257	1779[bcd]	-477[bc]	60.6	60.5	-0.3	17.0[b]	517.8[bc]	88.0[bc]	108.8[bc]	36.0[a]	124.0[bc]	144.7[bc]
Spectralab	7	14.3[bc]	2384	1665[bcd]	-719[bcd]	53.4	52.1	-1.3	11.1[bc]	298.6[c]	50.8[c]	62.7[c]	12.0[c]	62.8[c]	74.7[c]
ToDAYext	12	91.7[a]	2698	445[d]	-2253[d]	64.8	66.3	1.5	27.2[a]	869.5[a]	147.8[a]	182.6[a]	36.0[a]	183.8[a]	218.6[a]
ToDAYlab	5	60.0[ab]	1475	1217[bcd]	-258[c]	59.6	58.8	-0.8	21.8[a]	676.4[ab]	115.0[ab]	142.0[ab]	12.0[c]	124.6[ab]	151.6[ab]
SEM		19.4	918	670	814	8.8	9.4	6.5	2.6	122.1	20.8	25.7	0.32	20.9	25.8
P		0.001	0.5	0.002	0.004	0.2	0.63	0.83	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Overall	72	43.1	2094	1549	-544	64.3	65.3	1.1	15.7	508.7	86.5	106.8	26.2	111.9	132.3

[1] Number of quarters treated.
[2] The percentage of quarters treated with antibiotics that cured.
[3] Average SCC x 10^3 prior to treatment.
[4] Average SCC x 10^3 after treatment.
[5] Difference between pre-SCC and post-SCC x 10^3.
[6] Average daily milk production prior to treatment.
[7] Average daily milk production after to treatment.
[8] Difference between milk production pre- and post-treatment.
[9] Number of milkings that milk was discarded.
[10] Total pounds of milk discarded.
[11] Cost of milk discarded at $17/cwt.
[12] Cost of milk discarded at $21/cwt.
[13] Cost of antibiotic therapy.
[14] Total cost of milk discarded at $17/cwt + antibiotic therapy.
[15] Total cost of milk discarded at $21/cwt + antibiotic therapy.

Table 7. Comparison of labeled versus extended treatment by antibiotics for IMI caused by environmental streptococci.

Treatment	n[1]	Cure %[2]	Pre-SCC[3]	Post-SCC[4]	Diff SCC[5]	Pre-milk[6]	Post-milk[7]	Diff milk[8]	Milkings discard[9]	Lb milk discard[10]	Milk: $17[11]	Milk: $21[12]	Trt $ cost[13]	Tot. cost @ $17[14]	Tot. cost @ $21[15]
Amoxiext	5	40.0	1978	1899[b]	-48[b]	62.4	53.6[bc]	-8.8[c]	12.0[bc]	348.0	59.2	73.1	36.0[a]	95.2[ab]	109.8[ab]
Amoxilab	4	50.0	2843	2058[b]	-784[bc]	56.0	45.0[bc]	-11.0[c]	13.5[abc]	479.8	81.6	100.8	18.0[b]	99.6[ab]	118.8[ab]
Heta-Kext	4	75.0	3483	1128[b]	-2355[c]	66.3	69.0[ab]	2.8[bc]	15.0[abc]	497.3	84.5	104.4	36.0[a]	120.5[a]	140.4[a]
Heta-Klab	5	60.0	2255	851[b]	-1404[bc]	64.4	65.6[ab]	1.2[bcd]	15.8[abc]	455.3	77.4	95.6	18.0[b]	95.4[ab]	113.6[ab]
Pirsueext	8	75.0	2235	1016[b]	-1219[bc]	48.9	56.0[bc]	7.1[ab]	17.1[ab]	457.0	77.7	96.0	36.0[a]	113.7[a]	132.0[a]
Pirsuelab	5	80.0	1575	1456[b]	-119[bc]	75.2	81.6[ab]	6.4[ab]	7.8[c]	314.2	53.4	66.0	12.0[c]	65.4[bc]	78.0[bc]
Spectraext	7	71.4	1686	870[b]	-816[bc]	41.1	60.9[ab]	19.7[a]	18.4[ab]	506.8	86.2	106.4	36.0[a]	122.2[a]	142.4[a]
Spectralab	4	0.0	2192	4592[a]	2399[a]	55.0	59.5[abc]	4.5[abc]	8.5b[c]	260.3	44.2	54.7	12.0[c]	56.0[c]	66.7[c]
ToDAYext	4	75.0	1896	259[b]	-1637[bc]	64.0	60.3[abc]	-3.8[b]	20.0[a]	624.1	106.1	131.1	36.0[a]	142.1[a]	167.1[a]
ToDAYlab	4	50.0	1837	2554[ab]	717[abc]	38.5	39.3[c]	1.3[b]	19.3[ab]	357.9	60.8	75.2	12.0[c]	72.8[bc]	87.2[bc]
SEM		24.5	962	872	830	9.7	7.9	5.6	2.8	101.7	17.3	21.4	0.0	17.3	23.4
P		0.4	0.930	0.051	0.014	0.09	0.03	0.008	0.01	0.41	0.40	0.40	0.001	0.03	0.05
Overall	50	60.0	2150	1552	-576	56.2	60.1	3.9	15.0	438.9	74.6	92.2	26.5	102.1	119.7

[1] Number of quarters treated.
[2] The percentage of quarters treated with antibiotics that cured.
[3] Average SCC x 10^3 prior to treatment.
[4] Average SCC x 10^3 after treatment.
[5] Difference between pre-SCC and post-SCC x 10^3.
[6] Average daily milk production prior to treatment.
[7] Average daily milk production after to treatment.
[8] Difference between milk production pre- and post-treatment.
[9] Number of milkings that milk was discarded.
[10] Total pounds of milk discarded.
[11] Cost of milk discarded at $17/cwt.
[12] Cost of milk discarded at $21/cwt.
[13] Cost of antibiotic therapy.
[14] Total cost of milk discarded at $17/cwt + antibiotic therapy.
[15] Total cost of milk discarded at $21/cwt + antibiotic therapy.

Table 8. Comparison of labeled versus extended treatment by antibiotics for IMI caused by CNS.

Treatment	n[1]	Cure %[2]	Pre-SCC[3]	Post-SCC[4]	Diff SCC[5]	Pre-milk[6]	Post-milk[7]	Diff milk[8]	Milkings discard[9]	Lb milk discard[10]	Milk: $17[11]	Milk: $21[12]	Trt $ cost[13]	Tot. cost @ $17[14]	Tot. cost @ $21[15]
Amoxiext	3	100.0	381	329	-52	91.7[a]	75.3[ab]	-16.3[c]	17.3	705.0[a]	119.9[a]	148.1[a]	36[a]	155.9[a]	184.1[a]
Amoxilab	4	75.0	2747	962	-1785	62.5[bc]	55.3[cde]	-7.3[c]	13.5	384.7[b]	65.4[b]	80.8[b]	18[b]	83.4[bc]	98.8[bc]
Heta-Kext	5	100.0	791	140	-625	48.4[cd]	48.4[de]	0.0b[c]	12.4	303.4[bc]	51.6[bc]	63.7[bc]	36[a]	87.6[b]	99.7[b]
Heta-Klab	4	50.0	2008	1843	-165	50.0[cd]	45.5[e]	-4.5[b]	15.7	337.9[bc]	57.5[bc]	71.0[bc]	18[b]	75.5[bcd]	89.0[bcd]
Pirsueext	3	66.7	337	422	84	50.7[cd]	63.3[bcd]	12.7[ab]	12.3	352.3[bc]	59.9[bc]	74.0[bc]	36[a]	95.9[b]	110.0[b]
Pirsuelab	4	100.0	550	250	-299	69.3[abc]	81.0[a]	11.8[ab]	8.5	314.1[bc]	56.4[bc]	66.0[bc]	12[c]	65.4[bcd]	78.0[bcd]
Spectraext	3	100.0	2258	590	-1667	36.7[d]	54.3[cde]	17.7[a]	16.0	355.2[bc]	60.4[bc]	74.6[bc]	36[a]	96.4[b]	110.6[b]
Spectralab	2	100.0	698	265	-433	35.0[d]	22.0[f]	-13.0[c]	10.0	142.5[c]	24.2[c]	29.9[c]	12[c]	36.2[d]	41.9[d]
ToDAYext	4	100.0	513	105	-407	78.5[ab]	67.3[abc]	-11.3[c]	16.8	591.3[a]	100.5[a]	124.2[a]	36[a]	136.5[a]	160.2[a]
ToDAYlab	4	75.0	2145	1001	-1143	47.5[c]	45.0[e]	-2.5[bc]	11.3	262.9[bc]	44.7[bc]	55.2[bc]	12[c]	56.7[cd]	67.2[cd]
SEM		12.0	628	584	758	7.6	5.4	5.7	2.6	65.0	11.0	13.6	0.00	11.0	13.6
P		0.6	0.086	0.583	0.236	0.001	0.001	0.007	0.35	0.001	0.001	0.001	0.001	0.001	0.001
Overall	36	83.3	1281	608	-673	57.8	56.7	-1.1	13.4	377.9	64.2	79.4	25.3	89.6	104.7

[1] Number of quarters treated.
[2] The percentage of quarters treated with antibiotics that cured.
[3] Average SCC x 10^3 prior to treatment.
[4] Average SCC x 10^3 after treatment.
[5] Difference between pre-SCC and post-SCC x 10^3.
[6] Average daily milk production prior to treatment.
[7] Average daily milk production after to treatment.
[8] Difference between milk production pre- and post-treatment.
[9] Number of milkings that milk was discarded.
[10] Total pounds of milk discarded.
[11] Cost of milk discarded at $17/cwt.
[12] Cost of milk discarded at $21/cwt.
[13] Cost of antibiotic therapy.
[14] Total cost of milk discarded at $17/cwt + antibiotic therapy.
[15] Total cost of milk discarded at $21/cwt + antibiotic therapy.