The increased emphasis on production of more lean meat per unit of weight, has resulted in added emphasis being placed on muscling in pork carcasses. This, of course, raises the question as to what are the best measures of muscling and how they are related to cut-outs. Furthermore, one might ask what the relationship between shape or size of the muscle in cross-section is as compared to total muscle mass? Thus, for the purposes of this paper, I will attempt to discuss the more common methods of measuring muscling along with a few other methods, trying to point out some of the advantages and basic weaknesses of each method.

In measurement of muscling, one of the major problems is establishing the validity of the different methods. To do this, it is first necessary that standards be set up which accurately reflect muscling and can be used to validate new methods. Unfortunately, we have little information available which will make an accurate comparison possible. This is true primarily because of the basic concept that methodology is an unproductive field of endeavor. Thus, it is necessary to start with basic information on the composition of skeletal muscle, since this is our primary interest. Dukes (1943) gives the following composition of mammalism skeletal tissues:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>75%</td>
</tr>
<tr>
<td>Protein</td>
<td>18-20%</td>
</tr>
<tr>
<td>Carbohydrate (mainly glycogen)</td>
<td>1%</td>
</tr>
<tr>
<td>Soluble material (non-protein and non-carbohydrate)</td>
<td>3-5%</td>
</tr>
<tr>
<td>Fatty Acids* (minimum)</td>
<td>0.5-1.0%</td>
</tr>
</tbody>
</table>

*May be much higher due to increased storage fat.

It is obvious from the above table that there is great variability in composition of muscle tissues. This is especially noticeable in regard to fat content, and to some extent with moisture, which tends to vary inversely. Since muscles differ in intramuscular fat or marbling, basic information is needed on the effect of marbling on tenderness, juiciness and flavor. Work with beef, recently reported by Cover et al. (1956) indicates that the effect of marbling on tenderness is not a simple clear-cut relationship, but apparently other factors besides marbling are involved. It has been generally accepted that excessive fatness is undesirable in pork carcasses and though results indicate this to be true (Birmingham, 1956), we do not have information available indicating how far we can go in the opposite direction and still satisfy the
consumer. Furthermore, it is conceivable that we may have considerable muscling present in combination with excessive fatness, whereas a hog carcass may be lacking in fatness but still be deficient in muscling.

There would appear to be two valid measures for determining muscling of pork carcasses, first, dissection and separation, and second, chemical analysis. In my opinion, these are valid means of measuring the reliability of other methods for determining muscling. However, failure of other methods to be in complete agreement with these two would not preclude their usefulness under certain conditions. Consequently, I shall discuss each of these methods pointing out some of the short-comings and advantages.

The dissection-separation technique has been used extensively by Hammond (1921 and 1932) and others of his school (McMeekan, 1940; Hirzel, 1939; Palsson, 1939) for carcass evaluation. In this country it has been used by a number of workers (Hankins and Ellis, 1934; Hankins and Howe, 1946; Loeffel et al., 1943). This method has the advantage of including marbling with the lean tissues and in addition, gives one an opportunity to observe shape, color and other physical attributes of the muscles. However, it is a slow, painstaking task that involves subjective decisions in dividing the tissues into the component lean and fatty classifications. In addition, losses due to evaporation or absorption are possible added sources of error. However, in spite of the short-comings of the dissection-separation technique, it appears to be a valid measure of muscling.

Next, let us consider chemical analysis as a measure of muscling. Numerous workers (Warner et al., 1934; Hankins and Ellis, 1935; Callow, 1945 and 1948; Brown et al., 1951; Whiteman et al., 1953; Price et al., 1957) have used chemical analysis as a method of measuring leanness or fatness. Although chemical analysis is rather difficult to obtain on meat samples due to problems in sampling, it is easier and less tedious than the dissection-separation technique. It has the disadvantage of not including marbling in the lean tissues, but instead includes intra-muscular fat with other ether soluble material. Furthermore, chemical analysis gives an index of muscling only from the percentage viewpoint and ignores shape or appearance of the muscles. However, because of the relatively simpler application and the sound principles on which it is based, chemical analysis would seem to be a good measure of muscling.

The area of the "loin eye", or Longissimus dorsi muscle of the loin, has been the most commonly accepted measure of muscling in carcass studies. Failure to standardize the point of measurement, the muscle to be traced and the plane of cutting through the muscle have resulted in variability in results. Kline and Hazel (1955) have shown that the area of the "loin eye" was larger at the last rib than at the 10th rib and concluded that it made little difference which was used as long as it was standardized. Consequently, breed certification programs have generally adopted the area of the "loin eye" at the 10th rib. However, certification data reporting values above 6 square inches of "loin eye" may be viewed with some doubt, and it is likely such values are due to inclusion of the multifidus dorsi muscle or other small muscles adjacent to the "loin eye". It is well known that cutting of the "loin eye" at an angle greater than 90° will also increase the area. In addition, it is possible to increase or decrease the area of lean by pressing
against the muscle. In order to minimize changes due to altered surface area of the "loin eye", Bratzler (1957) began taking all tracings on the rough loin. This gives rigidity to the muscle and reduces errors due to altered surface area.

The loin area tracing is simple to make and allows one to accumulate the tracings for more leisurely measurement. Along this line of thought, it should be possible to develop an electronic device, which would read off the area directly. In addition, to possible sources of error in determining the loin-lean area, there is no concrete evidence that loin-lean is closely related to muscling in the remainder of the pork carcass. Data on cut-out and chemical analysis would indicate that "loin eye" is not closely correlated with total muscling of the entire carcass (Kline and Hazel, 1955; Price et al., 1957).

Specific gravity measurements have been used to ascertain leanness and results indicate that specific gravity more accurately reflects the loin-lean area than backfat thickness (Pearson et al., 1956a; Price et al., 1957). In addition, a higher correlation was obtained between the area of the "loin eye" and chemical analysis of the ham than was true for backfat thickness, which tends to verify the relationship between muscling and specific gravity. Oklahoma workers (Brown et al., 1951; Whiteman et al., 1953a and 1953b) found chemical analysis to be more closely related to leanness than backfat thickness. Similarly, Liuzzo et al., (1956) reported percentage fat and water specific gravity were closely related with an "r" value of .99. Thus, results would indicate that muscling is accurately reflected by specific gravity. However, specific gravity of the entire carcass or a single ham may not be closely related to loin-lean area. Unfortunately, specific gravity has not been a real good measure of cut-outs, but it should be mentioned that cut-outs are not free from variability as shown by errors in cutting opposite sides of the same carcass (Lasely and Kline, 1957).

The live probe and lean meter have both been used to predict backfat thickness (Hazel and Kline, 1952; Andrews et al., 1954) in the live animal and may possibly be useful in the carcass. Interestingly enough both measures have more accurately indicated cut-out on the live animal than was true for backfat thickness (Hazel and Kline, 1952; Pearson et al., 1957b). However, Price et al., (1957) found little difference between the two measures insofar as their relationship to the loin lean area is concerned.

Backfat has been used as an indicator of carcass value, and therefore, it would be assumed that it is related to muscling. Warner et al., (1934) showed backfat thickness was related to carcass cut-outs. The North Central Livestock Marketing Research Committee (1952) reported backfat accurately reflected lean cuts on the carcass basis with an "r" value of .84 and this was verified by Henning and Evans (1953). However, other workers have failed to obtain such high relationships (Brown et al., 1951; Whiteman et al., 1953a and 1953b; Pearson et al., 1956a; Price et al., 1957; Whatley et al., 1957). Although backfat is a simple measurement to make, it is obvious that even though it reflects cut-outs, it is not closely related to muscling.
Other measurements that have been suggested as possible measures of muscling include the defatted ham (Durham, 1957), the depth of lumbar lean (Bray, 1957), the area of the outer lumbar muscle (Pearson and Bratzler, 1957), all of which are not described in the literature. In addition, blood fat levels (Bowland and Hironka) have been reported to be related to area of loin-lean and to backfat. This has been partially verified by Morrow et al., (1956), but other variables have complicated the picture and make further study necessary. Other possible measures of muscling in the live animal include the helium dilution technique for determining specific gravity on intact animals or humans developed by Siri (1956) and the air displacement method (Luzzo et al., 1956). To date both methods need further validation and verification. Another suggested method of obtaining body volume is by photogrametry (Pierson and Montoye, 1957), although this method has not been used for this purpose, such usage has been suggested.

Additional carcass measurements such as length have been used, but results indicate low relationships with both muscling of the loin and cut-outs (Pearson et al., 1956b). Some simple cut indices have been used for evaluating pork carcasses (Pearson et al., 1957a), and in general, the loin indices would appear to be the most promising measure of muscling - at least as judged by relationships to cut-outs and "loin eye" area.

In conclusion, it is suggested that chemical analysis and physical separation are valid bases for development of sound techniques for measuring muscling in pork carcasses. Although a number of methods are available for measuring muscling, it is believed that validation of the available methods is needed.

List of References Cited


DR. STRONG: Thank you, Al, for bringing us up to date and taking a look at one of the rising stars that has come into prominence for use in pork carcass evaluation and what has been done at various points with regard to measuring of muscling.

Another aspect that we are interested in when evaluating pork carcasses, of course, is quality. You all realize that this is absolutely non-controversial. We have talked about it for the last three or four years at times, and we are all in complete agreement on it. However, so that you will know what we are in agreement on, since you may be confused from some of the discussions since George Wilson covered this subject back in 1953, we have asked Ernie Briskey, from Wisconsin, to give us a little reevaluation of this quality factor. Ernie.

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