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Autoxidative Stability of Rendered Fat from Growing and Mature Steers Fed Protected Safflower Oil

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ABSTRACT

Growing and mature steers with increased linoleic acid (18:2) in their adipose tissues were reared by the Nutrition Institute, U.S. Department of Agriculture. The 18:2 content of rendered fats from these animals fed protected safflower oil varied from 6.5-20.6% and from 3.4-5.8% for the growing and mature steers, respectively. Increasing the 18:2 levels resulted in decreased stability to autoxidation of the rendered subcutaneous fats.

INTRODUCTION

Recently, steers were reared by the Nutrition Institute, ARS, USDA, Beltsville, Md., on diets containing oil supplements that were protected from hydrogenation in the rumen, as described by Australian workers (1,2); meat samples from these animals were made available to us. On the basis of previous studies (2-4), one would expect the lipids in these animals to increase in linoleic acid content and in susceptibility to oxidation. Oxidation of neutral lipids or triglycerides may be a factor in the aging process for beef carcasses and in the freezer storage of beef cuts. Below -9 C, microbial growth does not occur in freezer-stored meats, and polar lipids or phospholipids are more stable than neutral lipids or triglycerides. If desiccation is prevented and amounts of lipases are not excessive, maintenance of quality of freezer-stored meat depends primarily upon the stability of the adipose tissues to oxidation (5).

The purpose of this investigation was to determine the autoxidative stability of rendered fats from subcutaneous adipose tissues of steers fed protected and unprotected safflower oil supplements. Fatty acid composition and tocopherol content also were determined, because the stability of rendered fats to autoxidation depends upon the degree of unsaturation and the presence of natural antioxidants.

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EXPERIMENTAL PROCEDURES

Meat samples were obtained from the Nutrition Institute. The history of the animals from which the meat was taken has been reported (6). Two sets of 6 growing steers (total, 12 animals), started on tests 2 weeks apart, were fed for 6.5 weeks on a regular basal diet, supplemented with 10 or 20% safflower oil-casein-formaldehyde (protected, P), or safflower oil-casein (unprotected, U). Three animals were used for each treatment. Two mature steers were fed for 7 weeks on the basal diet, supplemented with 11% safflower oil-casein-formaldehyde (P), and 1 animal each was fed safflower oil-casein (U) or 6% sodium caseinate (C). Every animal received 20 mg d-α-tocopheryl acetate/day.

Adipose tissues, excised from the caul (omental) on the day of slaughter, and from the rib, chuck, round (subcutaneous), and kidney (perirenal) 1 day after slaughter, were stored at -25 C. Ground fatty tissues, in beakers, were placed in a water bath at 90-95 C and stirred occasionally. The fat, rendered below 75 C was filtered through cheesecloth.

A 50 ml beaker containing 10 g rendered fat was placed in an oven maintained at 60 C to determine the autoxidative stability of the fat. The number of days required to reach a peroxide value of 15 meq/1000 g fat was considered the induction period. Peroxide values were determined by the method of Kenaston, et al. (7).

Tocopherols were determined by the method of Erickson and Dunkley (8).

Transesterification of the triglycerides to methyl esters was by the method of Luddy, et al. (9). The CS_2 solution of the methyl esters was transferred into a 15 x 45 mm vial and the solvent removed with a jet of nitrogen. To the residue was added 0.2 ml 1% methyl heptadecanoate in $CHCl_3$ (w/v) and the methyl esters analyzed by gas liquid chromatography (GLC), as previously described (10).

Data were treated by the analysis of variance. Average fatty acid composition from the subcutaneous (rib and round) and from the caul and kidney fats was based upon two fatty tissues from each animal. A split plot design was used for analysis of these data, with the main plot and subplot comprising the analysis between animals and tissues, respectively (11).

TABLE I

Average Fatty Acid Composition (wt, %) of Rendered Subcutaneous (Rib and Round) and of Caul and Kidney Fats[a]

Fatty acid	Rendered fat	Growing steers[b,c,d] 10% P	20% P	10% U	20% U	Mature steers[e,f] P	U, C
16:0	Rib and round	24.2[b]	20.4[c]	23.8[b]	23.4[b]	25.3	26.4
	Caul and kidney	23.8[b]	19.8[c]	24.2[b]	23.5[b]		
18:1	Rib and round	33.3	35.0	39.2	39.9	48.5	49.0
	Caul and kidney	24.2[b]	25.2[b,c]	30.2[c]	30.3[c]		
18:2	Rib and round	9.6[b]	15.3[c]	1.8[d]	2.6[d]	4.8[c]	2.3[f]
	Caul and kidney	8.5[b]	15.0[c]	1.8[d]	2.5[d]		

[a]Diet supplemented with protected (P) or unprotected (U) safflower oil, or sodium caseinate (C).

[b,c,d,e,f]Horizontal values on the same line not bearing same superscript for the growing steers (b,c,d) and for the mature steers (e,f) differ significantly ($P<.05$).

TABLE II

Summary of Stability Data on Rendered Subcutaneous Fats of Growing and Mature Steers[a]

	Growing steers												Mature steers				
	First set						Second set										
	428 10%U	470 20%U	451 20%U	437 10%P	456 20%P	287 20%P	422 20%P	452 10%P	455 10%P	420 20%U	444 10%U	462 10%U	200 P	210 P	212 U	218 C	Pork
Round fat																	
18:2 (wt %)	1.6	1.8	1.8	11.9	16.0	12.2	13.6	8.1	6.5	3.7	1.9	1.8	3.4	4.6	1.7	2.6	
Tocopherols μg/g	23	14	19	16	16	15	21	13	12	18	14	12	14	14	16	13	
Induction period[b] (days)	50	47	50	17	13	17	19	19	19	42	46	41	39	28	44	29	
Rib fat																	
18:2 (wt %)	1.4	2.1	2.0	14.6	20.6	14.6	14.5	9.1	7.6	3.9	2.2	1.8	5.8	5.2	1.8	2.9	10.2
Tocopherols μg/g	34	21	22	20	21	20							14	15	16	18	12
Induction period (days)	50	49	50	16	9	16							24	28	48	39	13
Chuck fat																	
18:2 (wt %)	1.4	1.8	1.8	12.5	18.0	13.0							4.2	4.4	1.8	2.5	
Tocopherols μg/g	37	25	22	15	34	27							15	19	20	21	
Induction period (days)	52	50	47	16	17	22							29	29	48	41	

[a]Diet supplemented with protected (P) or unprotected (U) safflower oil, or sodium caseinate (C).

[b]Time, in days, to reach a peroxide value of 15 meq/1,000 g of fat.

RESULTS AND DISCUSSION

Average fatty acid compositions of rendered subcutaneous (rib and round) and of caul and kidney fats for the growing steers are shown in Table I. Average linoleic acid (18:2) levels in all of the fats in animals fed protected safflower oil ranged from 8.5-15.3%, whereas the range in animals fed unprotected safflower oil was 1.8-2.6%. There was a significant difference ($P<0.5$) between animals receiving the 10 and 20% protected diets, but the fat of animals on the unprotected diets did not differ in their 18:2 level. The effect of incorporation of protected safflower oil into the diet upon the amount of 18:2 in the adipose tissues was marked. The contents of palmitic acid (16:0) in the fat of animals fed unprotected safflower oil or 10% protected safflower oil were comparable; however, in animals receiving 20% protected safflower oil, there was a significant decrease ($P<.05$) in 16:0 content. In general, the levels of oleic acid (18:1) were depressed in all fatty tissue from animals receiving the protected safflower oil in their diet.

Further statistical analysis of the data for the growing steers shows, for the 18:2 content, significant differences ($P<.05$) between the 10 and 20% treatments and highly significant differences ($P<.01$) between tissues (rib and round) and between the P and U treatments. The 16:0 level showed significant differences ($P<.01$) between tissues (caul and kidney) and between the 10 and 20% treatment ($P<.05$). Most of the latter difference was due to the 20% P treatment. For the 18:1 content, differences were significant ($P<.05$) between tissues (caul and kidney) and between the P and U treatment (caul and kidney). Increasing the 18:2 content of fats from the growing steers had a greater effect upon the levels of 16:0 and 18:1 than upon the other fatty acids analyzed (14:0, 16:1, 18:0, and 18:3), which varied between locations but did not depend upon treatment.

Average fatty acid compositions of rendered subcutaneous (rib and round) fats from mature steers also are shown in Table I. Subcutaneous fats showed significant difference ($P<.05$) for the 18:2 content (Table I) and a difference ($P<.10$) for the 16:0 content for treatment between animals.

The stability of rendered subcutaneous fats from the round, chuck, and rib for the mature and first set of growing steers and from the round for the second set of growing steers is summarized in Table II. The growing steers were lean animals, and the second set was leaner than the first. Not enough rendered fat could be obtained from the rib and enough from the chuck of only two of the six animals for the stability test at 60 C. For this reason, no stability data from the rib and chuck fats from the second set of growing steers are shown, except for the 18:2 levels from the rib fats. Tocopherol levels from the rendered subcutaneous fats varied widely, and, in general, the chuck showed the highest levels.

Autoxidative stability of fats depends upon the degree of unsaturation and upon the levels of antioxidant present. This interrelationship is well documented in Table II. For comparison, the stability of rendered pork back fat (fatty tissues obtained 1 day after slaughter) is shown in Table II. Rib fat from animal 456, with an induction period of 9 days and 20.6% 18:2, is the only fat with a lower induction period than that of rendered pork back fat.

The present results on rendered bovine subcutaneous fats with 18:2 concentrations of 12-18% suggest that freezer storage stability of meats from these animals should be comparable to, or greater than, that of pork. Aging, which decreases the level of tocopherols, would not be a factor with pork but must be considered in freezer-stored beef. For satisfactory aging and freezer-storage, beef having 18:2 levels of 12-21% probably would require greater deposition of tocopherol, in the depot fat, than that found in the present investigation.

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