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Effect of preweaning feeding of pasteurized and nonpasteurized milk on postweaning weight gain of heifer calves on a Californian dairy

A.A. Jamaluddin¹, D.W. Hird^{*}, M.C. Thurmond, T.E. Carpenter

Department of Medicine and Epidemiology, School of Veterinary Medicine, University of California, Davis, CA 95616, USA

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Abstract

The effect of preweaning feeding of pasteurized colostrum and pasteurized waste milk on postweaning performance of dairy heifers on a dairy in the Central Valley of California was investigated as an extension of a clinical trial examining the effect of preweaning growth and morbidity on performance at weaning. Of the 150 heifer calves originally enrolled in the field trial, 115 calves (59 treatment, 56 controls) were followed to about 6 months of age, during which time their weights were measured. After weights were adjusted for several potential risk factors and effect modifiers, calves fed pasteurized colostrum and pasteurized waste milk were 3.7 kg heavier at 180 days of age than those fed nonpasteurized colostrum and nonpasteurized milk.

Keywords: Cattle; Weight gain; Pasteurization

1. Introduction

A previous study indicated that feeding pasteurized colostrum and pasteurized waste milk to calves during the preweaning period resulted in reduced morbidity and improved weight gain compared with those fed nonpasteurized colostrum and nonpasteurized milk (Jamaluddin, 1995). Although several studies had examined the effects of previous exposure to waste milk on postweaning performance, they were focused mainly on examining an association between feeding of waste milk during calthood and develop-

^{*} Corresponding author: Tel. (916) 752-7675; Fax. (916) 752-0414; Email. dwhird@ucdavis.edu.

¹ Present address: Veterinary Research Institute, 59 Jalan Sultan Azlan Shah, 31400 Ipoh, Perak, Malaysia.

ment of mastitis at first milking (Schalm, 1942). Recent studies have shown no association between feeding waste milk to preweaned heifers and subsequent incidence of subclinical mastitis (caused by *Streptococcus agalactiae* and *Staphylococcus aureus*) (Barto et al., 1982; Roberson et al., 1990).

Studies on children have shown an association between the level of bacterial contamination of food and post weaning growth rates (Martorell et al., 1975; Condon-Paoloni et al., 1977; Coates, 1980; Bairagi et al., 1987; Cebu Study Team, 1991; Cebu Study Team, 1992; Walker et al., 1992; Adair et al., 1993). Similar studies in animals have indicated that feeding neonates with diets low in bacteria led to a lower incidence of gastrointestinal disorders and improvement in growth compared with animals that received diets with higher levels of bacterial contamination (Coates, 1980; Speck, 1983; Black et al., 1984b).

In calves, one possible approach to reduce gastrointestinal disease and perhaps subsequent malabsorption during the preweaning period may be through feeding of pasteurized milk (Coates, 1980; Jamaluddin, 1995). If diarrhea with accompanying gut inflammation and possible permanent reduction in gut absorption can be reduced during the preweaning period by feeding pasteurized milk, postweaning growth would be expected to be better for calves consuming pasteurized milk than for those consuming raw milk.

The objective of this observational study on a Californian dairy was to evaluate the effect of feeding pasteurized colostrum and pasteurized waste milk (versus unpasteurized colostrum and waste milk) during the preweaning period on postweaning weight gain of dairy heifers, controlling for demographic and morbidity variables simultaneously.

2. Materials and methods

2.1. Source of preweaning morbidity and growth data (previous trial)

One hundred and fifty Holstein-Friesian heifer calves, assessed as clinically healthy (i.e. calves that breathed, walked and nursed normally) had been enrolled in a clinical trial which lasted from birth to weaning at 10–12 weeks of age on a dairy milking 5000 cows in the Central Valley of California (Jamaluddin, 1995). The dairy was organized into five smaller dairies, four of which were about 1.5 km from each other; the fifth was located about 4 km from the others. Calves in this study originated from all five dairies and were raised at one site. Seventy-five of the calves in the previous trial were assigned to the treatment group (based on the dam's eartag number) and fed 2–4 l of pasteurized colostrum (obtained by pooling colostrum from all five dairies) within 2–3 h after birth, followed by pasteurized waste milk at 4 l day⁻¹ until weaning. Waste milk originated from cows with mastitis or other disorders, and treated with antibiotics. The other 75 calves were assigned to the control group and were fed the same quantities but of nonpasteurized, pooled colostrum and nonpasteurized waste milk. Daily, colostrum and waste milk from all five dairies were taken to a pasteurization site, pooled, and later divided into quantities to be fed either pasteurized or nonpasteurized. Calves were

housed individually in hutches and identified by an eartag. Calves were run concurrently; treated and control calves were placed in separate, adjacent rows of hutches on the same premises. Grain feeding consisted of calf-starter pellets (crude protein (CP), 22% dry matter (DM) basis; crude fat, 2.5% DM basis; crude fiber, 8% DM basis) and water ad libitum from the third day after birth until weaning. Age at occurrence, severity, and duration of each episode of diarrhea and respiratory signs were recorded daily after feeding by a trained worker supervised by the senior author, from birth to weaning. For calves with an episode of diarrhea or respiratory disease signs, recurrence of signs after 2 consecutive sign-free days was considered a new episode. Calf weight measured by a trained worker was estimated at birth and once every week until weaning using a heart-girth tape (Nasco Agricultural Science, Modesto, CA). The evaluator was not blinded regarding treatment group.

2.2. Postweaning growth data (present study)

Four of 75 calves in the control group from the previous study died during that study (crude mortality rate, 2.67%); no deaths occurred in the 75 calves in the treatment group. All calves ($n = 146$) were weaned at about 80–90 kg and moved from individual hutches into several common pens where they were mixed with weaned calves from several calf-raising areas on the dairy. Fifty-nine of 75 calves in the treatment group continued into the postweaning study; as part of the farm's normal culling procedure, eight freemartin calves and eight small calves were removed from the original study group at weaning, for later sale as beef. Of the 71 remaining calves in the control group, 56 were continued to the postweaning study; of the original group four freemartin calves and 11 small calves were removed. All weaned calves were placed in several dirt pens (approximately 30 m \times 30 m) that accommodated about 200 calves until about 6 months of age. Calves were fed a grain mixture (CP, 22% DM basis; crude fat, 2.5% DM basis; crude fiber, 8% DM basis) and alfalfa hay; water was provided twice daily. Calves were weighed at 34, 69 and 99 days after weaning during September–November, 1993.

2.3. Statistical analysis

2.3.1. Overall growth curve

Scatterplots of preweaning and postweaning weights versus age were created to visualize how the weights of the two treatment groups differed with time. An orthogonal polynomial function of degree 1 to 5 was fitted to the weight data using BMDP5R (Jennrich, 1993). The function with the greatest overall fit (that with the least significant *F*-statistic) was used to provide subjective comparison of calf overall weight gain between treatment and control groups.

2.3.2. Comparison of postweaning growth

Owing to the time-series nature of the postweaning weight data, autocorrelation was expected and subsequently tested by the Durbin–Watson statistic using ordinary least square regression (Shazam, 1993). Postweaning weights of calves were compared between the treatment groups, simultaneously controlling for age, birth weight, and

number of days calves experienced diarrhea and pneumonia during the preweaning period using a time series cross section regression (PROC TSCSREG) (Statistical Analysis Systems Institute Inc., 1993). Diarrhea was defined as watery or loose, unformed feces excreted in voluminous amounts. Severity was scored as 0 for no diarrhea, 1 for mild, 2 for moderate and 3 for severe diarrhea. Pneumonia was defined as the presence of respiratory signs such as coughing or dyspnea requiring treatment, and was scored in the same manner as diarrhea. Evidence of interaction between treatment and postweaning weight versus age was also examined, the presence of which indicated that postweaning weight gain pattern differed between the treatment groups. The Da Silva model was used to accommodate the structure of random error arising from correlated weight data. This model used a variance component and moving average method that took into account the varying effect of weight between animals for a particular age of weighing. The parameters were estimated using two-stage generalized least square regression (PROC TSCSREG) (Statistical Analysis Systems Institute Inc., 1993).

3. Results

3.1. Overall growth curve

A scatterplot of weight data from birth to the end of the study for treatment and control calves is shown in Fig. 1. A third degree polynomial function fitted to the weight data produced a good fit (unadjusted $r^2 = 0.9$) and showed an apparent slight difference

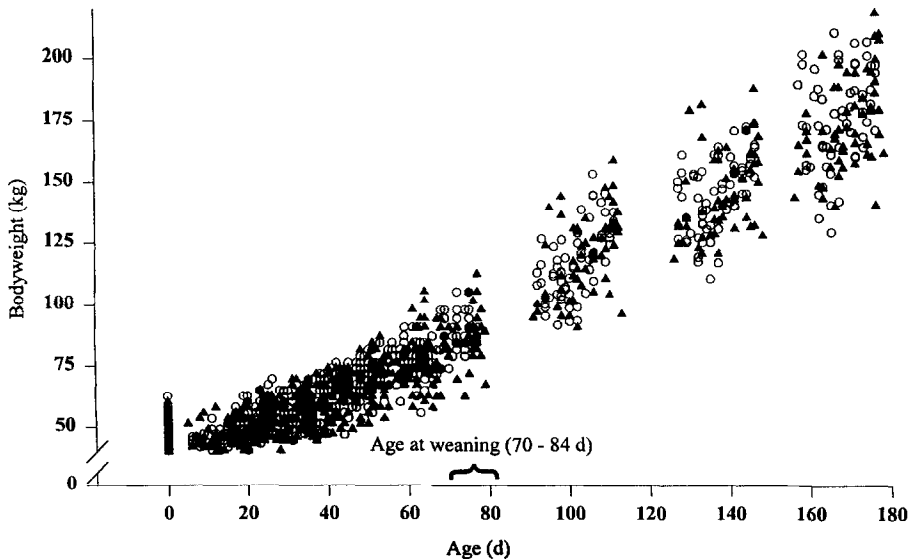


Fig. 1. Body weight of replacement heifers from birth to 6 months fed pasteurized milk (open circles) ($n = 70$) and nonpasteurized milk (solid triangles) ($n = 68$) in the preweaning period on a dairy in Central Valley, California.

Table 1

Estimates of regression parameters ^a from the Da Silva model of time series cross-section regression analysis of postweaning weight (kg) data of calves fed pasteurized milk ($n = 59$) and nonpasteurized milk ($n = 56$) on a Californian dairy

Parameter	Estimate	Asymptotic SE	P-value
Intercept	-32.633	14.624	0.03
Treatment ^b	-5.993	4.094	0.14
Age at weighing ^c	0.856	0.056	<0.001
Birth weight	0.601	0.124	<0.001
Treatment \times Age ^d	0.053	0.023	0.02
Days with diarrhea	-0.534	0.417	0.20
Days with pneumonia	-0.681	0.483	0.16

^a Obtained from the Da Silva model of time series cross-section regression analysis.

^b 1, pasteurized milk; 0, nonpasteurized milk.

^c With three levels, i.e. 34, 69, and 99 days post-weaning (when animals were weighed).

^d Interaction term.

in pattern between treatment and control groups. No statistical comparison was made between the polynomial functions of the treatment and control calves because weight data were not independent.

3.2. Comparison of postweaning growth

There was a positive first order autocorrelation in the postweaning weight data as indicated by the Durbin–Watson statistic, DW, of 0.985 (with $D = 0.512$) ($P < 0.01$).

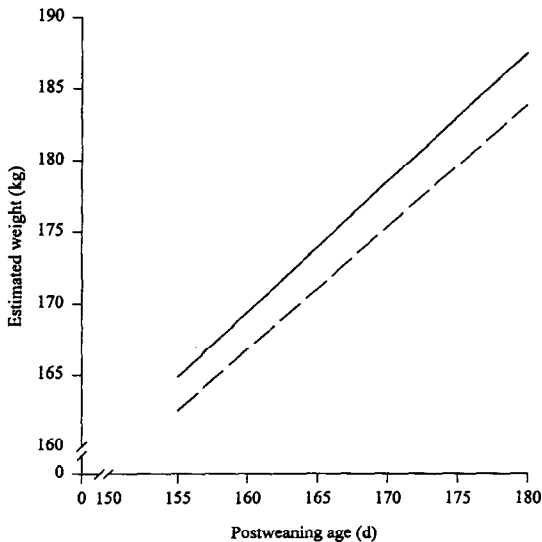


Fig. 2. Mean estimated weight (kg) versus postweaning age for groups of calves fed pasteurized (solid line) ($n = 59$) and nonpasteurized (broken line) ($n = 56$) milk on a dairy in Central Valley, California.

Results of the time series cross-section regression analysis using the Da Silva method of adjustment for autocorrelation indicated the presence of interaction between treatment and postweaning age, suggesting that treatment calves had a better postweaning weight gain pattern than control calves ($P < 0.05$) (Table 1). This interaction is illustrated in Fig. 2 using the unadjusted data (i.e. not data from the Da Silva model). At 180 days of age, calves in the treatment group were estimated to be 3.7 kg heavier than calves in the control group. Calves that experienced several days of diarrhea, pneumonia, or both during the preweaning period tended to be lighter than calves with little or no diarrhea and/or pneumonia, although this difference was not statistically significant ($P > 0.05$) (Table 1).

4. Discussion

Results of the present study indicated that calves fed pasteurized colostrum and pasteurized waste milk during the preweaning period continued to perform better after weaning than those fed nonpasteurized colostrum and nonpasteurized milk. We were not able to demonstrate compensatory growth in calves fed nonpasteurized colostrum and nonpasteurized milk before weaning, during the period between weaning and approximately 180 days of age. This was despite the fact that the calves appeared healthy and their diet seemed nutritionally adequate. At about 3 months after weaning, significantly higher postweaning weight was observed for calves fed pasteurized milk compared with those fed nonpasteurized milk, after adjusting for potential confounding factors, effect modifiers, and multiple observations from the same calf. Our results provide evidence that the benefit of feeding milk with lower bacterial count to calves persisted for a period of at least 3 months after weaning.

Several explanations may be offered for the results observed in the present study. In the preweaning trial (Jamaluddin, 1995), calves fed pasteurized colostrum and milk had onset of diarrhea 1 day later, experienced 1 day less of diarrhea in the preweaning period, and suffered less severe diarrhea than calves fed nonpasteurized milk and colostrum. Calves fed pasteurized colostrum and pasteurized waste milk may have had a healthier gut environment during the preweaning period and at weaning and hence experienced reduced morbidity and better weight gain than those fed nonpasteurized colostrum and nonpasteurized milk. This is in line with studies in children which demonstrated that gut flora with predominantly *Lactobacillus* and *Streptococcus* species were associated with less gastrointestinal disease (Coates, 1980; Speck, 1983) than gut flora with predominantly *Escherichia coli* (Black et al., 1984b).

Another explanation is that inflammation of the gastrointestinal mucosa may result in permanent damage to affected tissues, depending on its severity, and hence adversely affect assimilation and absorption (Black et al., 1984a). Diarrhea may affect growth by depriving growing cells of nutrition needed for growth (Torres et al., 1971; Torres-Medina et al., 1985; Hall et al., 1988). When a calf has diarrhea, perhaps as a consequence of consuming milk with a high bacterial count, the intestinal epithelium may undergo extensive damage, resulting in conditions such as pseudomembranous ileitis, mucohemorrhagic colitis or proctitis, as observed in *E. coli* infection (Schoonderwoerd et al., 1988; Janke et al., 1990). Other conditions of the intestinal epithelium

that may reduce absorption and assimilation include villous fusion, villous atrophy, or crypt hyperplasia, as observed in rotavirus infection, or villous atrophy of large and small intestines with destruction of crypt epithelium, as in coronavirus infection (Radostits et al., 1994). Damaged epithelium may result in reduced normal nutrient absorptive function of the intestine, while new epithelial cells regenerate, or damage to the epithelium may be too extensive for normal repair to take place, resulting in permanent malnutrition of calves. Consequently, calves fed pasteurized milk would be expected to have less compromised intestinal function even after weaning, and would continue to show better growth than calves fed nonpasteurized milk. Several studies conducted on humans (Black et al., 1984a; Barker and Osmond, 1986; Ebrahim, 1989) and in animals (Waltner-Toews et al., 1986; Correa et al., 1988; Thurmond and Paré, 1993) found a similar relationship in that neonatal morbidity adversely affected subsequent performance.

In our study, signs of respiratory disease early in calthood were associated with poor weight gain after weaning, although the association was not statistically significant. Our finding is consistent with those of previous studies that found a negative association between calthood pneumonia and weight gain (Thurmond and Paré, 1993), calving performance (Correa et al., 1988), and survivorship (Waltner-Toews et al., 1986). Calves that experienced many episodes of pneumonia took longer to reach 200 lb (Thurmond and Paré, 1993). Children exposed to acute respiratory infection had damaged airways, which caused abnormalities to respiratory function to persist into adulthood (Colley et al., 1973; Pullan and Hey, 1982; Mock and Simpson, 1984; Barker and Osmond, 1986).

Even though the negative associations we observed between preweaning exposure to diarrhea and pneumonia episodes and postweaning weight gain were not statistically significant (perhaps attributable to small sample size), there is evidence for similar (statistically significant) effects in human studies. For instance, several large, population-based, longitudinal surveys demonstrated that sick children did not grow as well as children who were not sick (Martorell et al., 1975; Condon-Paoloni et al., 1977; Black et al., 1984b; Bairagi et al., 1987; Cebu Study Team, 1991; Cebu Study Team, 1992; Walker et al., 1992).

5. Conclusions

We speculate that findings from this study may be applicable to other dairies, and that similar benefits from feeding calves pasteurized colostrum and pasteurized waste milk would be observed on other dairies. However, it must be emphasized that this study was performed on only one dairy, and therefore the results of this study do not necessarily apply to other dairies.

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