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Cholesterol and fat contents of animal adipose tissues

Hamza M. Abu-Tarboush* & Abdelbary A. Dawood

Food Science Department, King Saud University, PO Box 2460, Riyadh 11451, Saudi Arabia

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Adipose tissues dissected from camel, lamb and beef carcasses were analysed for total lipids and cholesterol contents in order to provide information to consumers and health care professionals. Differences were observed between the adipose tissues in term of lipids and cholesterol contents. The adipose tissues contained an average of 80·22% of lipids with individual samples ranging from 71·25% to 92·17%, while cholesterol values ranged from about 135 mg up to 184 mg per 100 g adipose tissues. This range of values, therefore, reflects natural levels. Camel adipose tissues tended to have lower levels of cholesterol than beef and lamb adipose tissues. The adipose tissue of kidneys has the highest concentration of cholesterol (greater than hump fat, tail fat and subcutaneous fat). Minor differences were observed in subcutaneous fat cholesterol levels between high and low energy feeds, and castrated and non-castrated beef at similar animal ages. Some beef adipose tissues contained higher amounts of cholesterol than literature values.

INTRODUCTION

Consumers presently are very conscious of the lipid content of foods as this is related to their health. In this connection, dietary cholesterol level has become an important issue since several publications have recommended a reduction in cholesterol consumption as a means of preventing heart disease. Dietary cholesterol, total quantity and saturation of the fat are the major areas of interest (Weir & Clifford, 1982). The food and nutrition board's committee on diet and health recommended that the fat content of the US diet should not exceed 30% of caloric intake, that less than 10% of calories should be provided from saturated fatty acids, and that dietary cholesterol should be less than 300 mg/day (NRC, 1989).

Fats from adipose tissues could have commercial applications as hardening agents, shortening, butter substitutes, and cooking oils (Bussey *et al.*, 1981; Defouw, 1981).

Feeley *et al.* (1972) reported that cholesterol may be avoided by selecting meat with little or no marbling and by trimming away separable fat. Total cholesterol intake from red meat must be reduced by trimming off the separable fat, especially subcutaneous or external fat (Rhee *et al.*, 1982*b*). However, the benefit of removing the separable fat is to reduce triglyceride intake rather than cholesterol intake since triglyceride is the starting material for the synthesis of cholesterol in the body.

On the other hand, Hoelscher *et al.* (1988) studied the subcellular distribution of cholesterol within muscle and adipose tissues of raw and cooked loin steaks from cattle of different USDA quality grades and subcutaneous adipose tissue trim levels. They indicated that trim levels had little effect on the subcellular distribution of cholesterol in adipose tissue. Consequently, meat with some marbling shrinks less during cooking and remains juicier. Subcutaneous fat also minimizes drying and moisture loss during dry heat roasting (Forrest *et al.*, 1975). The range of cholesterol values that are available for meat is wide and often affected by dietary factors, age, sex and analytical method used (Kunsman *et al.*, 1981). In a review of the cholesterol content of foods, beef fat ranged from 76 to 131 mg per 100 g of tissue (Sweeney & Weihrauch, 1976).

Ryan & Gray (1984) reported that beef tallow was found to contain 0·14% cholesterol by weight. Eichhorn *et al.* (1986) studied cholesterol content (mg per 100 g wet weight) of muscle and adipose tissue from bulls and steers. They found that sampling site effects were highly significant with subcutaneous adipose tissue (101·7) and perinephric adipose tissue (89·7) containing the most cholesterol, and longissimus muscle (58·3) containing the least. The use of young intact males, rather than castrates, for beef production can increase the percentage of polyunsaturated fatty acids in beef

* To whom correspondence should be addressed.

with no increase in cholesterol levels. Consumers have a misconception that high-fat meats contain high cholesterol levels. Researchers have reported no significant differences in cholesterol levels among steaks with seven different amounts of marbling (Rhee *et al.*, 1982*a*).

To date, the information on the quantification of cholesterol content of lipid deposits, especially in local animals, is limited. Little information is available pertaining to the cholesterol content of adipose tissues as affected by the fat location and animal species. Therefore, the objectives of this study were to investigate the quantity of fat and cholesterol contents for adipose tissues of different animal carcasses.

MATERIALS AND METHODS

Sixteen beef carcasses, castrated and non-castrated, raised on two different feeds, and fifteen camel carcasses, representing three different age groups, were used in this study. Beef and camel carcasses came from animals raised in King Saud University farms. Twelve lamb carcasses, about 2 years of age, representing equal numbers of Najdi and Merino, were selected randomly from a commercial plant in Riyadh city.

Samples of the external layer of subcutaneous fat were removed from the carcass surfaces at different locations, e.g. shoulder, ribs, loin, leg and flank. Perinephric adipose tissue was sampled from the kidney area. Other adipose tissues were excised randomly from camel hump and lamb tail areas. Samples then were frozen at −30°C, until they were analysed.

Total lipid content determination

Total lipid content was determined on the lipid extract according to the Folch procedure (Folch *et al.*, 1957) using chloroform and methanol (2:1, v/v) as the extraction solvents. A 10 ml aliquot (three replications/adipose tissue sample) of the lipid extract was freed of solvent and its lipid content was determined gravimetrically.

Cholesterol determination

The cholesterol content of each sample was determined in duplicate. A 0·10 g aliquot (equivalent to about 0·125 g tissue) of the lipid extract prepared by the Folch procedure was freed of solvent. The lipid residue was saponified by heating with 1 ml of 50% KOH and 3 ml of ethyl alcohol in a water bath-shaker at 55°C for 90 min. Distilled water (2 ml) was added to the mixture which was eventually cooled to room temperature. The unsaponifiable materials were treated three times with 1 ml of *n*-hexane for each extraction, and centrifuged for 10 min at 300*g*. The upper layer portions were combined (the hexane extract) and evaporated to dryness, and assayed for cholesterol concentration according to the colorimetric procedure of Varley (1960) using ferric chloride–acetic acid and concentrated H_2SO_4 as colour-developing reagents.

A standard curve was constructed by putting specific amounts of purified cholesterol through the colour development steps.

The cholesterol content of adipose tissues was measured as mg per 100 g fat and calculated on a wet adipose tissue basis.

Statistical analysis

Analysis of variance and, when appropriate, Duncan's multiple range test were conducted by using the SAS program (SAS, 1986).

RESULTS AND DISCUSSIONS

From a practical standpoint, the cholesterol content, based on dry weight, is of little use since meat is consumed by weight or servings rather than by amount of dry tissue. For this reason, in this study, cholesterol is expressed on a wet weight basis which is important in dietary planning and most informative for consumers.

Total lipids and cholesterol data for camel adipose tissues are shown in Tables 1 and 2. The amount of cholesterol per given wet weight of the adipose tissue (mg per 100 g) was different among the three ages and the mean values increased with age. No significant differences in cholesterol content of camel adipose tissues according to age were evident when the data were expressed on a lipid content basis.

Hump adipose tissue from the three ages contained, on the average, 83·87% lipid, 139 mg cholesterol/100 g wet tissue, and 166 mg cholesterol per 100 g lipid (Table 2). When the results for flank adipose tissues (subcutaneous fat) were compared with the data for hump adipose tissue and perirenal fat (kidney fat) from carcasses of the same age, total lipid content and cholesterol content of the flank adipose tissue were closer to those of the hump adipose tissue (mean values: 87·07% lipid; 138 mg cholesterol per 100 g wet

Table 1. Effect of age on the cholesterol level of camel adipose tissue[a]

Age (months) $n = 30$	Cholesterol (mg per 100 g fresh wt)	Cholesterol (mg per 100 g fat) Mean (±SE)
8	135	167[b]* (±1·31)[c]
16	148	168* (±1·25)
26	150	166* (±2·57)

[a] Means not followed by the same number of asterisks are significantly different ($p < 0·05$).
[b] Each value represents a mean of a duplicate determination.
[c] Values in parentheses represent standard errors.

Table 2. Fat and cholesterol contents of camel adipose tissues[a]

Character $n = 30$	Fat (g per 100 g fresh wt)	Cholesterol (mg per 100 g fresh wt)	Cholesterol (mg per 100 g fat) Mean (±SE)	
Hump fat	83·87	139	166[b]**	(±1·21)[c]
Perirenal fat	92·17	161	175*	(±1·50)
Subcutaneous fat	87·07	138	159***	(±1·21)

[a] Means not followed by the same number of asterisks are significantly different ($p < 0.05$).
[b] Each value represents a mean of a duplicate determination.
[c] Values in parentheses represent standard errors.

tissue, and 159 mg per 100 g lipid) than to those of perirenal fat (mean values; 92·17% lipid; 161 mg cholesterol per 100 g wet tissue, and 175 mg per 100 g lipid). The results in Table 2 indicate significant differences ($p < 0.05$) in cholesterol levels between kidney, hump and flank. To date, limited information exists regarding the cholesterol content of camel adipose tissue. Also, the present knowledge of composition of camel fat appears insufficient to compare with our data. However, it should be pointed out that total amounts of cholesterol contained in tested camel adipose tissues were lower than those for lamb and beef.

When the results for perirenal fat and tail fat for lamb samples were compared with the data of subcutaneous fats from wholesale cuts of the same carcasses, total lipid content and cholesterol content of the perirenal and tail fat tissues were higher than those of the subcutaneous fat. Statistically significant differences in cholesterol contents were found between fat samples. Adipose tissues (subcutaneous fat) trimmed from the surface of the four wholesale cuts of lambs contained, on the average, 74·77% lipids, 145 mg cholesterol per 100 g wet tissue and 193 mg cholesterol per 100 g lipid (Tables 3 and 4).

Although subcutaneous fat is present at a lower percentage than surface adipose tissue, cholesterol content (when compared on the basis mg cholesterol per 100 g of fat) was higher in subcutaneous fat than in tail fat.

Table 3. Fat and cholesterol contents of Najdi lamb adipose tissues[a]

Variable $n = 12$	Fat (g per 100 g fresh wt)	Cholesterol (mg per 100 g fresh wt)	Cholesterol (mg per 100 g fat) Mean (±SE)	
Tail fat	89·15	146	164[b]****	(±2·94)[c]
Perirenal fat	87·05	164	188******	(±1·78)
Subcutaneous fat				
Shoulder	75·95	151	199*	(±2·99)
Ribs	75·10	137	182***	(±3·14)
Loin	72·10	139	192***	(±2·22)
Leg	73·35	135	183***	(±2·32)

[a] Means not followed by the same number of asterisks are significantly different ($p < 0.05$).
[b] Each value represents a mean of a duplicate determination.
[c] Values in parentheses represent standard errors.

Table 4. Fat and cholesterol contents of Merino lamb adipose tissues[a]

Variable $n = 12$	Fat (g per 100 g fresh wt)	Cholesterol (mg per 100 g fresh wt)	Cholesterol (mg per 100 g fat) Mean (±SE)	
Perirenal fat	91·80	175	191[b]**	(±1·86)[c]
Subcutaneous fat				
Shoulder	77·05	161	209*	(±2·92)
Ribs	72·50	142	196**	(±2·20)
Loin	76·70	148	193**	(±1·76)
Leg	75·40	146	193**	(±2·98)

[a] Means not followed by the same number of asterisks are significantly different ($p < 0.05$).
[b] Each value represents a mean of a duplicate determination.
[c] Values in parentheses represent standard errors.

The adipose tissues of Merino lamb contained more fat and cholesterol than those of Najdi lamb (Tables 3 and 4).

Fat and cholesterol contents of adipose tissues for beef carcasses are presented in Tables 5 and 6. The adipose tissues contained an average of 78% lipids, with individual samples ranging from 71·25% to 90·15%. Lipids were present in the greatest percentage in perirenal fat (kidney fat) and were lowest in subcutaneous fat, on the loin surface. For each, the variable lipid values for low energy feed were higher than for high energy feed.

When cholesterol content was calculated on an adipose tissue content basis (mg per 100 g wet basis),

Table 5. Effect of feed energy on cholesterol level of beef adipose tissues[a]

Variable $n = 16$	Fat (g per 100 g fresh wt)	Cholesterol (mg per 100 g fresh wt)	Cholesterol (mg per 100 g fat) Mean (±SE)	
High energy feed				
Perirenal fat	88·25	170	193[b]**	(±1·83)[c]
Subcutaneous fat				
Shoulder	73·65	140	189**	(±3·33)
Ribs	79·00	164	207**	(±4·59)
Loin	71·25	151	212***	(±3·84)
Flank	73·85	152	206**	(±2·21)
Leg	73·00	162	221*	(±4·00)
Mean	76·50	156·5	204·7	
Low energy feed				
Perirenal fat	90·15	184	204**	(±3·27)
Subcutaneous fat				
Shoulder	80·90	164	202**	(±2·15)
Ribs	77·50	157	202**	(±4·96)
Loin	74·50	152	204**	(±1·94)
Flank	75·60	146	193**	(±1·97)
Leg	78·00	182	233*	(±7·76)
Mean	79·44	164·2	206·3	

[a] Means not followed by the same number of asterisks are significantly different ($p < 0.05$).
[b] Each value represents a mean of a duplicate determination.
[c] Values in parentheses represent standard errors.

Table 6. Effect of castration on the cholesterol level of beef adipose tissue[a]

Variable $n = 16$	Cholesterol (mg per 100 g fresh wt)	Cholesterol (mg per 100 g fat) Mean (±SE)
Castrated		
Perirenal fat	176	198[b]** (±3·44)[c]
Subcutaneous fat		
Shoulder	150	198** (±2·98)
Ribs	158	202** (±4·18)
Loin	153	211*** (±3·10)
Flank	153	205** (±2·14)
Leg	177	234* (±6·92)
Mean	161·2	208
Non-castrated		
Perirenal fat	178	200** (±2·63)
Subcutaneous fat		
Shoulder	146	194** (±3·54)
Ribs	163	208*** (±5·11)
Loin	153	201** (±2·74)
Flank	148	198** (±2·84)
Leg	167	221* (±5·16)
Mean	159·2	203·7

[a] Means not followed by the same number of asterisks are significantly different ($p < 0·05$).
[b] Each value represents a mean of a duplicate determination.
[c] Values in parentheses represent standard errors.

the overall mean values were about 156 mg cholesterol per 100 g wet adipose tissue for high energy feed samples, and about 164 mg cholesterol per 100 g wet adipose tissue for low energy feed tissues (Table 5). The differences noted between variables were more likely a reflection of the energy feed level and the varieties of adipose tissues. When the data for cholesterol content (mg per 100 g fat) of adipose tissues were analysed statistically to compare the perirenal fat and the subcutaneous fat fractions, cholesterol content (mg per 100 g fat) of the perirenal fat fraction was lower than that of the subcutaneous fat fraction ($p < 0·05$).

For subcutaneous fat samples (Table 5), no significant differences in cholesterol contents (g per 100 g lipid) were found except that the subcutaneous fat of leg and loin cuts contained significantly more cholesterol than other samples; no significant differences were found between subcutaneous fats from any of the other samples.

The cholesterol contents of adipose tissues for castrated and non-castrated beef carcasses are shown in Table 6. No significant differences in cholesterol contents were found among subcutaneous fat samples when the data were expressed on a lipid-content basis, except that leg and loin for castrated, and leg and ribs for non-castrated animals contained significantly more cholesterol than other samples. When cholesterol content was calculated on a fresh-weight basis, subcutaneous adipose tissue contained less cholesterol than perirenal fat (Table 6).

The results clearly show that adipose tissues of castrated beef carcasses do not contain more cholesterol than those of non-castrated beef carcasses, which is in agreement with the findings of Eichhorn *et al.* (1986). However, the magnitude of the difference in cholesterol content between the subcutaneous fat samples may be of little practical significance. Results of this study are in agreement with the findings of Stromer *et al.* (1966). The cholesterol content ranged from 113 to 150 mg per 100 g of subcutaneous fat, while the findings of Delvecchio *et al.* (1955) were 82 mg per 100 g of adipose tissue. The difference in cholesterol content in their study may be partly due to the cholesterol assay methodology that they used. According to Bohac *et al.* (1988) 60 min saponification without an antioxidant resulted in higher ($p < 0·05$) cholesterol values than did the omission of an antioxidant at a shorter saponification time (15 min) or the use of BHT at the prolonged saponification time (60 min).

REFERENCES

Bohac, C. E., Rhee, K. S., Cross, H. R. & Ono, K. (1988). Assessment of methodologies for colorimetric cholesterol assay of meats. *J. Food Sci.*, **53**, 1642–4, 1693.

Bussey, D. M., Ryan, J. I., Gray, J. I. & Zabic, M. E. (1981). Fractionation and characterization of edible tallow. *J. Food Sci.*, **46**, 526–30.

Defouw, C. L. (1981). The use of detergent fractioned, edible beef tallow in food systems. MSc thesis, Michigan State University, East Lansing, MI.

Delvecchio, A. D., Keys, A. & Anderson, J. T. (1955). Concentration and distribution of cholesterol in muscle and adipose tissue. *Proc. Soc. Exp. Biol. Med.*, **90**, 449–51.

Eichhorn, J. M., Wakayama, J. E., Blomquist, G. J. & Bailey, C. M. (1986). Cholesterol content of muscle and adipose tissue from crossbred bulls and steers. *Meat Sci.*, **16**, 71–8.

Feeley, R. M., Criner, P. E. & Watt, B. K. (1972). Cholesterol content of foods. *J. Am. Diet Assoc.*, **61**, 134–49.

Folch, J., Lees, M. & Stanley, G. H. S. (1957). A simple method for the isolation and purification of total lipids from animal tissues. *J. Biol. Chem.*, **226**, 497–509.

Forrest, J. C., Aberle, E. D., Hedrick, H. B., Judge, M. O. & Merkel, R. A. (1975). Palatability and cookery of meat. In *Principles of Meat Science*. W. H. Freeman, San Francisco, pp. 288–305.

Hoelscher, L. M., Savell, J. W., Smith, S. B. & Cross, H. R. (1988). Subcellular distribution of cholesterol within muscle and adipose tissues of beef loin steaks. *J. Food Sci.*, **53**, 718–22.

Kunsman, J. E., Collins, M. A., Field, R. A. & Miller, G. J. (1981). Cholesterol content of beef bone marrow and mechanically deboned meat. *J. Food Sci.*, **46**, 1785–8.

National Research Council (NRC) (1989). Diet and health: implication for reducing chronic disease risk. Report of the committee on diet and health, Food and Nutrition board. National Academy Press, Washington, DC.

Rhee, K. S., Dutson, T. R. & Smith, G. G. (1982*a*). Effect of change in intermuscular and subcutaneous fat levels on cholesterol content of raw and cooked beef steaks. *J. Food Sci.*, **47**, 1638–42.

Rhee, K. S., Dutson, T. R., Smith, G. C., Hostetler, R. L. & Reiser, R. (1982*b*). Cholesterol content of raw and cooked beef longissimus muscles with different degrees of marbling. *J. Food Sci.*, **47**, 716–19.

Ryan, T. C. & Gray, J. I. (1984). Distribution of cholesterol in fractionated beef tallow. *J. Food Sci.*, **49**, 1390–3.

SAS (1986). *SAS User's Guide: Statistics*. SAS Institute, Inc., Carry, NC.

Stromer, M. H., Goll, D. E. & Roberts, J. H. (1966). Cholesterol in subcutaneous and intramuscular lipid depots from bovine carcasses of different maturity and fatness. *J. Anim. Sci.*, **25**, 1145–7.

Sweeney, J. P. & Weihrauch, J. L. (1976). Summary of available data for cholesterol in foods and methods for its determination. *Crit. Rev. Food Sci. Nutr.*, **8**, 131–59.

Varley, H. (1960). Lipids. In *Practical Clinical Biochemistry*, 4th edn. Arnold-Heinemann.

Weir, W. C. & Clifford, A. J. (1982). Concerns of nutritional and medical experts about fat and cholesterol in the diet. *J. Dairy Sci.*, **65**, 479–83.