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PRELIMINARY RESULTS ON THE RELATIONSHIP BETWEEN CHOLESTEROL AND TRIGLYCERIDE SERUM LEVELS AND BODY WEIGHT AROUND WEANING IN PIGS

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Introduction

Cholesterol is synthesized by the liver, adipose tissue and the intestine and released into the bloodstream (YOUNG *et al.*, 1993). The part of the cholesterol not produced by the body itself may come from the ingestion of animal products, such as meat, fish, eggs, butter, cheese and milk. Cholesterol is needed to give strength to cell membranes and to serve as a template for steroid hormones, such as estrogen and testosterone. However, in humans, having too high cholesterol levels is one of the major risk factors for heart diseases (KANNEL and WILSON, 1992).

Cholesterol is transported through the blood stream in the form of lipoproteins, of which the two most commonly known are low-density-lipoprotein (LDL-C) and high-density-lipoprotein (HDL-C). LDL-C is also referred to as "bad" cholesterol, because it can contribute to the formation of plaques in the inner walls of the arteries that feed the heart and brain, a condition known as artherosclerosis, which can cause heart attack or stroke. Conversely, HDL-C is referred to as "good" cholesterol, because a high level of it protects against heart attack by preventing the build up and formation of plaques (GORDON *et al.*, 1989).

Triglycerides are chains of high-energy fatty acids, necessary for providing energy for cells to function. High triglyceride levels have been associated with heart disease often in relation with low HDL-C levels. However, there is some evidence that triglyceride levels are an independent risk factor for heart diseases (HE *et al.*, 2004).

The present study investigated Total-C, HDL-C, LDL-C and triglyceride levels in pigs. The aim of the present study was to preliminary investigate heritabilities and simple relationships between cholesterol

and triglyceride levels and body weight. Investigation of cholesterol levels in pigs may provide information on cholesterol levels in pig products for human consumption and the possibility to select for 'healthier' levels of cholesterol in pork. In addition, pigs could be used as a model for cholesterol issues in humans.

Material and Methods

The dataset used for the present preliminary investigation consisted of 103 pigs of the Duroc breed. Animals were born in August and September 2003 and where castrated sons of five sires distributed over three farms. At weaning (at 15 to 19 days of age), the pigs were moved to the test station "Centre de Control Porci" (CCP-IRTA), where they all received the same treatment. Two to three days after, body weight (BW) was taken. Blood cholesterol (Total-C, HDL-C and LDL-C) and triglyceride levels were measured once at 33 to 55 days of age. For estimates of heritabilities and phenotypic correlations, al measurements were adjusted for sire and farm according to the following model:

$$Y_{ijk} = \mu + Sire_i + Farm_j + e_{ijk}, \quad (1)$$

where μ = overall mean, $Sire_i$ = effect of sire i (1 to 5), $Farm_j$ = effect of farm j (1 to 3), e_{ijk} = error term of animal k, $e_{ijk} \sim NID(0, \sigma^2_e)$. Y_{ijk} denotes all traits tested with this model, as measured on animal k of sire i and farm j. All effects were considered to be fixed effects.

Results and Discussion

Heritabilities (± sampling variance) and means (± standard errors of the means) of Total-C, HDL-C and LDL-C and triglyceride levels in serum are presented in table 1. POND *et al.* (1986) estimated a heritability of Total-C in serum of 0.45; YOUNG *et al.* (1993) reported a realized heritability on Total-C in serum of 0.31. The high heritabilities found in this study suggest that selection for levels of these traits in serum could be successful. However, these heritabilities should be estimated with a larger number of animals in order to reduce the large sampling variance observed in this study. Further investigation should aim to determine how serum levels of cholesterol

Table 1. Heritabilities (h^2; ± approximate sampling variance), means (± standard errors of the means) and the range of normal values in humans of total cholesterol (Total-C), high-density-lipoprotein cholesterol (HDL-C), low-density-lipoprotein cholesterol (LDL-C) and triglyceride levels in serum

	h^2 (± sampling variance)	Mean (± s.e.)	Range in humans[a]
Total-C (mg/dL)	0.43 (± 0.15)	78.5 (± 1.36)	100-240
HDL-C (mg/dL)	0.30 (± 0.11)	32.3 (± 0.57)	35-100
LDL-C (mg/dL)	0.57 (± 0.24)	35.2 (± 0.87)	60-120
Triglycerides (mg/dL)	0.97 (± 0.38)	54.4 (± 2.09)	10-190

[a]Medline Plus, 2004

and triglycerides relate to levels in animal products most widely used for human consumption, such as muscle. Table 1 furthermore gives the range of normal levels of the traits in humans. The values of cholesterol levels obtained in pigs are outside this range, especially Total-C and LDL-C. This means that other ranges are applicable to

Table 2. Phenotypic correlations between total cholesterol (Total-C), high-density-lipoprotein cholesterol (HDL-C), low-density-lipoprotein cholesterol (LDL-C), triglycerides, and body weight (BW)

	Total-C	HDL-C	LDL-C	Triglycerides
HDL-C	0.79 ***			
LDL-C	0.83 ***	0.45 ***		
Triglycerides	0.38 ***	0.20 *	-0.03	
BW	0.22 *	0.10	0.30**	-0.05

***: P<0.001; **: P<0.01; *: P<0.05.

cholesterol levels in pigs. Average body weight was 4.70 (± 0.09) kg.

The results show that animals with a high Total-C level have high levels of HDL-C, LDL-C and triglycerides. Animals with high levels of HDL-C also have high levels of LDL-C and triglycerides. Also in humans a significant relationship is found between the level of triglycerides and HDL-C, but this is found to be negative (e.g., Fredenrich and Bayer, 2003; Olswold and De Andrade, 2003). In agreement with our results, in humans, PING *et al.* (2000) observed a significant correlation between total and LDL-C levels (r = 0.68).

The results show furthermore that heavier animals have higher levels of total and LD-C. In a selection experiment for serum cholesterol concentration in pigs, animals from the high cholesterol line were heavier after three generations of selection than those of the low cholesterol line (YOUNG *et al.*, 1993). In mice, DUNNINGTON *et al.* (1981) also observed an increased weight of females with selection for high cholesterol concentrations. Furthermore, in the same study selection for high body weight at 56 days was accompanied by an increase in serum cholesterol. The results are in agreement with the observation that people who are overweight have higher blood cholesterol levels than people of desirable weight. WILSGAARD and ARNESEN (2004) concluded that, in humans, an increase in body mass index was associated with adverse changes in HDL-C and Total-C, and in triglycerides. Also in the study of DEVROEY *et al.* (2004), in humans, obesity was correlated with low HDL-C and high triglycerides. In the present study in pigs, no relationship was found between BW and HDL-C or triglycerides levels. Further analysis will investigate cholesterol levels at later ages and higher body weights, which may be better for comparison with the situation in humans.

In conclusion, high heritabilities for all traits indicate the possibility to select for cholesterol and triglyceride serum levels in

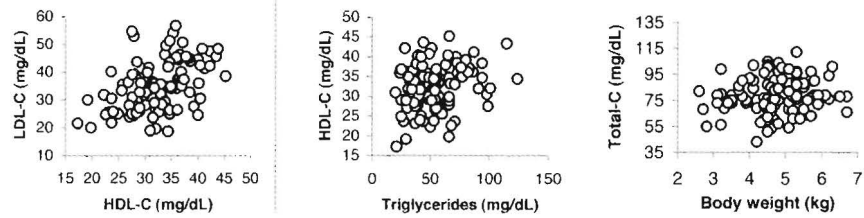

Figure 1. Phenotypic relationship between HDL-C and LDL-C, triglycerides and HDL-C, and body weight and Total-C.

pigs. The values in pigs were not in the range of human cholesterol levels. As in humans, there was a positive relationship between cholesterol levels and body weight. Selection for increased body weight in piglets may yield animals with high cholesterol levels, as is also indicated by the study of DUNNINGTON *et al.* in mice (1981). It is still needed to determine the relationship between serum and muscle cholesterol levels. An interesting observation in this study is the positive correlation between HDL-C and triglycerides, whereas this relationship is found to be negative in humans. Further analysis will include a larger amount of data, including measurements on cholesterol and triglycerides, body weight, growth, food intake and food efficiency at slaughter.

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