STATUS OF METHODOLOGY IN PORK CARCASS EVALUATION

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The interest of the Reciprocal Meat Conference (RMC) Associates in pork carcass evaluation, in its broad sense, dates back to June, 1948. Prior to this time members of the Cooperative Meat Investigation group were keen on this subject. One step further back, before the turn of the century men of the caliber of Armsby[204], Sanborn[205], Waters[206], Schweitzer[207], etc., were working in closely related areas. Many of the early investigators visited and/or corresponded with European researchers; noted the validity of their efforts and started similar investigations in this country. It was their foresight and interest that led the way in this important endeavour of live animal and carcass evaluation in the U. S. That this interest has continued is verified by one or more reports covering various aspects of this subject in each of the RMC Annual Proceedings. I am sure all of us are grateful to our predecessors (present or absent) for the time and effort given in assembling all of this information. The purpose of this report is to continue this tradition by gathering under one cover many methodologies that have been used to evaluate "composition of value" of pork carcasses. Occasionally methods may be referred to that have not been tested with pork but may warrant critical validation toward this end.

Live Hog

At this time it is appropriate to look back for about 15 minutes to review where we have been, presently are and possibly will go in the future in the area of pork evaluation.

Accurate selection and ranking of the carcass from the visual appraisal, or scores of live hogs is of limited value [1 through 4,7,8,193]. Experienced live stock men apparently can "adequately" place groups of hogs on an average value basis[193,198]. It has been illustrated that experienced people can increase their accuracy in placing live hogs and carcasses through critical training [193,198]. Live hog tape measurements appear to be guides to shape, size and weight but not necessarily lean-fat-bone ratios[194].

The ruler probe as an aid in evaluating the carcass from the live hog has been generally accepted[5,6,23,196]. The lean meter[9] has not been graced by this wide acceptance. The differences in cost of equipment, skill required and possibly degree of precision between these two methods accounts for the difference in general acceptance.

Biopsy techniques[10 through 16] have been developed through which muscle, fat, bone and organ tissue samples can be obtained from the live animal. Quantitative as well as qualitative values of these tissues can be studied. Biopsy methodologies provide a means of evaluating tissue changes, with time, as influenced by various treatments without sacrificing the animal.

High frequency sound (H.F.S.)[17 through 43,47,52] techniques are being used in Europe, the U. S. and elsewhere to determine muscle and fat (area, thickness and ratio respectively) of hogs, cattle and sheep. These measurements are associated with the lean-fat ratio. Some investigators are also studying the association of the thickness of individual backfat deposits to other fat deposits[44]. At the present time most of the H.F.S. measurements are taken over the back of the animal. However, several investigators have studied other sites on the live animal[45,46,47]. Our present H.F.S. techniques are not applicable to the chilled carcass. The rate of sound penetration through different media has been checked by several workers[48 through 51,53,54]. H.F.S. techniques have the advantage of being non-destructive, painless, acceptably accurate and can provide a profile of the lean and fat tissue of the live animal.

X-ray observations by direct screening and photographs have been used to evaluate the development of bone and fat in the live hog and in other animals [111 through 120]. One investigator reported that fat shadow radiography and ultrasonic measurements produced nearly identical results. Proper positioning and restraining of the animal plus correction for non-parallel X-ray beams appear to be the chief drawbacks to this method other than the cost of equipment. However, a small portable X-ray apparatus for measuring backfat thickness is available[123].

Various attempts have been made to measure the specific gravity of whole dead and live animals[55 through 59,189] with varied success. Investigators recently[60] reported very encouraging results between the specific gravity of live hogs and body fat and water. Residual air volumes were considered.

Gas displacement appears to be a method of determining body specific gravity without corrections for residual or trapped air. Several workers[61,62,63,64,65,189,199] have reported investigations employing this technique. Major criticisms of this technique are: that it is time consuming, tedious and rather difficult to control the effects of temperature and humidity in the enclosed environment.

Quantity of urinary creatinine appears to be a reasonable index of muscle in humans[66,67,121]; though studies with hogs of this non-protein nitrogen substance have not been shown to be associated consistently or strongly with muscle mass[68,69,70]. It appears that the physiological stresses imposed during urine collection unpredictably alters the quantity of creatinine and urine excreted[70].

The potassium isotope, K^{40}, has been reported to be associated with total body potassium[71,72], quantity of protein, fat[73], body water[74] and muscularity in humans[75 through 78], sheep[79,91], beef[122], hogs[80] and pork samples[81 through 84]. The consistency of results between workers studying the relationship of K^{40} to indices of muscle mass leaves much to be desired. This fact in itself should not be discouraging since the facilities involved in these evaluations were elaborate, complex, different and, for the most part, their capabilities were little understood. Furthermore, the conditions under which the various studies were conducted were not alike. The relationship of total potassium to potassium-40 has been shown to be relatively constant in nature[85]. Many unresolved problems remain in this area.

Although regarded as confusing and possibly not completely resolved, the use of blood volume and components of blood as indices of lean-fat ratio has received much attention in humans[86,87,88] and animals [89,90,92].

Since muscle tissue contains more blood per unit than fatty tissue it is logical to assume that total blood volume or volume of some blood constituent, i.e., red cell volume, is associated with muscularity, body water, etc.

Some early workers[88] endeavored to determine blood volume directly by attempting to collect all of the blood in the body by washing out the vascular system and leaching the macerated tissue. Volume was then determined by a comparison of a given constituent in the diluted and normal blood from a given animal. Later, various dyes[87] such as Brilliant Vital Red, Vital Red, Congo Red, Trypan Red, Evans Blue, etc., were employed by dilution methodologies to depict volume. Most recently, isotope dilution procedures have become fashionable for determining quantity of blood or a blood constituent[89,90,92,97,98]. Blood or blood constituent volume methods can be used as an index to the lean-fat ratio of hogs[92,93]. However, due to the nature of the materials employed as markers to quantify the blood or component, these procedures probably will be used to evaluate breeding stock or young animals that will not be used for food unless their systems are acceptably cleansed of the dilutant.

Other dilution techniques including antipyrene[94] , N-acetyl-4 amino antipyrene[94], I_{131} labeled 4-ido-antipyrine[95], tritium [94,96] and deuterium[201] have been used as <u>in vivo</u> blood dilutants to determine total body water, which is a reflection of lean-fat ratio. The reduction in body water content with the increased fattening of animals has been observed by several investigators. Procedural details of these methodologies are described in the literature[95,99,100]. Methods which involve the separation of total body water from extracellular water have also been reported[101,102,103]. This difference, total body water minus extracellular water, equals intracellular water which presumably forms a constant percentage of the weight of the cell mass. Allowing a factor for bone, body fat would be the difference between total body water and cell weight plus extracellular water. The continued advances in detection instrumentation and tracer methods will no doubt usher these techniques to a more important position for evaluating live animals in terms of their carcasses.

Photogrammetry procedures as determinants of body area were first recorded in Germany[104] and France[105]. The rapid post World War II advances in photomapping techniques suggested non-topographic stereophotogrammetry as a valid means of determining body volume[106 through 109]. Armour and Company[110] adapted the technique as a beef cutability determinant.

<u>In vivo</u> tissue temperature differences[190], gas absorption[192] and the use of anesthetics technics as means of determining body composition have not been extensively investigated.

It is generally agreed[124] that the live animal is more difficult to evaluate than the carcass. Yet, an acceptable evaluation of the carcass

is no simple task. The complexity, importance and continued interest in this endeavour is brought to the foreground when we realize that the early researchers investigating this problem could have celebrated their centennial better than a decade ago[125 through 129].

The weight and visual appraisal of the carcass apparently is adequate for some packing house carcass-lot evaluations. Backfat measurements combined with complete cut-out data or the weight of a given cut from randomly selected carcasses serves the purpose of other packers[136]. Subjective quality appraisal and carcass weight supplemented by backfat thickness, loin-eye area and carcass length satisfy some specific needs[130]. Complete carcass cutout combined with carcass measurements and quality appraisals better serve the objectives of those interested in differences and relationships between the physical characteristics under study on a large number of carcasses[131,132,133].

A barometer of the producer's interest in carcass evaluation is registered by the increased frequency and size of carcass contests. This development coupled with a need for rapid, acceptable evaluation methods has brought forth several indices of carcass value[134 through 142]. These methodologies usually include subjective qualitative appraisal as well as some carcass measurements, cut-out and often other value determinants. None of these evaluations are "free of sin" to quote our Tennessee associate[143]. Nevertheless, methods of evaluating the carcass that include the procedures of the Recommended Procedures for Quality Carcass Contests[144] will allow some degree of standardization which will further facilitate more useful utilization of the data for comparative purposes.

The more dedicated individuals or those not completely satisfied with these evaluation results try to peer deeper into this complex problem.

One of the most direct classical methods of determining the quantity of skin, bone[209], fatty and muscular tissue components of the complete carcass is by physical separation. This method has been used by several[127,145 through 152] early and present day investigators[153 through 158]. When meticulously carried out the separation technique can unquestionably yield valuable information in terms of the ratio or increase of the separated entities. Since the procedure is quite costly in terms of time and tedious labor, much effort has been directed toward the selection of sample portions of the carcass which are representative or associated with the various carcass components[148,156 through 165]. The carcass and sample separation methods have the common basic weakness of not evaluating the very important but elusive term "quality". Preceding[125,168], concurrent to[126,127,128] and since [165 through 168] the innovation about a century ago of the separation techniques carcass and live animal "evaluators" were chemically analyzing samples from animals and carcasses. Proximate and more detailed chemical analyses of carcass samples possibly are not necessary in many carcass evaluations. However, in the more detailed investigations concerning the effects of treatment or the relationship between elemental entities, chemical analyses are essential for accurate description and identification purposes[195].

Archimedes' principle, when applied to carcasses or components thereof, has been shown to be a reasonable index of the lean-fat ratio or percentage of moisture, protein and ether extractable materials

(fat)[169 through 173]. As is often the case, several researchers have not been able to refine this procedure to satisfaction[174,175]. Specific gravity literature dating from 1757 to 1958 have previously been comprehensively surveyed[176, 177]. Two very interesting (1956) publications[175,178] critically discuss the adequacy of this technique for accurate determinations and comparative purposes.

Some carcass measurements which include length, depth, width, circumference, plumpness of the carcass and ham are of little practical significance as indices of carcass lean-fat ratio and possibly have been overly emphasized by virtue of their frequent reference in the literature. These variables do serve as descriptive measurements of carcass conformation and size and should be expected to be associated in the same general way to the lean-fat-bone composition[193]. The mean of the conventional backfat measurements remains as one of the most practical measurements of total separable or extractable carcass fat[148,179]. However, backfat measurements usually account for approximately 50% or less[133] of the variation in carcass trim fat. This is possibly due to human inconsistencies in trimming and also to quantitative differences in where the fat is deposited as influenced by managerial practices, sex, etc. These differences in fat deposition may account for the difficulty in establishing a strong relationship between backfat and inter-intra-muscular fats. There is also evidence which suggests that the three traditional backfat measurements are possibly not as strongly associated with total carcass trim fat as are fat measurements obtained at other sites[180]. Preliminary data analyses suggest that the thickness of the various fat deposits that comprise the total backfat thickness may lead to a reasonable index of inter-muscular and total carcass trim fat and possibly marbling. These fatty tissue deposits are easily measured *in vivo* or from cross-sectional cuts of the untrimmed loins[181]. "Fat" figuratively speaking is probably the most alterable and variable constituent of flesh.

Area of the cut surface of a specific muscle or muscles determined by photometric[182,183,184,200] planimeter or cross-sectional measurements have been one of the more widely used indices of muscularity. There is reason to believe that it may no longer be necessary to cut loins and trace the *Longissimus dorsi* in the established manner. Reports indicate that there may be little choice, in terms of usefulness, between the 10th rib and last rib *Longissimus dorsi* area[185], ham lean area[155,186,187] and the sirloin end total lean area[188]. If these results are further confirmed, we may eventually stop cutting loins to obtain this measurement. Conversely, several reports suggest that the utility of the *Longissimus dorsi* area has been over rated. Possibly this inference is well founded for the specific usage intended. Loin-eye area correlated with ratios based on large weight differences do, in extreme cases, result in correlation coefficients which are negative or which do not differ from zero. It is difficult to explain, on a functional basis, reasons why the 10th rib, last rib or other area of the *Longissimus dorsi*[202] should be any more strongly related to total carcass lean than other similar area measurements of the carcass muscles as long as the area is taken identically each time[197]. This same thought applies to areas of fat[185,186,187] and area ratios of lean to fat[155].

In conclusion the needs for practical validated methods of evaluating the live hog in terms of its carcass are obvious from the

producers', packers', and etc., viewpoint. Similarly, it is necessary to re-evaluate some aspects of carcass methodologies. More conclusive basic knowledge concerning growth and development is needed to augment more precise approaches to evaluation and selection from the live and carcass point of view. The two methods suggested at the 10th RMC[208] appear to be the accepted validation procedures, namely, physical separation and/or chemical analysis. It appears that too little consideration has been given to the ultimate usefulness "on the plate" of many of the selection criteria.

And, finally, friendly differences of opinion should be encouraged and exchanged. Differences of opinion should stimulate, and this needs to be emphasized, validation of results.

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