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Environmental and Genetic Effects on the Composition of Ovine Fats

D. A. Cramer
Colorado Agricultural Experiment Station, Fort Collins

Lamb and mutton are preferred meats in many parts of the world, however this is not true in the United States. In fact, the consumption of lamb by American people is at such a low level that the future existence of the United States sheep industry is threatened.

Many factors are offered as reasons for the development of such a condition. Among the reasons that have stood out in survey reports and should be of interest to meat researchers are: (1) mutton fat is not highly palatable and (2) the flavor of lamb needs improvement. If this is true, consumption of lamb will not increase until a more desirable product is made available; because, regardless of the economic and marketing aspects, people will not buy lamb if they do not like it.

On the assumption that the real problem in the sheep industry lies in the eating quality of lamb, the Colorado Agricultural Experiment Station initiated a research project designed to study the possibilities of improving the palatability of lamb. This report is a summary of a portion of the research conducted over a five year period by the meats section of the Animal Science Department at Colorado State University. The paper is limited to investigations on the composition of lamb fat and attempts to alter fat composition.

The undesirable feature of lamb fat is probably due to its highly saturated nature because mutton tallow has lower iodine values and higher melting ranges than any other fat used for human consumption (AMIF, 1960). Alteration of fat composition appears to be quite feasible because the variation in the percentages of different fatty acids is sufficient to make production of a more unsaturated lamb fat possible. As an example, a range in oleic acid content in mutton tallow of more than 20% was reported by Dugan (1957).

There is a volume of literature concerned with changes in depot fat composition resulting from changes in the types and amounts of dietary fats in monogastric animals, but such changes do not occur in the adipose tissue of ruminants such as sheep. Unsaturated fatty acids are rapidly hydrogenated in the rumen (Shorland, 1955; Reiser and Reddy, 1956) which makes control of depot fat composition by dietary fat alterations very difficult.

Changes in fat composition may be brought about by other factors however. Iodine values of ruminant fats have been reported to be affected by environmental temperature, maturity, rate of fattening and degree of fatness (Henriques and Hansen, 1901; Shorland, 1953; Callow, 1958; Sink et al., 1964).

Another possibility is to reduce the rate of rumen hydrogenation by altering the rumen fermentation pattern. Shaw, et al., (1960) produced changes in the volatile fatty acid ratios in the rumen and increased iodine values in subcutaneous fat in Holstein steers by feeding steam flaked and pelleted feeds. This indicates that feed additives such as antibiotics may become useful in controlling fat composition.

Preliminary Investigations

In the early phases of the project it was necessary to select a site on the lamb carcass for collection of samples of fat that would be representative of the carcass fat in general. Iodine numbers (IN) and melting points (MP) were determined on fat samples from eight different parts of 82 lamb carcasses.

The leg and dock areas had the softest fat (table 1). The IN were fairly constant for fat from the loin, rack, shoulder and neck. Cod fat was somewhat harder and kidney fat was very highly saturated.

TABLE 1. AVERAGE IODINE NUMBERS AND MELTING POINTS OF LAMB FAT BY AREA OF THE CARCASS AND THE AVERAGE CORRELATION (r) OF EACH AREA WITH THE OTHER SEVEN AREAS.

Area of carcass	Iodine number	Melting point[a]	Iodine number r	Melting point r
Dock	46.9	43.2	0.82	0.46
Cod	44.0	44.6	0.67	0.38
Kidney	38.5	48.4	0.76	0.26
Leg	47.3	42.8	0.81	0.39
Loin	45.6	43.1	0.82	0.44
Neck	45.5	43.9	0.83	0.26
Rack	45.0	43.6	0.83	0.51
Shoulder	45.2	43.6	0.81	0.51
Average	44.8	44.2		

[a]Units = degrees Centigrade

The dock was selected as the site for future sampling because carcass appearance is not damaged by cutting around the dock, it is a desirable location for biopsy, there is usually sufficient fat in this region, and the correlation was high between iodine numbers of dock fat and fat from other parts of the carcass (table 1).

Environmental Effects

Experiments were conducted for two consecutive years to determine the effect of ambient temperature on lamb fat composition. Twenty white-face wether lambs were randomly allotted to two treatments in each experiment and fed for approximately 90 days. When the lambs were slaughtered samples of fat were collected for IN and MP determinations. Ten of the lambs (Lot I) were kept out in the open exposed to average temperatures of 20 to 50°F. The other 10 lambs (Lot II) were housed in a specially constructructed room held at temperatures ranging from 75-90°F. In the first experiment 5 lambs in each treatment were shorn at the beginning and again at the midpoint of the trial.

The results of the fat analyses are listed in table 2. Decreasing environmental temperature apparently causes an increase in the unsaturation and softening of subcutaneous fat. The temperature effect is quite noticeable with the shorn

and fully wooled lambs of the first experiment. IN decrease and MP increase in a stepwise fashion. The differences are highly significant statistically.

TABLE 2. IODINE NUMBERS AND MELTING POINTS OF FAT FROM LAMBS FED OUT AT DIFFERENT ENVIRONMENTAL TEMPERATURES

	1961		1962	
Treatment	IN	MP	IN	MP
Lot I	52.6	41.7	49.4	40.7
shorn	52.9	40.9		
unshorn	52.4	42.4		
Lot II	46.9	44.0	47.7	41.1
shorn	48.4	43.0		
unshorn	45.4	45.0		

In another study, 12 Columbia lambs were obtained from the CSU breeding flock and managed under farm flock conditions until they were approximately 18 months old. They were fat biopsied at 9 weeks of age and rebiopsied every 9 weeks until termination of the study. Figure 1 shows the highly significant seasonal effect on IN and MP determined on the biopsy samples. The average IN was increasing during the initial stages of growth in the spring of 1962. A maximum was reached in August followed by a decrease in the winter. A secondary maximum occurred in August 1963. MP appeared to be inversely related to IN to about December 1962; but oddly enough it paralleled IN thereafter.

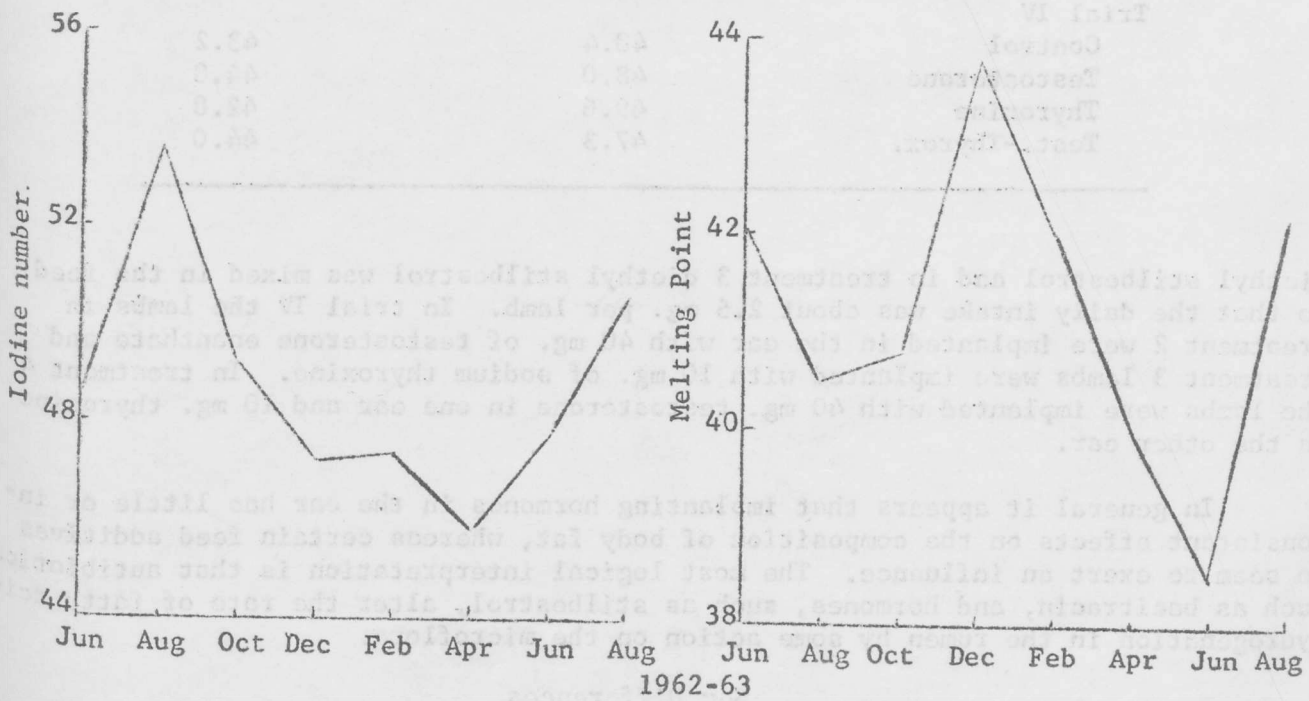

Figure 1. Average iodine numbers and melting points of lamb fat taken at nine week intervals to eighteen months of age.

Nutritional Effects

Using a "try it and see" approach, several sets of lambs were fed out under a variety of treatments to study the effects of different feed additives and hormone implants on fat composition. Table 3 is a summary of the results of these trials.

In trials I and II Zinc Bacitracin was added to the feed at such a level that the lambs would consume approximately 40 or 60 mg. per head per day. The Synovex used in Trials II and III was an ear implant consisting of 50 mg. progesterone and 5 mg. estradiol. Treatment 2 of trial III was an ear implant of 10 mg.

TABLE 3. IODINE NUMBERS AND MELTING POINTS OF FAT FROM LAMBS SUBJECTED TO A VARIETY OF NUTRITIONAL TREATMENTS

Treatment	IN	MP
Trial I		
Control	46.0	42.6
Zinc Bacitracin (40 mg.)	47.9	42.2
Trial II		
Control	45.8	44.8
Zinc Bacitracin (40 mg.)	48.2	43.4
Zinc Bacitracin (60 mg.)	46.8	44.3
Synovex	47.2	43.6
Trial III		
Control	45.3	44.0
Stilbestrol (implant)	45.8	43.8
Stilbestrol (oral)	44.6	45.0
Synovex	43.6	44.0
Trial IV		
Control	48.4	43.2
Testosterone	48.0	44.8
Thyroxine	49.6	42.8
Test.-Thyrox.	47.3	44.0

diethyl stilbestrol and in treatment 3 diethyl stilbestrol was mixed in the feed so that the daily intake was about 2.5 mg. per lamb. In trial IV the lambs in treatment 2 were implanted in the ear with 40 mg. of testosterone enanthate and treatment 3 lambs were implanted with 10 mg. of sodium thyroxine. In treatment 4 the lambs were implanted with 40 mg. testosterone in one ear and 10 mg. thyroxine in the other ear.

In general it appears that implanting hormones in the ear has little or inconsistant effects on the composition of body fat, whereas certain feed additives do seem to exert an influence. The most logical interpretation is that antibiotics, such as bacitracin, and hormones, such as stilbestrol, alter the rate of fatty acid hydrogenation in the rumen by some action on the microflora.

Sex Differences

The effects of sex on fat composition were studied using the 12 lambs mentioned above in Figure 1. The lambs were fat biopsied periodically from 9 weeks to 18 months of age.

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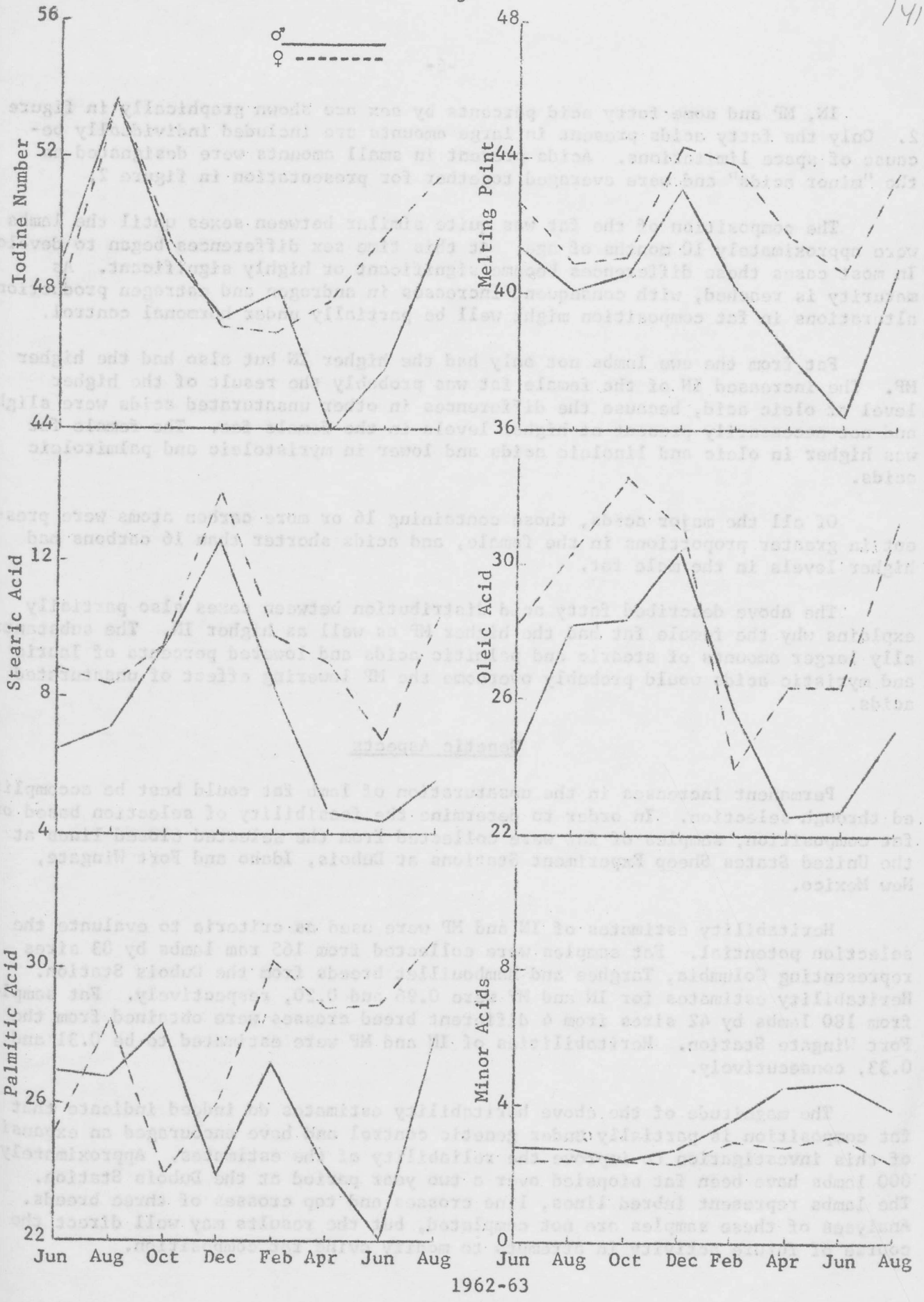

Figure 2. Percent of fatty acids in lamb fat plotted by sex.

IN, MP and some fatty acid percents by sex are shown graphically in figure 2. Only the fatty acids present in large amounts are included individually because of space limitations. Acids present in small amounts were designated as the "minor acids" and were averaged together for presentation in figure 2.

The composition of the fat was quite similar between sexes until the lambs were approximately 10 months of age. At this time sex differences began to develop. In most cases these differences became significant or highly significant. As maturity is reached, with consequent increases in androgen and estrogen production, alterations in fat composition might well be partially under hormonal control.

Fat from the ewe lambs not only had the higher IN but also had the higher MP. The increased IN of the female fat was probably the result of the higher level of oleic acid, because the differences in other unsaturated acids were slight and not necessarily present at higher levels in the female fat. The female fat was higher in oleic and linoleic acids and lower in myristoleic and palmitoleic acids.

Of all the major acids, those containing 16 or more carbon atoms were present in greater proportions in the female, and acids shorter than 16 carbons had higher levels in the male fat.

The above described fatty acid distribution between sexes also partially explains why the female fat had the higher MP as well as higher IN. The substantially larger amounts of stearic and palmitic acids and lowered percents of lauric and myristic acids would probably overcome the MP lowering effect of unsaturated acids.

Genetic Aspects

Permanent increases in the unsaturation of lamb fat could best be accomplished through selection. In order to determine the feasibility of selection based on fat composition, samples of fat were collected from the selected closed lines at the United States Sheep Experiment Stations at Dubois, Idaho and Fort Wingate, New Mexico.

Heritability estimates of IN and MP were used as criteria to evaluate the selection potential. Fat samples were collected from 165 ram lambs by 83 sires representing Columbia, Targhee and Rambouillet breeds from the Dubois Station. Heritability estimates for IN and MP were 0.96 and 0.20, respectively. Fat samples from 180 lambs by 42 sires from 4 different breed crosses were obtained from the Fort Wingate Station. Heritabilities of IN and MP were estimated to be 0.31 and 0.33, consecutively.

The magnitude of the above heritability estimates do indeed indicate that fat composition is partially under genetic control and have encouraged an expansion of this investigation to improve the reliability of the estimates. Approximately 800 lambs have been fat biopsied over a two year period at the Dubois Station. The lambs represent inbred lines, line crosses and top crosses of three breeds. Analyses of these samples are not completed, but the results may well direct the course of future activity in attempts to modify ovine fat composition.

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ABSTRACT

Environmental and Genetic Effects on the Composition of Ovine Fats

D.A. Cramer, Colorado Agricultural Experiment Station, Fort Collins

Mutton fat is considered somewhat unpalatable in the United States. Studies on fat composition and attempts to increase the unsaturation of lamb fat are summarized. A great deal of variation occurs in iodine values of fat from different parts of the lamb carcass, but the pattern is similar from lamb to lamb. Therefore, the composition of fat from any part of the carcass may be estimated by analysis of a single sample. That the environment may affect fat composition is indicated by studies demonstrating that increased ambient temperature increases the saturation of subcutaneous fat. Certain feed additives, such as antibiotics, change fat composition by apparently altering rumen fermentation. Ear implantation of hormones affects fat composition in some cases. A recent study indicates seasonal fluctuations and sex differences in lamb fat composition. Fat composition also appears to be somewhat heritable. Heritability estimates for iodine values and melting points, respectively, are as follows: (1) 0.96 and 0.20 for fat from 165 ram lambs by 83 sires from the United States Sheep Experiment Station, Dubois, Idaho, and (2) 0.31 and 0.33 for fat from 180 lambs by 42 sires from the United States Sheep Station, Fort Wingate, New Mexico.

Abstraktum

Umgebungs- und genetische Einflusse auf die Zusammensetzung von Schaffetten.

D.A. Cramer, Colorado Landwirtschaftliche Experimentalstelle, Fort Collins

In den Vereinigten Staaten wird Hammelfett als ziemlich ungeniessbar angesehen. Studien in Bezug auf die Fettzusammensetzung und auf Entsattigungsversuche der Lammfette werden zusammengefasst. Mehrere Verschiedenheiten bestehen in den Jodwerten der Fette von verschiedenen Teilen des Lammkadavers, das Muster ist jedoch von einem Lamm zum anderen dasselbe. Die Zusammensetzung des Fettes eines beliebigen Teiles des Kadavers kann daher durch Analyse einer einzigen Probe geschätzt werden. Dass die Umgebung die Fettzusammensetzung beeinflusst, wird durch Studien angedeutet, die zeigen, dass bei erhöhter Umgebungstemperatur die Sättingung des subkutanen Fettes erhöht wird. Gewisse Futterzusätze, wie Antikörper, ändern die Fettzusammensetzung durch Veränderung der Pansengärung. In einigen Fällen wird die Fettzusammensetzung durch Ohreinimpfung von Hormonen beeinflusst. Kurzlich wurden jahreszeitliche Schwankungen und geschlechtliche Unterschiede in Lammfettzusammensetzung festgestellt. Fettzusammensetzung scheint auch zu einem gewissen Grade erblich zu sein. Erbfähigkeit wird für Jodwerte und Schmelzpunkt je wie folgt geschätzt: (1) 0,96 und 0,20 für Fett von 165 Schafböcken durch 83 Stammtiere von der U.S. Experimentalstelle, Dubois, Idaho, und (2) 0,31 und 0,33 für Fett von 180 Lammern durch 42 Stammtiere von der U.S. Schafstelle, Fort Wingate, New Mexico.