FATTY ACID PROFILE OF BEEF MUSCLE:

SERUM CHOLESTEROL POTENTIAL

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Abstract

Worldwide beef consumption has been impacted by the perception that diets containing beef will raise serum cholesterol. Early research implicated all saturated fatty acids while subsequent studies have shown only myristic and palmitic acid to have a consistent cholesterolemic affect. To determine if differences in cholesterolemic effect exists among beef animals, muscle samples from 230 crossbred steer carcasses were analyzed for fatty acid profile and total cholesterol. The term “cholesterol number” (CN) was applied to a value calculated from a multiple regression equation which predicts cholesterolemic affect utilizing the percentage of energy (en%) derived from C14:0 (myristic), C16:0 (palmitic), and C18:2 (linoleic) in a diet containing cholesterol. The formula was: CN = 135 + 5.2(en%14:0) + 1.5(en%16:0) - 73(Logen%18:2) + 0.18(Ch). CN was the predicted level of total serum cholesterol (mg/dl) produced in the subject which consumed the sample; the log of the energy supplied by linoleic acid was necessitated because the cholesterolemic affect of C18:2 is not linear; Ch = mg of dietary cholesterol. Further assumptions: the muscle sample was the sole diet; the diet will have no more than 30% of calories from fat and contain 300 mg cholesterol; total daily intake of 2500 calories. Sire was known on 181 of the animals. Comparison of the calculated CN was converted to an EPD of each sire for total serum cholesterol potential to a consumer. Sire group means ranged from a low of 200mg/dl to a high of 228mg/dl (p<.01) with a mean of 212mg/dl (sd = 12). Sire EPD for CN ranged from a low of -9.4 to a high of +10.4. Based on selection of the best sire (-9 4), with no female selection, two generations of selective breeding would be required to reduce the cholesterolemic potential of beef to a CN equivalent of skinless chicken meat (CN = 186). While these data suggest a selection program could be implemented to lower the cholesterolemic effect of beef, the greater significance may be that producers are perceived to provide a product which addresses consumer’s concerns.

INTRODUCTION

The effect of dietary fat on blood serum cholesterol has been the focus of studies for nearly 40 years. The generally accepted conclusion of these studies is that saturated fats raise serum cholesterol, whereas polyunsaturated fats have a lowering effect. This simplistic conclusion has had a negative impact on beef consumption worldwide. Research (Hayes and Khosla, 1992, 1996; Hajri et al., 1998; Khosla et al., 1997; Hayes et al., 1997) has accumulated toward the understanding of the relationship of the various fatty acids and/or dietary cholesterol with respect to levels of serum cholesterol. Current thinking is that among the fatty acids found in beef muscle the most significant in the bio-manufacture of cholesterol is myristic (C14:0). While some data indicates a hypercholesterolemic affect associated with dietary palmitic acid (C16:0), other researchers have suggested palmitic acid has a cholesterolemic effect only if the diet contains relatively high levels of cholesterol. Stearic (C18:0) and Oleic (C18:1) acids are considered neutral while linoleic (C18:2) is hypocholesterolemic. Because the bio-manufacture of cholesterol is dependant upon dietary fatty acids, the fatty acid profiles of various fats and oils have become marketing issues in recent years. Several research groups have developed regression equations which predict the level of total serum cholesterol of a subject based on the fatty acid profile its’ diet (Hayes and Khosla, 1992; Pronczuk et al., 1994). The potential of a given diet or individual food-stuff may thus have a calculated “Cholesterol Number” (CN) based on the ratio of the various fatty acids. Generally, diets rich in C14:0 will have a high CN while diets rich in C18:2 will have a low CN. Since fats and oils have unique fatty acid profiles and there are differences among fats of the various animal species used for human food, the question is: “are there differences among individual animals and, if so, are these differences genetically exploitable?”

Objective

To compare fatty acid profiles of beef animals grouped by sire, calculate a “Cholesterol Number” (CN) for each group based on fatty acid composition and create an EPD for “CN”.

Materials and Methods

Hanging tender (diaphragm) muscle was collected from 230 beef carcasses. Samples were denuded of visible fat and individually wrapped in oxygen vapor barrier bags, frozen and stored at –15ºC until analyzed.

Each sample was evaluated for fatty acid profile. Individual acids were expressed as a percentage of the total lipid of the sample (Folch et al., 1956).

CN was calculated on individual samples using the regression equation of Pronczuk et al. (1994). The equation is:

CN = 135 + 5.2(en%C14:0) + 1.5(en%C16:0) – 73(*log* en%C18:2) + .18(Ch)

Where:

CN = predicted total serum cholesterol of a subject consuming the diet.

En% = percent of the energy of the diet supplied by the fatty acid.

Log the cholesterolemic affect of C18:2 is not linear, therefore a log conversion was required (Pronczuk et al., 1994).

Ch = the cholesterol level of the diet in mg.

Assumptions:

- Total calories of the diet was 2500
- All the fat in the diet was from the beef sample
- The diet contained 300 mg total cholesterol

Observations were grouped by sire and averaged. Forty-nine of the samples could not be positively attributed to a specific sire. EPD for CN was for each sire group using the within herd EPD formula of Spike et al. (1995).

$$EPD_{CN} = \frac{Hh^2 \quad *}{[2(1+(N-1)t)]} (P_p - P_s)$$

Where N = offspring number per group

h^2 = assumed heritability for fatty acid profile (.5)

t = relationship among group members (.25)

P_p = population mean

P_s = sire group mean

Statistical analysis was performed using the General Linear Model (GLM) of SAS (Cary, NC).

Results

For comparative purposes, table 1 shows the C14:0, C16:0, C18:2 and calculated CN for various fats and oils. These values represent average values for the various fatty acid percentages and are from data collected in this experiment and from various published sources. Table 2 summarizes the data on the 230 samples into 22 sire groups. Although a complete long-chain fatty acid (C12:0 through C22:3) profile was established, only C14:0, C16:0 and C18:2 percentages are reported as they are the major cholesterolemic fatty acids found in beef intramuscular fat and are the components of the CN regression equation. Since these were a random sample of cattle from commercial feedlots, a relatively large numberof the steers were of unknown ancestry (group labeled NoID) and several sires were represented by one or two offspring and were pooled into a group labeled VAR. The data of both groups was included in the analysis to add to the strength of the test, however calculation of an EPD for these groups would be inappropriate. The P-values for difference among means is report in Table 2 only for CN. There are numerous differences among the means for C14:0, C16:0 and C18:2, but the focus of the study was the potential of a sire relative to the cholesterolemic affect of the fatty acid profile rather than the specific fatty acids. The EPD values are comparisons of sire group means to the overall mean and the value for each sire varies with the number of offspring represented. A direct comparison of EPDs with accompanying P values was not attempted. The range in EPDs (from -9.42 to +10.44) indicates selection for CN could successfully reduce the potential cholesterolemic affect of beef based on the fatty acid profile regression equation of Pronczuk et al. (1994) .

Table 1. Comparison of Cholesterol Number calculated for various fats and oils

Sample	C14:0 %	C16:0 %	C18:2 %	CN
Beef tallow	3.3	25.5	2.2	218.8
Lard	1.0	24.9	13.3	157.7
Mutton tallow	5.2	23.6	4.0	201.8
Butter	10.8	26.2	2.4	232.7
Corn oil	0	12.2	57.0	104.4
Olive	0	13.7	10.0	160.2
Soybean	.1	11.0	53.2	106.2
Sunflower	.2	6.8	68.2	96.7
Safflower	.1	6.5	77.7	92.2
Beef intramuscle lipid	2.48	24.56	2. 73	212.4
Lamb intramuscle lipid	3.13	22.82	8.05	176.0
Pork intramuscle lipid	1.31	24.39	9.66	168.1
Veal intramuscle lipid	1.92	23.56	10.10	167.3
Chicken white and dark lipid extract	5.0	19.0	6.1	186.2

Table 2. Percentage of Myristic, Palmitic, Linoleic Acids, Calculated Cholesterol Number and CN EPD for Various Sire groups.

Sire ID	N	C14:0 %	C16:0 %	C18:2 %	CN[a]	EPD_{chol}
A	24	2.79	23.01	3.79	200.4[w]	-9.42
B	16	2.03	25.80	2.14	218.7[yz]	4.94
C	14	2.57	26.77	2.57	217.2[y]	3.68
D	11	2.52	25.50	2.32	217.1[y]	3.35
E	10	2.72	31.02	1.75	228.4[z]	10.44
F	9	2.25	25.25	3.07	210.7[wxy]	-0.82
G	9	2.50	28.24	2.20	221.4[yz]	5.74
H	9	2.48	23.57	2.31	215.6[y]	2.20
I	8	2.25	25.65	3.07	210.7[wxy]	-0.78
J	8	2.46	27.00	3.04	211.2[wxy]	-0.45
K	8	2.65	26.03	2.42	216.4[y]	2.6
L	7	3.12	24.94	2.18	218.9[yz]	3.79
M	7	2.59	28.34	2.38	218.0[y]	3.31
N	6	2.56	22.91	2.44	213.7[xy]	0.89
O	5	2.96	22.87	2.68	211.3[wxy]	-0.35
P	4	2.89	27.75	1.98	223.3[yz]	4.66
Q	4	2.36	22.56	2.02	218.7[yz]	2.77
R	3	2.42	28.30	1.88	223.5[yz]	3.96
S	3	2.8	23.39	2.87	208.8[wxy]	-1.12
T	3	2.52	23.96	2.37	214.6[xy]	0.88
VAR	11	2.65	25.39	2.48	214.9[xy]	
UNID	49	216	20.67	3.34	202.6[wx]	

Least squares means values for C14:0, C16;0, C18:2 an CN were 2.48, 24.56, 2.73, and 212, respectively
Fatty acids determined by the method of Folch et al. (1957)
[a] CN stands for “cholesterol number” and was calculated using the equation of Pronczuk et al. (1994)
[wxyz] Means (CN) in the same column with different superscripts differ ($P > 0.01$)

CONCLUSIONS

Sufficient variation in fatty acid profile among sire groups was demonstrated to suggest selection could attain change in cholesterolemic potential of beef. Based on this data, mating the sire with the lowest EPD_{col} (-9.42) to cows of average CN = 212 (EPD_{col}= 0) would require two generations to reduce average beef CN to that of chicken and four generations to match pork, veal or lamb. By using the best half of the cow herd, the improvement could be increased to -14.2CN units per generation.

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