

## A TECHNICAL NOTE ON ARTIFICIAL MILK FEEDING OF RABBIT KITS WEANED AT 14 DAYS

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**ABSTRACT :** The effect of early weaning on kit growth and survival performance using an artificial milk feeding regimen was investigated. New Zealand White kits (n = 191) from 23 litters were either naturally or artificially fed a milk diet. The artificial milk diet (A) consisted of a commercial milk replacer which was fed from days 15 to 21, following weaning at 14 d postpartum. Control litters (C) nursed their dams until d 28 when they were weaned. From 15 to 21 d, half of the amount of milk consumed by C kits at the same age was fed to A kits via a stomach tube. Both C and A kit body weights (BW) were recorded weekly from 0 to 70 d. Litter variables measured on a weekly basis included 0 to 70 d litter size (LS), 28 to 70 d total feed intake (FI), and market weight uniformity (coefficient of variation in BW among littermates, CV). Least squares models for individual kit and litter traits consisted of diet treatment (T), litter within T, weeks of age (W), T\*W interaction, and residual error. No initial (14 d) treatment differences existed for

LS, LW or CV (P>0.05). From weekly BW analyses, C fryers were heavier at 70 d of age than A fryers by 0.20 kg (P < 0.05). The LS at 70d was numerically but not significantly larger for C than A litters (6.83 vs 5.75 kits, respectively). There was no significant treatment difference for CV at 70 d (8.30 and 7.72% for C and A, respectively). Total FI was numerically lower for A than C (29.16 and 25.83 kg, respectively). From a contingency  $\chi^2$  analysis, survival rate from 14 to 70 d (86.2 and 93.8% in A and C litters) was independent of treatment (P>0.05). Artificial feeding of kits is technically possible, although this method may not be economically feasible. In addition to the observed decrease in growth and survival performance, the high cost of artificial milk and the degree of skill involved are limitations of this method. Despite our negative preliminary results, this potential application warrants further investigation.

**RESUME :** Note technique sur l'allaitement artificiel de lapereaux sevrés à 14 jours.

Les auteurs ont étudié l'effet du sevrage précoce avec utilisation d'un aliment lacto remplaçant sur la croissance et les taux de survie des lapereaux. Des lapereaux Néo-zélandais blancs (n = 191) provenant de 23 portées ont été allaités soit naturellement soit artificiellement. Le lait artificiel était un substitut du commerce qui a été donné aux âges de 15 et 21 jours après un sevrage qui a eu lieu 14 jours post partum. Les portées de contrôle (C) ont été nourries par leur mère jusqu'à 28 jours puis sevrées. De 15 à 21 jours la moitié de la quantité de lait consommée par les lapereaux C au même âge a été délivrée aux lapereaux A via une canule stomacale. Les poids vifs des lapereaux A et C ont été hebdomadairement enregistrés de 0 à 70 jours. Les variables prises en compte sur une base hebdomadaire sont la taille de la portée entre 0 et 70 jours (LS), la consommation alimentaire totale entre 28 et 70 jours (FI) et la conformité au poids de vente (coefficient de variation du poids vif à l'intérieur des portées, CV). Une comparaison par la méthode des moindres carrés concernant les caractéristiques de chaque lapereau ou de la portée a été appliquée dans un modèle

comprenant les effets du régime (T), de la portée intra régime, de l'âge en semaines (W), l'interaction T\*W et l'erreur résiduelle. Il n'y a pas de différence entre les lots à 14 jours pour LS, LW ou CV (P>0.05). L'analyse des poids vifs (BW) enregistrés hebdomadairement montre que à 70 jours les lapins du lot C étaient plus lourds de 0,2 kg (P<0.05) que ceux du lot A. La différence de taille de la portée à 70 jours était en faveur du lot C par rapport au lot A mais non significative (6,83 vs 5,75 lapereaux, respectivement). Il n'y avait pas de différence significative à 70 jours entre les lots concernant le CV (8,30 et 7,72% pour C et A respectivement). L'ingéré total (FI) était plus faible pour C que pour A (29,16 et 25,83kg, respectivement). L'analyse des  $\chi^2$  montre que le taux de survie entre 14 et 70 jours (86,2 et 93,8% pour les portées A et C) était indépendant du traitement (P>0.05). L'allaitement artificiel des lapereaux est techniquement possible mais économiquement irréaliste. De plus, la diminution de la croissance et des taux de survie, le coût élevé du lait artificiel et la grande habileté nécessaire sont les facteurs limitant de cette méthode. Malgré ces premiers résultats négatifs, les utilisations potentielles de cette méthode mériteraient des recherches plus approfondies.

### INTRODUCTION

Techniques have been developed for feeding newborn rabbits to produce specific-pathogen-free rabbits using rabbit milk (APPEL *et al.* 1971; DABARD *et al.* 1976) or artificial diets (BACQUES *et al.* 1980) from birth to 14 d or more. Prud'hon and Bel (1968) reported success at weaning at 14 d using milk powder and pelleted feed. They suggested that weaning at 14 d, coupled with post-partum rebreeding, might improve reproductive performance of the does. Subsequent studies (MCNITT and MOODY, 1992, 1993) have not confirmed the reported success with early weaning. Those authors reported difficulties in training the 14 d weaned rabbits to eat solid food. The method, despite the potential benefits, has not been accepted by the commercial industry.

Hand feeding of early weaned kits using an artificial milk formula could effectively reduce lactation stress on the doe, especially in early post-partum breeding

regimens, thereby doe production efficiency could be generally improved. In addition, artificial feeding of kits using measured quantities of milk formula could circumvent the otherwise natural competition for milk that occurs among siblings (especially in large litters), thereby reducing mortality levels and possibly improving uniformity of market weight. The survival of kits and the longevity of does could also be expected to improve. The above goals should be obtainable with more research on artificial milk feeding of rabbit kits.

Our research objective was to examine individual fryer growth response and preweaning and postweaning litter trait performance as associated with combined 14 d weaning and artificial milk feeding.

### MATERIALS AND METHODS

#### Animals and management

The commercial Ozark strain of New Zealand White rabbits was used. The experiment was conducted from

**Table 1 : Numbers of animals by treatment group<sup>a</sup>**

Item	Control	Experimental p	Total
Sires	8	5	13
Dams	11	11	22
Litters	11	12	23
Offspring <sup>b</sup>	95	96	191

<sup>a</sup>Treatments:

Control = litters reared by dams and weaned at 28 d, Experimental = litters weaned at 14 d and fed an artificial milk replacer diet from 15 to 21 d of age

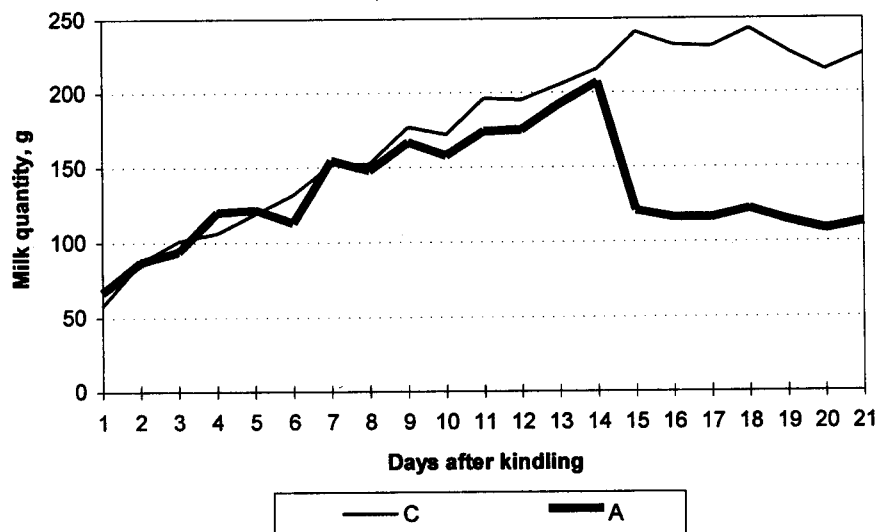
<sup>b</sup>Total litter size born alive

February to April 1995 at the rabbit research facility at Texas A&M University-Kingsville. Rabbits were housed in all-wire cages (76 x 76 x 46 cm) with a 16:8 L:D ratio. Water was continuously available via an automatic watering system. Lactating does and fryers were fed a commercial pelleted rabbit diet (Nutrena®, Cargill-Nutrena Feeds Division, Minneapolis, MN) containing 10.6% moisture, 16.1% crude protein, 7.7% ether extract, 20.3% ADF, 38.2% NDF, and 9.3% ash. Producing does and litters were fed *ad libitum*.

Does were remated 14 d after kindling and palpated 14 d later. Open does were remated immediately. Pregnant does were provided nest boxes 28 d post service. All matings were made at random with the restriction that repeat matings and matings involving closely related animals were avoided in subsequent litters.

Table 1 summarizes the number of litters and rabbits used in this study for control group (C rabbits) and experimental group (A rabbits). Four dams contributed two litters. A total of 191 kits were involved.

**Figure 1 : Lactation curves for does weaning litters at 28 d (1 to 21d ; C) or at 14 d (1 to 14 d ; A) and level of artificial milk feeding of A litters from 15 to 21 d.**



### Artificial kit feeding

To regulate the time of nursing of litters from d 1 to 14, a wire (1.27 cm mesh) top was placed on the nest box. Each day, kits were first weighed and then allowed to nurse their dams. After being nursed, kits were weighed again to estimate total milk consumption, via weigh-suckle-weigh method (LUKEFAHR *et al.*, 1983). Daily lactation yields were averaged by group and plotted to determine pre-treatment differences (Fig. 1). From d 15 to 21, experimental kits were artificially fed (A) once a day in the early morning hours to mimic the natural nursing behavior of the doe (ZARROW *et al.*, 1965; HUDSON and DISTEL, 1982, 1990). Weaning involved transferring the 14 d-old litter with their nest box to an empty cage. The same weigh-suckle-weigh procedure was continued from 15 to 21 d for control (C) litters. To standardize the milk intake, mean milk consumption per kit in C litters was used to determine the amount of milk received by A kits of the same age. From d 15 to 21, A kits were fed only half the average milk consumption of C kits (Figure 1). On d 15 to 21, C kits consumed, on average, 33.6, 32.4, 32.2, 33.9, 31.8, 30.0 and 31.5 g of milk, respectively. The A kits were fed exactly half this quantity. Our rationale for providing milk was to promote early consumption of pellets, while minimizing possible digestive/pathological conditions, especially those related to changes in the microbial populations of the gut due to changes in feed (FONTY *et al.*, 1979). In preliminary trials, some difficulties were encountered in delivering the total milk quantity consumed by C kits to the artificially milk fed kits. We therefore decided to feed half that amount. Between 15 and 21 d, A kits were presented with mashed pellets and a water bottle to facilitate the transition from a liquid (milk) to a solid, pelleted diet. After d 21, the diet consisted solely of rabbit pellets. The C litters were weaned at d 28 by being placed as an intact litter into a separate cage until 70 d (market age).

The artificial milk diet was a commercially available dry powder formulation used for young felines (KMR®, Pet-Ag, Hampshire, IL) with a guaranteed analysis of 40% crude protein (minimum), 27% crude fat (minimum), 5% moisture (maximum), 7% ash (maximum), and 0% crude fiber. Our rationale was that commercial producers could easily obtain the KMR® product, pending successful experimental results.

Water was boiled for five min and allowed to cool to approximately 37 °C before being

**Table 2. Litter trait performance (LSM ± SEM) due to treatment**

Trait <sup>a</sup>	Control <sup>b</sup>	Experimental <sup>b</sup>
LS14	7.17 ± 0.50	6.67 ± 0.55
LW14	1.53 ± 0.11	1.41 ± 0.11
CV14	15.31 ± 1.82	12.97 ± 1.82
BW14	0.215 ± 0.06	0.204 ± 0.06
BW21	0.338 ± 0.06	0.255 ± 0.08
BW28	0.517 ± 0.06	0.355 ± 0.08
FI15-28 <sup>c</sup>	5.52 ± 0.33	4.63 ± 0.39
FI28-70	29.16 ± 2.16	25.83 ± 2.25
LS70	6.83 ± 0.47	5.75 ± 0.47
BW70	2.00 ± 0.06 <sup>e</sup>	1.80 ± 0.07 <sup>d</sup>
CV70	8.30 ± 1.52	7.72 ± 1.66

<sup>a</sup>Trait abbreviations: LS14 = litter size at 14 d; LW14 = total litter weight at 14 d, kg; CV14 = within-litter uniformity (coefficient of variation for 14 d body weight among full-sibs), %; BW14, BW21 and BW28 = kit body weight at 14, 21 and 28 d, kg; FI15-28 and FI28-70 d = total litter feed intake, kg; LS70 = litter size at 70 d; BW70 = fryer body weight at 70 d, kg; CV70 = within-litter uniformity (coefficient of variation for 70 d body weight among full-sibs), %.

<sup>b</sup>Control = litters reared by dams from 1 to 28 d; Experimental = litters weaned at 14 d and fed an artificial milk replacer diet from 15 to 21 d of age.

<sup>c</sup>In control litters the FI accounted for doe and litter consumption, whereas in experimental litters the FI accounted for litter consumption and 0.15 kg of feed consumed daily by the doe.

<sup>d,e</sup>Values in the same row lacking a common superscript letter differ at the probability level of  $P < 0.05$ .

added to the dry powder (dilution rate of 35 g of milk powder to 65 ml of water). The mixed formula approximated the nutrient composition found in rabbit's milk from 14 to 21 d with 13% crude protein and 9% crude fat (LEBAS, 1971), although the DM content was actually higher than that of rabbit's milk. The milk formula was usually prepared on the day of feeding. Prior to feeding, the milk was warmed on a hot plate to a temperature of 37 °C. Unused milk was refrigerated at 5 °C until the next feeding. Milk was not kept beyond 48 h to prevent spoilage.

The equipment used for hand feeding consisted of a modified cat urinary catheter (manufactured by Monoject, Division of Sherwood Medical, St. Louis, MO 63103), a 10 ml hypodermic syringe and a lubricant (KY Jelly®). The lubricant eased the insertion of the catheter through the esophagus and into the stomach of the kit. Once the catheter was properly placed (determined by a mark on the catheter), a syringe was attached and the calculated quantity of warmed milk formula was slowly discharged through the catheter. After feeding was completed, the catheter was gently removed. Generally, the time required to insert the catheter and deliver the formula to feed each kit varied from three and five min. In some cases, however, less than 30 sec was involved.

#### Fryer and litter traits studied

The numbers of kits born alive and dead were recorded. No attempt was made to equalize litter size,

either between or within groups. Newborn kits were individually weighed and identified using a felt pen marker. Litter size at 14 d differed between C and A groups by approximately one-half kit (7.17 and 6.67 kits, respectively). Individual kit body weights (BW) and litter size (LS) were recorded weekly from birth to 70 d for both C and A kits. Total litter feed intake (FI) was measured from 28 to 70 d. Feed consumption of A and C litters was recorded from 15 to 28 d, whereas feed consumption in the latter group included that of the doe. During the same period, does that reared A litters were fed 0.15 kg of feed daily. Uniformity was determined based on individual 70 d BW among siblings, and expressed as the within-litter coefficient of variation (CV).

#### Statistical analysis

Individual kit body weight and litter trait data were analyzed according to a split-plot design using the LSMLMW software package by HARVEY (1990). The statistical model was as follows:

$$Y_{ijkl} = \mu + T_i + I_{ji} + W_k + (T*W)_{ik} + \epsilon_{ijkl}$$

where

$Y_{ijkl}$  = observed value of a given dependent variable,

$\mu$  = overall mean;

$T_i$  = fixed effect of the  $i^{\text{th}}$  treatment ( $i = C$  or  $A$ ),

$I_{ji}$  = random effect of the  $j^{\text{th}}$  litter nested within the  $i^{\text{th}}$  treatment, assumed to be NID ( $0, \sigma^2_{I}$ );

$W_k$  = fixed effect of the  $k^{\text{th}}$  week of age of the litter ( $k = 0$  through 10 wk);

$(T*W)_{ik}$  = fixed effect due to treatment by week interaction,

$\epsilon_{ijkl}$  = the random error, assumed to be NID ( $0, s^2_{\epsilon}$ ).

For plotting best fit response curves, the sum of squares due to  $T$ ,  $W$  and  $T*W$  were partitioned from ANOVA results to obtain orthogonal polynomial prediction equations (HARVEY, 1990). For analysis of end-point litter traits (e.g., LS, LW and CV at 14 d, LS and CV at 70 d, and 15 to 28 and 28 to 70 d FI), all sources of variation in the above model were eliminated except for the treatment effect. In addition, a contingency Chi-square analysis was used to test whether 14 to 70 d survival rate was related to treatment.

## RESULTS AND DISCUSSION

#### Individual fryer growth response

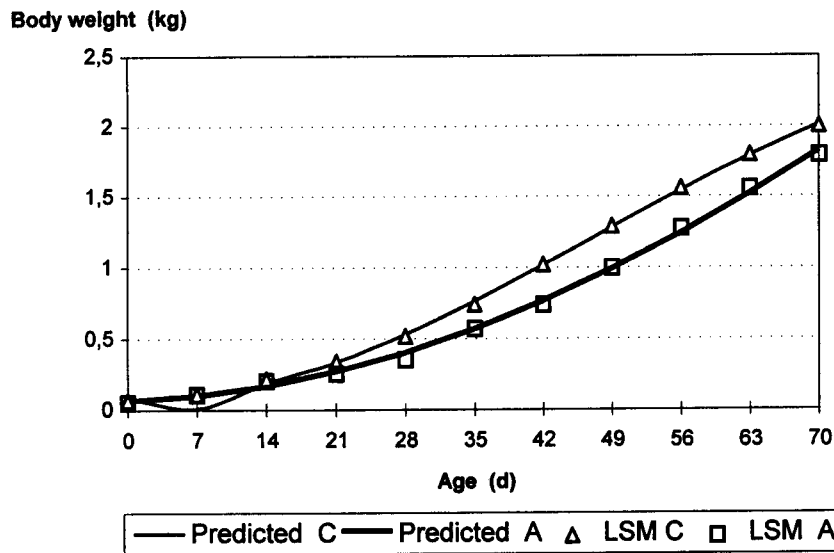
Individual weekly growth rate from birth to 70 d was more rapid ( $P < 0.01$ ) for C than A fryers (Figure 2). A significant treatment (linear) by week (cubic) interaction was also detected. However, there was only limited evidence of compensatory gains in experimental fryers as a result of their previous 14 d weaning age and(or) artificial milk feeding background. By 70 d, C fryers were heavier than A by approximately 0.02 kg

( $P < 0.05$ ). The prediction equation for 0 to 70 d individual fryer growth rate was:

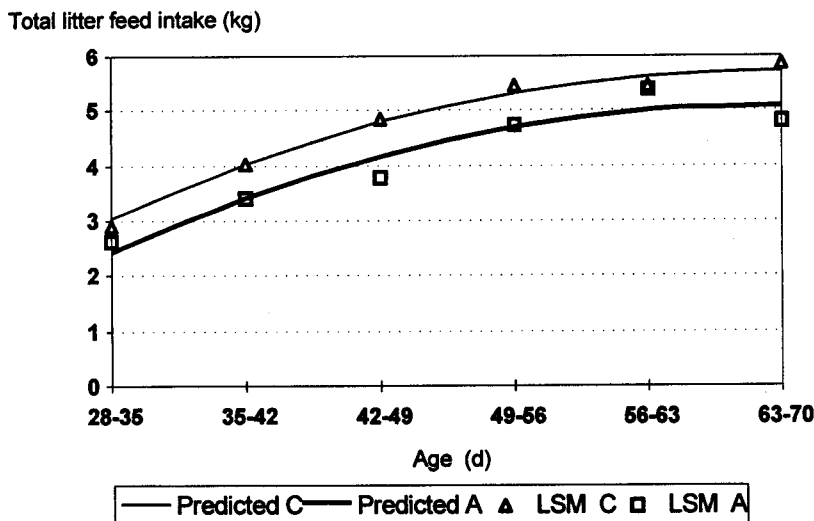
$$Y = 666.8 - 194.1(T_i - 0.5) + 30.44(W_k - 35) + 0.2701(W_k - 35)^2 - 0.0033(W_k - 35)^3 - 9.086(T_i - 0.5)(W_k - 35) + 0.0763(T_i - 0.5)(W_k - 35)^2 + 0.0055(T_i - 0.5)(W_k - 35)^3$$

where Y is a prediction of weekly individual kit BW. The C and A groups were coded as 0 and 1, respectively. When T\*W subclass least squares means were applied to orthogonal polynomial regression procedures, an outstanding fit was obtained ( $R^2 = 0.999$ ), yielding the above prediction formula.

**Figure 2 : Growth of rabbits nursed by dams and weaned at 28d (C) or weaned at 14d and artificially milk fed (A) to 21d. (LSM = Least squares means)**



**Figure 3 : Total weekly litter feed intake (FI) in liters nursed by dams and weaned at 28d (C) or weaned at 14d and artificially milk fed (A) to 21d. (LSM = Least Squares means)**



MCNITT and MOODY (1992) also reported slower postweaning growth rates in 14 versus 28 d weaned kits. In contrast, PRUD'HON and BEL (1968) compared 14 versus 49 d weaning effects (the former group was supplemented 10 g/d with milk powder formula containing 26% fat) and found no significant differences in growth rates (2 to 8 wk) or in market weight (8 wk).

**Litter trait performance**

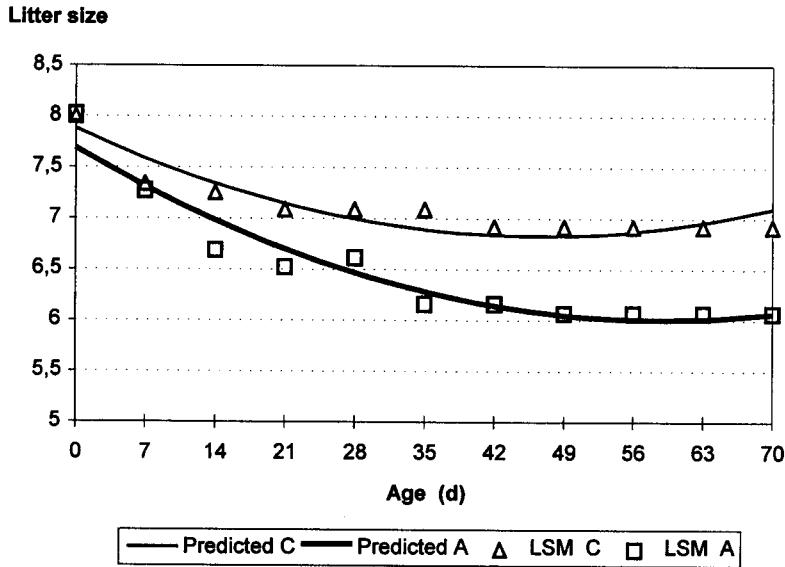
There were no significant differences between the C and A groups at 14 d for LS, LW and CV (Table 2). Individual kit body weights at 14, 21 and 28 d were not different ( $P > 0.05$ ) between treatments, although A kits were consistently lighter than C kits. At 70 d, LS for C was larger by 1.08 fryers. For A litters, average 15 to 21 d FI per kit was  $24.7 \pm 4.8$  g/d, and for 22 to 28 d FI was  $43.5 \pm 4.3$  g/d. For comparison purposes, total 15 to 28 d FI in C litters and dams was  $5.52 \pm 0.33$  kg, whereas in A litters was  $4.63 \pm 0.39$  kg (the latter figure included 0.15 kg of feed provided daily to the dam). This difference approached significance ( $P = 0.09$ ) and amounted to a feed savings of 0.89 kg. Also, when comparing A to C litters and dams for total 14 to 28 FI, the coefficient of variation was higher in the former group (30.7 versus 20.3%), suggesting that certain A litters may have been more sensitive to the artificial formula and/or management procedure. Total 28 to 70 d FI was

numerically but not significantly higher by 3.33 kg in C than in A litters. The smaller 70-d LS in A litters could also explain the lower FI. No difference was detected in CV at 70 d between A and C litters, suggesting comparable uniformity of market fryers.

Weekly plots of least squares means and fitted slopes from prediction equations for litter traits (FI, LS

and WILLIAMS-SMITH, 1966). The stress or trauma associated with artificial milk feeding might have also reduced survival, not to mention possible digestive and pathogenic problems associated with the artificial milk diet. MCNITT and MOODY (1992) noted a decrease in survival in the early (14 d) compared to 28 d weaned kits. PRUD'HON and BEL (1968) reported that mortality did not differ for 14 d weaned kits as compared to 49 d weaned kits when the pelleted diet was supplemented with a milk powder.

**Figure 4 : Litter size (LS) of litters nursed by dams and weaned at 28d (C) or weaned at 14d and artificially mild fed (A) to 21d. (LSM = Least squares means)**



**CONCLUSION**

Although the artificial milk feeding of kits from 15 to 21 d is technically possible, this practice would not appear to be an economically feasible intervention for commercial producers based on our preliminary results. The cost of the milk formula is high and this practice requires skilled labor. Although statistical differences were not always detected, growth and survival performance was numerically less than satisfactory compared to control animals. In our study, it would have been

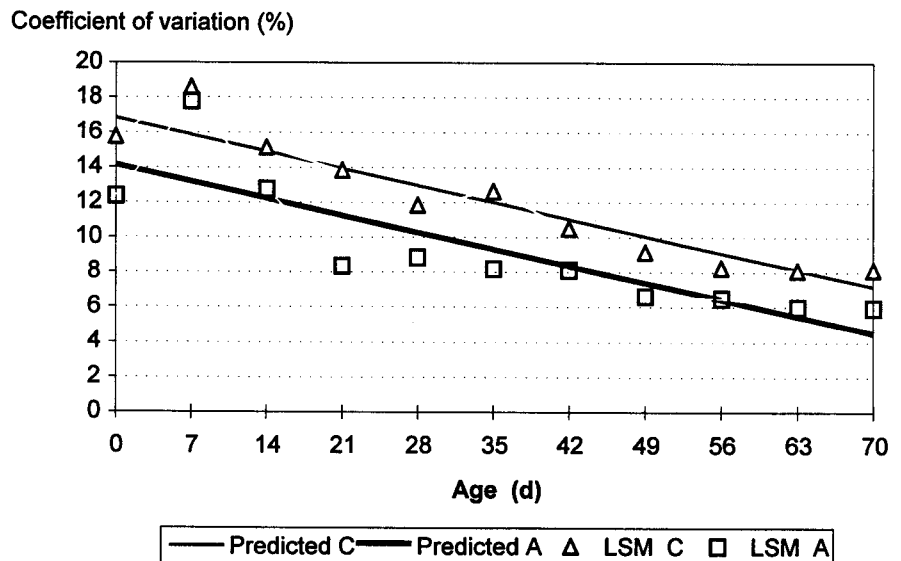
and CV) are shown in Figures 3 through 5. For all litter traits studied, best fit slopes for A and C rabbits were parallel as confirmed by non-significant treatment x week interactions. However, FI, LS and CV performance in A litters were consistently poorer than in C litters throughout the growth period. This may have been due, in part, to the lower milk quantity fed between 15 and 21 d (Figure 1). In Figure 4, the increased LS from 21 to 28 d is a mere statistical artifact since least squares means rather than actual means were plotted.

useful if another treatment group had been included involving 14-d weaned kits that were not fed the artificial milk formula.

Areas of improvement include a need for a milk

The 14 to 70 d survival rate for C (93.8%) and A fryers (86.2%) was not significantly different ( $\chi^2 = 0.10$ ;  $P > 0.05$ ). Most of the mortality in the A group occurred between 14 and 35 d. The numerically smaller 14 d LS (by 0.50 kits) and lower subsequent survival in A litters account for the smaller LS by d 70 (by 1.08 kits). With early weaning at 14 d, kits may have lacked the antimicrobial benefits of the milk (CANAS-RODRIGUEZ

**Figure 5 : Uniformity in body weight (CV) in litters nursed by dams and weaned at 28d (C) or weaned at 14d and artificially milk fed (A) to 21d. (LSM = Least squares means)**



formula specifically designed to meet the kit's nutrient requirements, and a more expeditious method for delivering the artificial milk to kits. Because of the high potential of this artificial feeding system, further research would be justified.

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