THE USE OF MEAT QUALITY FACTORS FOR AN EVALUATION OF LAMB CARCASSES

Desmond B. Watt
MONTANA STATE COLLEGE
BOZEMAN, MONTANA

INTRODUCTION:

One of the greatest stumbling blocks that researchers in meats have confronting them in evaluating meat quality, is "human error." This is unfortunate because in the last analysis meat quality can be evaluated only by the palate. One thing seems to be clear: because of the extremely variable tool we must use, namely man himself, inherent variations may be accounted for by setting up and analyzing our experiments along lines adapted to statistical study. There seems to be no question of the part statistical analysis is and will be playing in the future.

Another condition determining the form meat research will take is the availability and cost of materials. Slaughter studies have always been expensive; therefore, the meat worker must look again to statistical analysis to be sure he is using sound sampling techniques, which will assure him that his necessarily small samples are representative of the entire theoretical population, and will allow him to draw unbiased conclusions from his results.

The other need realized by research men in the meats field, is that of a closer linkage or correlation of purely objective and subjective methods for the definition and measurement of meat quality. Possibly before this, however, a better and clearer definition of these two terms is needed. Even today workers differ as to the connotations derived from the two terms. In other words, what is required is a standard nomenclature to be used and interpreted uniformly by all workers in the field.

This paper is concerned with the use of meat quality factors in evaluating the carcass quality of lamb. Meat quality factors, whether they apply to lamb, beef or pork, are the attributes possessed by the meat that manifest themselves in such a way that they can be interpreted as desirable or not, by the senses of taste, smell and sight. What is pleasing to one may not be to another. It is this point that makes unbiased and fully adequate evaluation of meat quality difficult. There is nothing quite so unbiased as a purely objective test, because objectivity itself presupposes an unbiased measurement of a chemical or physical property. If it could be possible to measure or evaluate flavor, aroma, tenderness, juiciness, texture and color objectively, a very important step in meat research will have been taken. But it is entirely likely that such will not be the case. If so, the next best thing is to try to correlate purely objective testing as closely as possible with purely subjective evaluation. Perhaps therein lies the real answer: a supplementation of one measurement by the other. It may be that we can get a truer picture of meat quality by this means than if we relied solely on either one of the two. In fact, experience has demonstrated the need for supplementing human judgment by objective testing and vice versa.

REVIEW OF THE LITERATURE:

Ordinarily, in distinguishing between purely subjective and objective evaluations, the observer will think that the former refers to tests which depend almost entirely on the use of the senses of sight, taste and smell, and that the latter will depend on impersonal chemical and physical tests. However, there are finer lines of distinction that can be drawn. In a recent book entitled "Advances In Food Research" (1) a different approach to distinguishing between objectivity and subjectivity is attempted. The term subjective is used to designate tests that measure the preferences of individuals, and objective to designate tests that measure differences in or between samples, whether measured by the human senses or not. It is undoubtedly true that many would not agree with this explanation, but this serves as an example of the range of interpretation taken on this point. To my way of thinking, it seems that any classification between subjective and objective testings must be such as to alienate as much as possible objective chemical and physical tests from the influence of individual judgment. Wherever personal judgment enters into the interpretation of results, a shade of subjectivity enters also. On the other hand, strictly subjective tests fall almost exclusively under the realm of human judgment.

The more one reviews the literature, the greater becomes the conviction that it would be unwise to alienate one method from the other. They compliment one another, one being able to measure finite chemical and physical properties, which have been proven to reflect one attribute, and the other able to measure subtle blendings of a myriad of influencing properties which no conceived chemical and physical test could hope to catch. In order that meat workers in general can properly coordinate their efforts, two steps are thought to be necessary (a) the establishment of a standard yet fully satisfactory definition, classification and interpretation of subjective and objective measurements and (b) continued work in the direction of studying the correlations between measurable chemical and physical factors and resulting flavors, aromas and colors as evaluated by the palate. Work in these two directions would have to be meat research of a fundamental nature in that results would apply equally to all our classes of domestic meats. In the past more research has been conducted on beef and pork than on lamb or mutton. This no doubt reflects our national meat-eating habits.

Perhaps a review of some fundamental work done on basic factors affecting lamb and mutton quality would be wise at this point. Reference is made to that of Hammond (2) at the University of Cambridge, on the growth and development of mutton qualities in sheep. Generally in proportion, the loin and thorax contain more fat than the whole carcass; the leg and shoulder contain slightly less; and the neck much less. In plotting fat content of various cuts with the fat content of the entire carcass, the cut approximating closest to the carcass as a whole is that of the shoulder, with the leg coming next. Because of the greater precision with which the leg is able to be cut, it has been used more for basing a separable fat estimate of the whole carcass. The mechanically separated fat can be subdivided into subcutaneous, intermuscular fat, and intramuscular fat. The amount of subcutaneous fat in the carcass is slightly under-estimated by using the leg cut, while the intermuscular fat is under-estimated even more. The percent in the entire carcass is just about double that in the leg, because of the large amounts layed down elsewhere, notably in the region of the thorax and shoulder. This perhaps explains why the percent fat in the shoulder approximates that of the whole carcass more closely than the leg. In the latter there is not enough intermuscular connective tissue in which the fat can be accumulated, to keep up with fat

deposition in the shoulder. Other workers have shown that the percent of marbling fat in sheep legs is consistently below that of the carcass as a whole. As for the use of one cut for an estimation of fat distribution of the entire carcass, the selection of the sample cut will depend upon the degree of finish and the age of the animal. These two factors affect the distribution of fat in the body. Perhaps the answer lies in the use of the leg as an estimate of percent fat in animals not deemed to be in a high state of finish, and the shoulder for use in evaluating carcasses carrying a high degree of finish. Just where the distinction exists between an animal that is not considered highly finished and one that is, is arbitrary and subject to human error.

Hammond (2) goes on to report on the various factors affecting the proportion of meat or muscling in the carcass. It is generally known that the percent of carcass to live weight increases with age, because the muscles, fat and bone together, grow at a faster rate than the skin, hair and organs. Within this trend there exists still another, in that there seem to be consistent changes in all sexes, due to age, in the proportion of meat (muscle and fat) and the proportion of bone and tendon. The former rises in proportion to the latter. The percentage of muscle rises to about three months of age, but after this it falls because of the increasing amounts of fat. However, the actual amount of muscle continues to increase beyond this age.

According to the observations of Otis (3) the apparent increase of the muscle on fattening is almost entirely due to the increase of fat between the muscle.

Hammond (2) records observations on the effect of breed on body tissue proportions. The early maturing breeds, Southdown and Suffolks, have a higher percentage of muscle and a lower percentage of bone than the later developing or maturing Welsh and Lincoln. The proportion of muscle to bone is greater in early maturing breeds than in late maturing, but it is also influenced by the general size of the breed.

If an individual muscle is to be taken as a sample of a carcass, it would be best to select one with a greater postnatal development, since it would show greater variations than one of the slower developing muscles. It would reflect the physiological changes the animal has undergone during growth.

As for distribution of fat, Hammond (2) states that most of the intermuscular fat lies in the connective tissue between the individual muscles. It lies mainly in those areas where the large blood vessels and nerves run between the individual muscles and where the connective tissue is found in greatest amounts.

As for intramuscular fat, it lies inside the individual muscles between the muscle bundles, and sometimes between the individual fibers. When present in small amounts, it cannot be seen by the naked eye; but in large quantities it forms a white net-work over the surface of the cut muscle. The fat is deposited mainly in the connective tissue cells between the muscle bundles. It is most plentiful where the tissue is most developed, which is on the periphery of the muscle (epimysium). In very fat animals no distinct line can be seen between muscle and fat, but the two gradually merge into one another. As the animal grows older, more subcutaneous fat is laid down than in the intermuscular region. Histological studies show that older animals have more marbling.

As for sex differences Hammond (2) found that at five months of age, and under identical feeding conditions, the percent of total fat in the leg was smallest in the ram and greatest in the wether, with the ewe in between. It is quite likely that the rate of muscular growth and development plays an important role in determining fat distribution.

As for breed effects on fat distribution, Hammond (2) states that the subcutaneous fat is probably involved in varying distribution more than is the intermuscular fat. He feels that the amount of subcutaneous fat and variation in its distribution is dependent on the predevelopment of connective tissue.

Nathusius (4) found that the English breeds (Southdown and Cotswold) have a much greater development of subcutaneous connective tissue than the wool breeds (Merino). Perhaps therein, lies an explanation of the fattening qualities of some breeds of sheep.

It may be that in a study of the histological properties of muscle there lies a partial answer to some of the perplexing problems of texture, tenderness, and even flavors and aromas. A muscle is a complete unit in itself, but it is in turn made up of smaller units or cells called "muscle fibers". These muscle fibers are the building blocks, and it could be that they hold locked in their interiors some of the answers we seek.

Continuing to refer to Hammond's (2) work, it is stated that in the prenatal states of growth, the cells first of all increase in number, and afterward each cell just increases in size. The muscle fiber is a single, multinucleate cell. Montfeillet (5) states that the sheep has relatively short fibers, while those of the goat are long and those of the bull are shorter than those of the steer. It seems that the muscle which makes the greatest postnatal growth has the largest average sized fiber. The actual size of the muscle, however, does not seem to have too much effect on the size of the fiber. This can probably be explained by the fact that a muscle's size can be attributed mainly to the number of fibers per bundle and/or the number of bundles in the muscle, and not to the size of the fibers.

According to reports of Bell and Bullard (6), nutrition, apart from exercise, seems to increase the size of the fiber. They noticed granules of a fatty nature in muscle fibers, and record that these granules are increased by feeding and decreased by starvation.

Waters (7) found that the average diameter of the fiber in the biceps of a steer was 45 microns in what he describes as ordinary condition; in the fattened state it was increased only to 50 microns. The big change came with the submaintenance diet, when the average fiber diameter was reduced to 20 microns. In reporting findings of Suffolk rams, with age, the diameter of the fibers increased from an average of 12.8 microns at birth to 40.3 microns at five months, and 54.7 microns at four years old. The same was observed with wethers. These observations tend to support the belief that up to birth there is an increase in the number of cells, and that during postnatal life increase in the size of the cell occurs.

Adametz (8) found that the muscle fibers in bulls were much larger than those of cows, but he found only slight differences between bulls and steers.

Warringholz (9) has shown that when different species of farm animals are compared there is no relation between size of animal and size of muscle fiber. The pig, cow, horse and sheep respectively, formed a series decreasing in size of muscle fiber.

There are some very interesting findings on muscle color brought out in Hammond's (2) work on sheep. These variations in color are explained at the muscle fiber level. There is a difference in the color of muscle fibers, independent of their size. There is little doubt that the color of the muscle is due to its content of hemoglobin.

Sustschowa (10) has shown that castration diminishes the hemoglobin and erythrocyte content of the blood and that this is also affected by age.

A similar explanation probably accounts for the darker color of the leg than the thigh muscles in sheep. The thigh muscles, having a later development, will be able to increase the number of their fibers to a greater extent than the leg muscles which develope early, while the latter will have to depend more on an increase in their hemoglobin content to achieve the same result (i.e.) a more efficient exchange of oxygen.

It is believed, though no work has been done, that the muscles of the more active sheep (Blackfaced Welsh, Cheviot) are darker than those which lead less active lives (Southdown, Shropshire).

Brozert (11) suggests that normally the breakdown of red blood corpuscles in the muscle is dependent on its action, and that the muscles which function most and for the longest time, break down the most hemoglobin and become red.

In a systematic examination of fibers in sections of different muscles of adult sheep, fibers of different colors are present. In some muscles most of the fibers are light; in others they are dark, while in practically all muscles, fibers intermediate in color are numerous. No marked or constant difference tends to appear in the structure of the fibers. No muscle has been observed in which all the fibers are of uniform color, except those of the lamb at birth. As to the cause of the difference in color, it seems to be a matter of hemoglobin content, which varies according to the function of the fiber. It would appear that there was no fixed amount of hemoglobin in any of the fibers, but that the amount varied with age or exercise. There is, however, probably a different function for each fiber to perform in any one muscle (i.e.) some to keep tone and some to contract violently. It is probably such differences as these which account for the color variations of the fibers. The proportion of each present is representative of the function of the muscle as a whole, and secondarily determining the muscle color.

It would appear that the color of muscle or meat is chiefly influenced by the age. The younger animals having light-colored and the older, dark-colored flesh. It is also greatly influenced by the function of the muscle. The meat of animals in continual movement is likely to be darker than those relatively inactive.

The grain of the meat has much to do with the texture and eating qualities. Generally, the finer the grain, the better the meat. According to Hammond (2) those muscles which have the greatest rate of postnatal growth seem to have the coarsest grain. There are exceptions, however; but in these

exceptions the fiber size is smaller. It appears that when the fiber is small, the size of the grain does not increase so much with age as it does in muscles with larger fibers. There seems to be ample evidence that coarseness increases with age. This follows on the assumption that the formation of new fibers ceases after birth, and that growth of fiber size only, occurs after this time. No new bundles are formed, but the enlargement consists in an increase in size of existing bundles. Sex too, influences grain. At five months the muscles of the ram were coarser than those of the wether which in turn were coarser than those of the ewe. The diameter of the muscle fiber is larger in the ram than the wether, and in turn larger than that of the ewe. This size difference in fiber is associated with actual difference in muscle size and body size. Of the breeds, the Suffolk had the coarsest grained meat, followed by the Merino, Shetland, Soay, and Hampshire.

As for marbling Hammond (2) states that the amount of connective tissue is greatest in the neighborhood of the large blood vessels of a muscle, and it is around these that fat is deposited first and in greatest quantity.

Diffloth (12) states that there is a correlation between the grain of meat and the marbling. The finer the grain the more the marbling is diffused. With age there is an increased tendency to lay on fat, and with this the marbling increases too.

Hammond (2) found that the marbling in rams was coarser than that of wethers, this corresponding to the differences in grain between the muscles of the two sexes. Differences in the distribution of connective tissue between the two sexes probably accounts for the meat of males being tougher, unless the connective tissues have been distended and broken up by deposition of fat.

The improved mutton breeds (Hampshire and Suffolk) showed much more marbling than the semi-wild (Soay and Shetland). The wool breed (Merino) was intermediate. The differences between breeds, as regards marbling were greater in the muscles of the thigh, where most fat is deposited, than those of the leg where little is deposited. It would appear that the thigh muscle is affected by improvement more than the leg. This probably is associated with the later growth of the thigh muscles in the post-natal development of the animal. Another breed difference might be in the amount of connective tissue present in which fat can be deposited. The distribution of fat is much finer in the Shetland and Soay than in the Merino or Suffolk.

Hall (13) states that marbling is less developed and is of course of less importance in mutton than beef. This is probably because beef is naturally coarser and tougher. The importance of marbling consists mainly in its influence of tenderness, the elasticity of the connective tissue being decreased by marbling.

Referring once again to the work of Hammond (2), there is a strong positive correlation ($r=0.71$) for the tenderest muscles to have the smallest muscle fibers. There is also a tendency for the tenderest muscles to have the finest grain ($r=0.33$), and a very slight relation between tenderness and pale color ($r=0.20$). In any one animal there is practically no relation between the amount of marbling and tenderness ($r=0.11$).

It is believed that muscles of males have a stronger flavor than those of females, and that muscles of older animals are more highly flavored than those of young ones.

Montfeillet (5) carried out some interesting correlations with flavor. He found some association between high flavor and dark color in muscle (r=0.45). There also seems to be a positive correlation between high flavor and coarseness (r=0.48). Suprisingly enough, he found little or no correlation between flavor and marbling (r=0.02). As for flavor and fiber size, there was virtually no correlation (r=0.01).

The correlations between high flavor and dark color are in agreement with differences existing between red and white muscles of fowls, and also between rabbits and hares. They are also in agreement with the sexual differences, the male being darker colored and stronger flavored than the castrates and the females. The correlations correspond to age changes too, the pale muscles of young are relatively tasteless, while those of adults are darker and more flavorfull.

The correlation existing between high flavor and coarse grain is probably partly due to the association between grain and color. The larger the grain, the more necessary does the hemoglobin become to maintain respiratory exchange; and hence the tendency for the association between size of grain and high flavor.

AN APPRAISAL OF PRESENT DAY FACTORS AND METHODS:

That there remains much to be learned of basic factors influencing the qualities of meat is evident upon reviewing the literature. An appraisal of present day methods of evaluating quality would center around organoleptic testing and some of the chemical and physical tests which have been shown to be accurate in what they measure. All of the present-day techniques have been used on the three classes of domestic meats, but the literature reveals that much more investigational work has been done on beef and pork and considerably less on lamb or mutton.

A description of the paired-eating method was published in 1938 (14). In this technique of evaluating the cooked sample, only two samples are used. The success of the test depends on the two samples being carefully paired. Paired roasts are obtained by using identical cuts from the right and left sides of the same carcass. One roast is used for one treatment and the other for another. An important advantage lies in the method of obtaining data by the paired-eating method, which lends itself readily to a statistical analysis. By and large, the paired-eating method has been limited to its use in testing tenderness in meat. However, there is no reason why some other factor of palatability in meat could not be so tested. It should be emphasized that this method is applicable only to those cases in which the difference between two comparable samples is the important consideration. It cannot be used for comparing a larger number of individual samples with each other, nor for comparing individual samples cooked on different days.

In the "triangle test" three samples are examined, two of which are duplicates. The judges are to select the identical samples, and in addition indicate whether the odd or duplicate samples have the distinguishing characteristics to the more pronounced degree. The latter data are then analyzed as in the paired-eating method, which involved the Chi-square method. The Chi-square evaluated the probability that the number of judges indicating a difference between samples is no greater than might have been obtained by chance.

It has been shown, however, that when judgments were matched between the triangle and paired eating tests, that as many give incorrect answers on one as the other. Therefore, one test was not more precise than the other in the practical interpretation of results. However, the triangle test inspires more confidence in the results because of the opportunity to eliminate judges who cannot identify duplicate samples.

Perhaps the most frequently used subjective technique is the scoring test involving a numerical rating of the samples. The fact that considerable lattitude is given in the design of these tests is evident by the variety of score sheets one will encounter. The factors to be scored are placed on record in a logical sequence or order. First, usually, are the factors judged by sight, followed by those judged by odor and finally those which cannot be scored until the food is taken into the mouth. Generally speaking any form which simplifies recording and leaves the judge free to concentrate on decisions is advantageous. Considerable variations in range occur, but scales of one to five, one to seven, and one to ten are most common. A larger number of intervals increases the variability of scores and thus the experimental error. Ten intervals seem to be sufficient in most cases. Statistical significance is usually tested by the "t" test, when two treatments are compared, or by analysis of variance when two or more treatments are compared. Both procedures test the hypothesis that the samples were drawn from the same population and that the difference between the samples is no larger than would be expected by random sampling.

Ranking tests present still another organoleptic method open to meat researchers. Here the judges are asked to rank samples in decreasing or increasing order of one particular characteristic (eg) degree of rancidity in fat. The results can be summarized by enumerating the number of judges who give each rank to a sample or by averaging the ranks. The ranks can be converted to scores by using Table 20 in Fischer and Yates; "Statistical Tables For Biological, Agricultural and Medical Research" (1).

The four preceding organoleptic tests represent the subjective techniques applicable to the meats field. It can be seen that all depend upon the technique of unbiased sampling and that before interpretations can be made the degree of chance results must be allowed for.

If sensory difference tests are to serve research to the fullest, it is important that specific terms be developed for each product evaluated. The obvious advantage here is that all terms would mean the same thing to all persons who use them. This is a matter of special investigations for the purpose of isolating and identifying the characteristics, and also a matter of training the judges.

Cooking will vary or influence conclusions. Little is known regarding the effect of variation in cooking methods. One of the first decisions to be made in planning a project for a cooked sample is to select a cooking method that will yield a standard product to be tested. Very often this decision is arbitrary. Even when the method or product has been selected, there is difficulty in reproducing it, especially in determining the end point for "doneness." In this respect the meat thermometer is coming to the fore. The need for standardized cooking methods is great. More basic information about the foods themselves would help. Such work as Hammond's (2) is cited in this instance. In the absence of such basic information, it is essential that cooking methods be carefully described for correct interpretation of results from different laboratories.

Investigations have shown that variability of scores is much higher on foods of low quality than foods of higher quality. Workers should recognize this fact and avoid scoring at different times with samples of differing quality, unless such a comparison is desired. This would apply particularlly to the paired-eating and triangle tests.

Because judges can give only comparative, not absolute values to samples, a reference point is often useful. A standard may be labeled or coded and presented with the unknowns. When labeled it is meant to serve as a guide to the judges. The presence of a standard has a tendency to stabilize a judge's score. However, it must be remembered that a standard may be misleading if its quality is not practically constant.

The number of replications depends upon the variability of the samples, the variability of the judges results, the magnitude of difference between samples, and the completeness of information desired in one experiment. Variability of a food sample may be reduced by making it more homogeneous. As far as meat research is concerned, the use of comminuted samples represents this procedure. If this cannot be done, the number of replicates must be increased to produce significance.

Another important consideration in determining the number of replications is the accuracy of the judges. It has been pointed out that the size of panel required to produce an average assessment of specified accuracy may be calculated if the magnitude of the descrepancies between individuals is known. It has also been shown that because of individual variations, more judges are needed for a given degree of reproducibility in interpanel than in intrapanel comparisons. In general, the number of judges should be large enough to counteract unusual variability such as illnesses or any of the many other factors that may influence judges from day to day.

Before setting up a panel, the investigator must give attention to a number of personality factors affecting the judges which may or may not contribute to variability of results. The need for preliminary training of judges is recognized although in all cases it is not done. Whenever possible, selection of judges should be restricted to those demonstrating the greatest degree of acuity and consistency in detecting differences. Some means of checking on the continued performance of the judges is also desirable, because there is no guarantee that their initially high plane of acuity will be maintained throughout an experiment. The rather delicate task of creating a desirable attitude without giving out too much information is recognized. Fatigue, too, must be recognized and includes not only the question of actual tiring of the sense organs, but also the possible mental or psychological fatigue that results when a panel is presented with too many samples at one time.

Another point the investigator might well keep in mind is the effect of age on the ability of the panel judge. It has been found that young and more mature people do not evaluate certain foods the same. Young people distinguish differences between different strengths of food flavors when older people will not. In this same line, younger judges seem to be more capable of distinguishing between strengths of saltiness and sweetness.

Chemical and physical tests are valuable supplements to panel tests, but few are available that even partially replace sensory tests (15). It is usually desirable to show that a chemical or physical test measures a

characteristic that correlates with something detected by the panels. In the meats field much work has been done in an attempt to correlate physical measurements of tenderness, texture, and juiciness with the panel scores for the same qualities. Of these, The Warner-Bratzler shear has shown the most promising results. This shear measures the force required to cut across a cylinder of meat of a known diameter. Other physical tests, used to explain differences in tenderness found by panels, are the determination of size and number of fibers in muscle bundles, estimations of the proportion of elastic and collagenous tissue, and histological changes in muscle fibers. There remains, however, much to be done in this connection.

Most of the results of work done on press fluids have found no correlation between press fluid and juiciness. However, some workers have reported that the method can be used for beef, lamb and pork, at least in cases where the variation in juiciness is due to animal production factors or to differences in the internal temperature of the cooked meat.

In discussing the induction period for oxidative rancidity, there seems to be a belief that there is a reliable test. However, such does not seem to be the case, for it has been in the experience of the writer that traces or indications of rancidity can be detected before they show up in the form of a peroxide number. In fact it seems that in the final analysis, rancidity must be detected through organoleptic observation. No one chemical test has been devised which can accurately measure and correlate all of the factors which act simultaneously to produce the odors and flavors of rancidity.

Factors of palatability as measured by the grading sheet are interrelated. Interdependence has been found between aroma and flavor, quantity and quality of juice, flavor-aroma and juiciness, texture and tenderness, flavor-aroma and tenderness, and tenderness and juiciness. Where mechanical methods were involved, no such relationship existed (eg) between press fluid and shear stress, and between press fluid and flavor-aroma. The grading sheet is an accurate measure of tenderness because there is a high correlation between the grading sheet score and the mechanical shear score. No correlation has been found between the quantity of juice as judged by a grading sheet and the press fluid. Juiciness as judged by the senses probably involves other palatability factors, such as flavor-aroma, which stimulates the flow of saliva, while press fluid can mean only the amount of juice expressed under given conditions. Data on 115 lambs and sheep were contradictory and inconclusive. On the whole there appeared to be no significant relationships between subjective and objective methods of assessing juiciness factors in the lamb and mutton studied.

Recent work with beef has shown a negative correlation between tenderness scores and alkali-insoluble proteins (15). It is a negative correlation because a high score for tenderness actually indicates a tough cut. Similar studies have shown no correlation between tenderness scores and total nitrogen, trichloroacetic acid-soluble nitrogen, non-protein-nitrogen, or heat coagulable protein. There seems to be a low, yet significant correlation between marbling and tenderness, a high correlation between carcass grade and tenderness, and absolutely no correlation between tenderness and pH, moisture, lactic acid, or inorganic phosphate. The fact that these studies were carried on with beef probably lessens the chances that a different story would be obtained with lamb or mutton. Of the biochemical factors studied to date, alkali insoluble protein and muscle plasma as represented by muscle hemoglobin seem most closely correlated with changes in tenderness. General observations are interpreted as indicating the importance of muscle plasma in tenderness.

Many studies have been carried out on the effect of stage of fatness on tenderness. Work with beef indicates that there is a positive correlation between the two. However, the same does not seem to be true with lamb. Most of the work so reported indicates that state of fatness has no distinct effect on tenderness of lamb or mutton. This might be due to the fact that tenderness as a rule presents no problem in lamb or mutton.

Referring once again to beef research, it has been shown that feed and breed can affect the color of the carcass fat. While there seems to be no record of a similar investigation on lamb or mutton, it is entirely possible that the carotene content of the feed, as well as the particular breed, might produce similar results. Generally, however, one finds that lamb or mutton fat varies little in color from a bleached white appearance.

In evaluating the carcass from one cut, the worker must keep in mind the possible variance of tenderness from muscle to muscle and, in some instances, variations within the muscle. Shear readings on cooked samples seem to be well correlated with those obtained on raw samples. But there seems to be a consistently lower shear value on cooked samples than on raw. It seems that the mechanical shear detects a factor in the raw samples that does not exist in the cooked. No doubt the collagen to gelatin change is involved here. Although these results were obtained with beef, it is possible that similar results might be obtained with lamb and mutton, although they have not been reported.

SUGGESTIONS FOR FUTURE WORK:

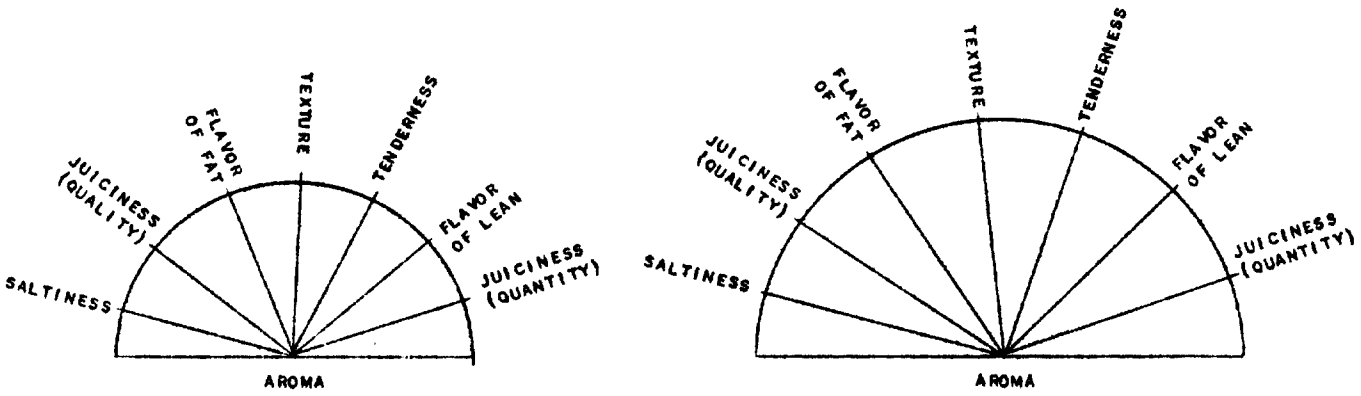
It is quite possible that one day the human taste panel will be replaced by chemical and-or physical testing equipment in so far as measuring differences are concerned. But the individual must always be called upon to pass judgment in terms of preferences, likes and dislikes, or to indicate the rate at which he would desire to consume the food. Therefore, in order for the panel to perform its function fully it must provide two kinds of information: (a) it must be able to detect differences known to exist between two otherwise similar samples, and (b) it must be able to predict, to a certain degree, the relative acceptability of the two different samples by the general public (16).

This two-fold requirement of a tasting panel must be made possible by attention to certain details in the organization of the test and to the kind of record to be secured. Most generally the paired-eating, triangle test, and ranking tests would be best adapted to detecting differences between two treatment samples, whereas the more widely used scoring sheet would be better adapted to preference testing. In some instances these two functions of the flavor panel may be separated for convenience, but in the end they must be combined before a complete picture is obtained.

A different approach to quality evaluation of which we might possibly be hearing more in the future is reference to "flavor profiles" (17). This presents a descriptive analysis of flavor expressing in common language terms the characteristic attributes of both aroma and total flavor, their order of appearance and intensities and the amplitudes of total aroma and total flavor. It presents a method of flavor analysis which makes it possible to indicate degrees of difference between samples on the basis of the intensity of individual character attributes, the degree of blending and the overall amplitude. The flavor profile is a kind of flavor spectrum and

may be expressed in either diagrammatic or tabular form. The diagrammatic expression of flavor profiles perhaps gives a clearer idea of what this technique can do. Following are two examples based on those appearing in a recent issue of Food Technology (17).

Hypothetical Flavor Profiles for Lamb:



Amplitudes are represented by the areas of the semicircles and "thresholds" by the perimeters of the semicircles. The individual attributes are designated by solid lines that originate at the center. Some lines just reach the perimeter, being just at the recognition level. The distances to which the other lines extend beyond the threshold indicate the detectable intensity which they represent over and above recognition by the senses.

Flavor, juiciness, and aroma are perhaps the quality factors that require the most attention by workers. With lamb and mutton we are not so concerned with tenderness and texture as they do not present the problem they do in beef, where most of the work in that connection has been done. More can be done about increasing consumer acceptance of lamb by better understanding the fundamental causes of flavor, aroma and juiciness, and perhaps their alteration to suit consumer tastes through improved and newer cooking methods. It may be that certain feeding operations adversely affect flavor, aroma or juiciness. If so therein lies a challenge to meat research men. What is more evident, is that we have a psychological problem on our hands. It might be that research could be better directed along lines of proving that much of the opposition to lamb or mutton is psychological and not factual. This might involve a series of paired-eating or triangle test investigations showing that differences detected by panels existed only in their minds.

SUMMARY AND CONCLUSIONS:

Summarizing the following points should be remembered:

(1) Research should be organized along lines well adapted to statistical tests of significance.

(2) Standard nomenclature should be adopted and used in scoring sheets which themselves, should be organized along standard

patterns, taking into consideration the limited facilities of the smaller laboratories.

(3) There should be a continual emphasis on the organization and selection of a tasting panel, with special reference to personality factors of the judges.

(4) Future work might well be directed along lines investigating fundamental concepts of sheep muscle in an attempt to arrive at basic causes of resulting quality.

(5) A clearer idea of lamb and mutton quality probably lies in greater knowledge of the internal physiology of the muscle and muscle fiber.

(6) There must be continued emphasis on research devoted to developing supplementary chemical and physical techniques which will be able to measure the quality factors of juiciness, flavor, aroma, and texture detected by the panel.

(7) The tasting panel is still a very important research tool in determining meat quality and it is capable of detecting and evaluating certain attributes and combinations of attributes that purely objective tests are not able to do.

(8) The tasting panel can fulfill two objectives (a) to detect differences between two otherwise similar foods, and (b) to predict to a degree the relative acceptability of a sample material to the general public.

(9) Future use of the "Flavor Profile" may allow a clearer concept and interpretation of recordings of the impressions of a taste panel.

This report has shown one thing in particular; that as far as carcass quality investigations with sheep are concerned, much remains to be done. As a nation we are not lamb or mutton eaters. Coming from the western part of the country, I have no doubt run up against this problem more than those of you who are from the east. The majority of the work in the past has been on beef and pork, but much of it has been of a fundamental nature and could be applied, with allowances, to lamb and mutton. The fact that our national consumption of lamb and mutton is so low, indicates the need for increased effort in the meat research field. Our present high prices for beef and mutton, especially the former, could be partially remedied through increased sheep production. The only way sheep production can be increased and a measure of stability introduced into the industry, is by increasing consumer acceptance and demand. It is in this connection that the meat researcher can play an important role, by directing efforts towards increasing and understanding quality factors as they apply to production, processing and cooking.

LITERATURE CITED

1. Mrak, E. M. and G. F. Stewart
Advanced In Food Research, Vol. II, 1949
Academic Press Inc., New York, N. Y.

2. Hammond J. and Appleton, A. B.
Growth and Development of Mutton Qualities In The Sheep
Oliver and Boyd, London, 1932.

3. Otis, Kansas State College, Ibid
Bul. 118, 1903.

4. Nathusius, Ibid
Landwirtschaft Jahrbuch, 20, 1891

5. Montfeillet, Ibid
Introduction a l'étude des viandes
Paris, 1903.

6. Bell and Bullard, Ibid
American Jour. Anat. 9, 1909; 14, 1912-13.

7. Waters, Ibid
Proc.Soc.Prom. of Agrig.Sci., 30th & 35th Meetings, Portland, Ore., 1909

8. Adametz, Ibid
Landwirtschaft Jahrbuch, 17, 1888

9. Warringholz, Ibid
Arch. f. prakt. Tierheilk., 29, 1903

10. Sustschowa, Ibid
Arch. Anat. u. Physiol., Phys. Abt. 1910, #1, 2.

11. Brozert, Ibid
Arch. f. d. ges. Physiol., 3, 1870

12. Diffloth, Ibid
Zootechnie speciale, Paris, 1908

13. Hall, Ibid
Illinois Agr. Expt. Sta. Bul. 147, 1910.

14. Cover, S., 1936
A New Subjective Method of Testing Tenderness In Meat-The Paired-Eating Method, Food Res. 1, 287.

15. Husaini, S. A.
Biochemistry of Beef As Related To Tenderness
Food Tech. 4: 313-16, Ag '50

16. Quartermaster Corps. Manual 17-9
War Dept., Committee on Food Research
Office of the Quartermaster General

17. Cairncross, S. E. and L. B. Sjostrom
Flavor Profiles - A New Approach To Flavor Problems
Food Tech. 4: 308-311, Aug. '50

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CHAIRMAN VANDER NOOT: The next speaker on our program is Mr. Carl Roubicek from the University of Wyoming, who will present a paper on, "Lamb Carcass Evaluation as a Part of Sheep Breeding Experiments."

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