EFFECT OF FEEDING CRYSTALLINE CHOLESTEROL PLUS BUTTER ON HYPERCHOLESTEROLEMIA IN SWINE

B.Z. de Rodas[1], S.E. Gilliland[2], C.V. Maxwell[3] and M.L. Rose[4]

Story in Brief

The objective of this study was to determine the effects of dietary cholesterol on blood cholesterol concentrations in pigs. Thirty three Yorkshire barrows (4 replicates; 203 lb) with indwelling jugular catheters were fed a diet supplemented with .5% crystalline cholesterol plus 10% butter for 14 days. Blood samples were collected daily for 15 days; sera were analyzed for total, and high density lipoprotein cholesterol. Serum total cholesterol averaged 85.4 mg/dl on day 1 and increased to 294.6 mg/dl on day 15, a 2.4 fold increase with no indication of a plateau. Concentrations of high density lipoprotein cholesterol averaged 41.3 mg/dl on day 1 and 63.9 mg/dl on day 15, an increase of 55% with a tendency to plateau after 10 days. These results indicate that hypercholesterolemia can be induced in 203 lb barrows by feeding a diet supplemented with .5% cholesterol and 10% butter for 14 days. This model of induction of hypercholesterolemia will be used in future studies to evaluate factors to reduce serum cholesterol.

(Key Words: Hypercholesterolemia, Crystalline Cholesterol, Pigs.)

Introduction

Increased levels of total serum cholesterol and low density lipoprotein (LDL) cholesterol are correlated with the incidence of coronary heart disease. Thus, considerable research has been conducted to discover factors to lower serum cholesterol levels; these include dietary modifications and pharmacological agents. Some factors that lower plasma cholesterol in hypercholesterolemic individuals (Danielson et al., 1989; Gilliland et al., 1985) have no effect on individuals with "normal" plasma level (Thompson et al., 1982).

In recent decades, the pig has been used as an animal model for cardiovascular research. The pig is similar to humans in its omnivorous eating habits, cardiovascular physiology, metabolism of cholesterol, and serum lipoproteins. Furthermore, hypercholesterolemia and aortic atherosclerosis can be induced by feeding diets high in cholesterol and fat (Mahley et al., 1975; Gilliland et al., 1985; Danielson et al., 1989). Previous research, however, has provided only limited information concerning the daily increase in serum

[1]Research Associate [2]Regents Professor [3]Professor [4]Graduate Assistant

cholesterol in pigs fed diets containing high levels of cholesterol. Studies that can be used to estimate the length of time and level of cholesterol feeding necessary to create a hypercholesterolemic condition in swine are needed. Therefore, the present study was conducted to determine the temporal effects of feeding a diet high in cholesterol on hypercholesterolemia in swine.

Materials and Methods

Thirty three Yorkshire barrows (3 replicates of 8 pigs and 1 replicate of 9 pigs) weighing approximately 203 lb were surgically fitted with indwelling jugular catheters. Following recovery, all pigs were fed a diet at 12 hour intervals (1.4% BW) supplemented with .5% crystalline cholesterol and 10% butter (Table 1) for 14 days. In addition, all pigs received 250 ml of sterile 10% reconstituted nonfat dried milk just prior to feeding the dry ration as a means of training pigs to consume a dietary adjunct. Pigs had ad libitum access to water throughout the experiment. Pigs were weighed at the initiation and at the end of the trial. Blood samples were collected daily from the jugular catheter prior to the morning feeding and sera were analyzed for total and HDL (high density lipoprotein) cholesterol. The sampling period started following the convalescence period and continued for 15 days.

Nonlinear equations were fitted to total and HDL cholesterol concentrations to predict changes in these variables in response to cholesterol feeding using non-linear procedures of SAS and solved using Marquart's method. The model included the following prediction equation:
$Y=d+a[1-\exp(-b(day-1))]$ where 'Y' is the dependent variable, 'd' is the pretreatment value of Y, 'a' represents the increase in average of Y over the length of the test, and 'b' measures the rate of increase of Y.

Results and Discussion

During the 14-day period when a diet high in cholesterol was fed, serum cholesterol level increased in all animals. It increased rapidly at first and then more slowly (Figure 1). Cholesterol concentration averaged 85.4 mg/dl on day 1 (just prior to the initiation of the cholesterol feeding period) and increased to 294.6 mg/dl on day 15 (one day after the last cholesterol feeding), a rise of 209.2 mg/dl (2.4 fold increase). Figure 2 shows the daily changes in HDL cholesterol concentration in response to cholesterol feeding and the regression equation. Concentrations of HDL cholesterol averaged 41.3 mg/dl on day 1 and 63.9 mg/dl on day 15, an increase of 55% with a tendency to plateau after 10 days.

This ability to increase serum cholesterol in pigs by increasing dietary cholesterol has been reported in other studies (Gilliland et al., 1985; Danielson et al., 1989). However, previous studies have provided only limited

information concerning the daily increase in serum cholesterol in pigs fed diets containing high levels of cholesterol. The present study provides information which can be used for future studies to predict the plasma concentration of cholesterol in pigs fed a diet containing .5% crystalline cholesterol plus 10% butter for a period of 14 days. The effect on serum cholesterol appeared to be due primarily to the inclusion of crystalline cholesterol in the diet since serum cholesterol decreased to almost pretreatment values when the diet containing butter was continued without crystalline cholesterol (de Rodas et al., 1994) for a 15-day period. Training pigs to consume a dietary adjunct was successful and provides a means to test the efficacy of dietary additives as a means of reducing plasma cholesterol levels.

This research was conducted to determine the length of time and level of dietary cholesterol necessary to create a hypercholesterolemic conditions in growing swine. This defined response will be used as a model in later studies to evaluate factors which have the potential to reduce serum cholesterol. These results should facilitate the use of the pig as an animal model in hypercholesterolemia research.

Literature Cited

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Table 1. Composition of experimental diet.

Ingredient	%
Yellow corn	67.425
Nonfat dried milk	20.00
Butter	10.00
Lysine, HCl	.03
Calcium carbonate	.32
Dicalcium phosphate	1.15
Deflourinate phosphate	--
Vitamin, TM premix[b]	.25
Salt	.30
Ethoxyquin	.025
Cholesterol[c]	.50

Calculated analysis (%)	
Crude protein	12.36
Lysine	.70
Calcium	.70
Phosphorus	.60

[a] As fed basis; each ingredient presented on percentage basis.

[b] Supplied 4950 IU vitamin A, 550 IU vitamin D, 27.5 IU vitamin E, 24.75 mg pantothenic acid, 38.5 mg niacin, 6.6 mg riboflavin, 3.63 mg menadione, 27.5 ug vitamin B12, 110 mg choline, .30 mg selenium, 19.96 mg manganese, 99.79 mg zinc, 99.79 mg iron, 9.97 mg cooper and .20 mg iodine per kg of feed.

[c] Purity at least equivalent to USP/NF (Sigma Chemical Co., St. Louis, MO).

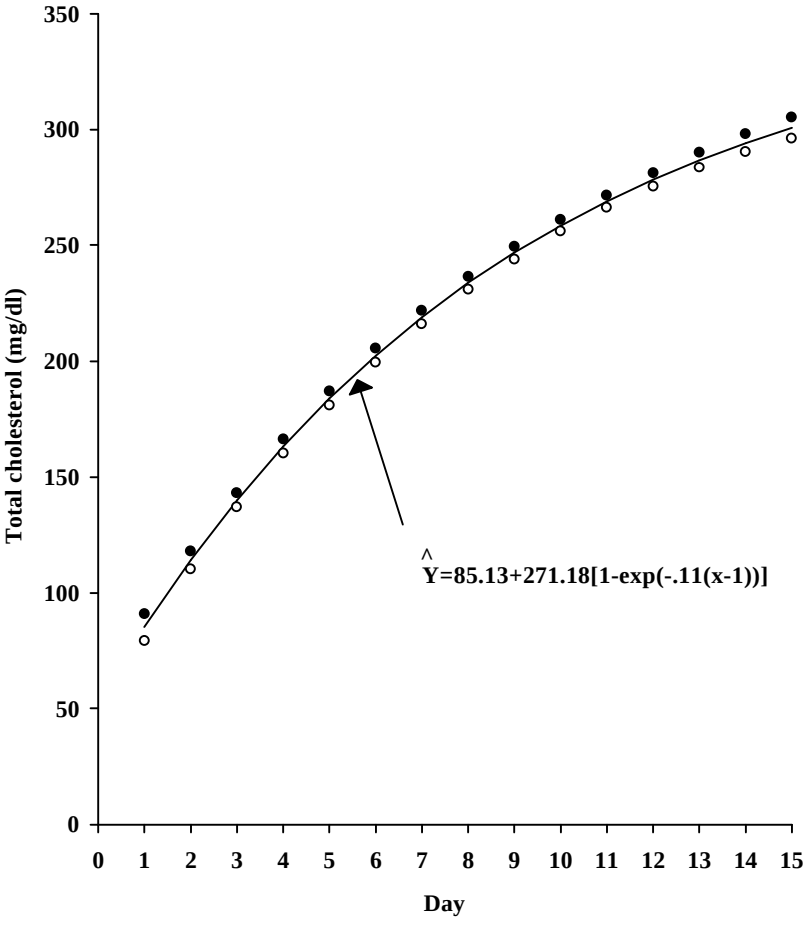

Figure 1. Regression of total cholesterol concentration on day of cholesterol feeding and upper (•) and lower (o) 95% confidence limits for the expected means.

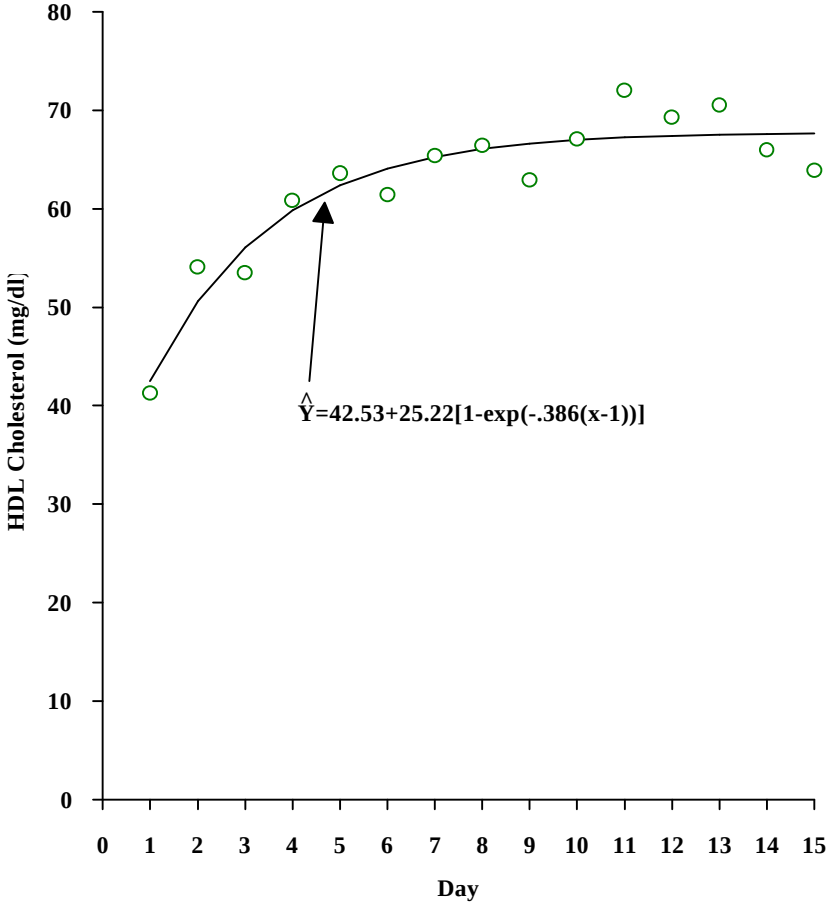

Figure 2. Regression of high density lipoprotein (HDL) cholesterol concentration on day of cholesterol feeding (o = actual means).