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THE CHEW COUNT AS A MEASURE OF TENDERNESS IN PORK LOINS WITH VARYING DEGREES OF MARBLING

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The experiment to be described had two objectives,

(a) to study the "chew count" as a method of evaluating the tenderness of pork chops and

(b) to study the variation in tenderness among a sample of pork chops with varying degrees of marbling.

Lowe (1949) suggested that, as far as the ordinary consumer is concerned, a major difference between tough and tender meat is the time and effort required to masticate a portion in the mouth. The number of chews needed to do this might, therefore, be a valuable way of measuring gross tenderness variations. As this characteristic varies a good deal from person to person, care must be taken to use the same panel throughout an experiment, to supply them with samples of standard size and to specify precisely the end-point of the chewing process.

Various workers have used different definitions of this end-point. Aldrich (1960) requires the sample to be "masticated so completely that nothing remains in the mouth", the taster being allowed to cut his own portions for chewing (about ½" x ½") from slices of beef. Cobb (1960) has examined several different end-points using 1" x 1" samples from cold slices of beef roasts cut 3/8" thick, and prefers "chewing to the consistency at which the sample would normally be swallowed". This is similar to the definition used in studies of veal by Hanning, Bray, Allen and Neidermeyer (1957) and in the present studies of pork.

The chew count method is likely to be of value only if the meat under test contains no large deposits of tough connective tissue which would render a sample impossible to chew to any of the above end-points - a criterion which is usually satisfied by samples from the centre of the *longissimus dorsi* muscle of pigs which were used in this study. However it has also proved successful in an investigation of the effect of cold storage and cooking methods on commercial grade cow beef (Paul, Bean & Bratzler, 1957). As far as the authors are aware, these works of Hanning *et al*. (1957), Paul *et al*. (1957) and Wisconsin studies reviewed by Kauffman (1960), are the only published investigations in which chew counts have been used; in no case is detailed information given on within-judge repeatability of tenderness evaluations by this method.

Tenderness of pork has received much less attention from meat research workers than has that of beef. However it is likely to gain importance in view of the increasing emphasis placed on the leanness of pigs over the last few years. It is often stated that quality of flesh may deteriorate as quantity is increased, for a decrease in subcutaneous fat usually brings with it a decrease in the intramuscular or "marbling" fat frequently associated with superior eating qualities (Kauffman, 1960).

METHODS

Repeatability trial

The main experiment was preceeded by a small-scale repeatability trial involving 9 tasters. As repeatability cannot be measured by giving tasters the same sample twice, the next best thing is to ask them to make independent assessments on immediately adjacent samples. This was achieved by taking 1" cores from cold pork chops, removing the browned surfaces and dividing the remainder into equal halves by cutting across the fibres. When this had been done for two chops, the four samples so produced were arranged on a plate in random positions. The panel member recorded his count on each sample and his standard error was calculated from differences between values given to the two halves of the same core. Each of the nine tasters was given four plates set up in this way.

Main experiment

Thirty-six loins were chosen at the time of cutting from pigs slaughtered in the Michigan State University Meat Laboratory, 7 were from Yorkshires, 13 from Duroc x Hampshires, 9 from Chester White x Hampshires and 7 from second and third crosses of these breeds, representing a range in lean cut yield from 47.8 to 58.4%. These were always chosen in pairs or "blocks", the two loins of a block being kept together and treated alike throughout the the experiment. One loin of the block had relatively abundant marbling fat whereas the other was considered to be deficient in this characteristic.

Seven 1½" thick chops were cut from each loin, the first being anterior to the 10th rib cut and the others in succession down the loin posteriorly. These were immediately wrapped and frozen at -20°C. Three chops from each loin were used for tasting, two for shearing and two for chemical analysis, always from the same positions.

A subjective marbling assessment was made on a single chop from each loin using a black and white Polaroid photograph taken when the chop was still frozen. The pictures, projected about twice full size, were scored by six judges on a 5 point scale with the halp of the photographic reference standards provided by Batcher & Dawson (1960). The values used here are the total scores of these six judges.

The chops for objective tenderness appraisal were thawed and cooked in the same way as those for tasting (see below). After cooling to room temperature, five ½" cores were removed from each chop and sheared on the Warner-Bratzler apparatus. The value for each loin is therefore the average of 10 shears.

The two chops for chemical analysis were partially thawed to allow the eye muscles to be separated and ground. Duplicate values of intramuscular fat content (calculated on a fresh weight basis) were obtained on each chop, so the values used here are the average of four determinations on each loin.

The three chops for tasting from each of the two loins of a block were thawed at room temperature and cooked in deep fat (at 138°C) to an internal temperature of 80°C, having been allocated to the six positions in the fryer at random. They were cooled overnight and tasted cold the following morning. Two 1" cores were taken from each chop and so six from each loin, the six tasters being allocated core positions at random for a particular comparison. The tasting was carried out in six sessions, three blocks being compared at each session. For the first three sessions, the allocation of cores to plates was the same as for the small-scale repeatability trial described above, the two chops compared on a particular plate being in this case the pair of chops forming a particular block. It is possible that the judges could have been able to pair off the duplicates on a plate by eye because of slight differences in colour and texture between the two loins. To test this possibility, the design was changed for the second three sessions of the experiment. At these, two plates only were given to each taster, the first having single samples from six different loins (from 3 blocks), whereas their duplicates were on the second plate in a different random order (see Figure 1).

Analysis

All correlations have been calculated on a "within-block" basis; these have 17 degrees of freedom. Such correlations are not influenced by the effects of extraneous variations on the characteristics correlated, such as length of time kept in the frozen state, since the members of a block were kept together and treated alike from the time they were chosen throughout the experiment. In the case of those correlations involving chew counts, the within-block correlations are not infleunced by variations in the tasters' standards from session to session.

RESULTS

Variability of chew counts

The standard errors of repeated chew counts for the nine tasters in the small-scale preliminary study ranged from 2.3 to 12.8 chews, each being on 8 degrees of freedom. However, standard errors for six tasters lay in the range 2.3 to 3.4 and these were chosen for the main experiment, tasters with standard errors 5.2, 6.3 and 12.8 being rejected.

Table 1 shows the standard errors of repeated chew counts found in the two stages of the main experiment, together with measures of judging discrimination. Several of the tasters tended to be less repeatable in the experiment than they had been in the trial, the pooled standard error in fact increasing from 2.8 to 4.6, but there was no evidence that their repeatability was any better when the duplicate sample appeared on the same plate than when they appeared on different plates.

A taster could be repeatable in this sense merely by not allowing his scores to vary to any extent; if he did his standard error would be small but he would not be discriminating between loins very well. It is for this reason that measures of each taster's discriminating ability (the F ratio of mean squares "between" and "within" loins in the same block, and the intraclass correlation) have been included in Table 1. These show that, although taster E had a large standard error he proved to be the most discriminating, with C, who had the smallest standard error, the next most discriminating. The low values of A for discriminating ability suggest that his small standard error was to some extent achieved by conscious or unconscious equalization of the counts for the samples in a particular session.

Mean chew counts ranged from 25.3 to 47.0 with one exceptional loin having a value of 60.0; these are averages of duplicate assessments by the six judges. A standard error of 4 chews for a single observation shows that the standard error of the difference between two loin means in this experiment would be 1.6 chews (if there were no "taster x loin" interaction). Differences of less than 3½-4 chews between mean chew counts could therefore be regarded as showing no significant difference in tenderness.

Variability in shear values

The standard error of repeated shears on the same loin was 1.33 lb. although some of this variation was due to differences in tenderness between the 5 positions within the chops from which the cores were taken. The standard error of the difference between two loins was 0.59 lb. since each loin mean was based on 10 shear values; these means ranged from 5.1 to 9.1 lb. with the exceptionally tough loin having a shear value of 12.9 lb.

Shears from the more anterior of the two chops chosen for this objective measurement of tenderness were significantly greater than those from the posterior chop (7.3 lb. compared with 6.8 lb.), though this difference showed significant variation from loin to loin.

Relation between objective and subjective tenderness

The results of calculating the regression of chew count on the objective measure of tenderness (using loin mean values in both cases) for each taster and for the mean counts of the whole panel are shown in Table 2. These are calculated within blocks of loins.

The two tenderness measures were highly related, some 85% of the variation in chew counts averaged over the six tasters being explained by shear values. The correlations dropped to 0.85 (72% of the variation explained) when the block containing the extremely tough loin was omitted from the analysis. On average, an increase of 1 lb. in shear value was equivalent to an increase of 4 in the chew count, although the regression coefficient differed between the six tasters.

These results suggest that if increased toughness of pork results, at least as far as the average consumer is concerned, essentially in increasing the difficulty of chewing then the shearing apparatus gives a reasonably good prediction of toughness over a wide range, despite the fact that it simulates only one particular feature of the chewing process. It may not, however, be sufficiently sensitive to detect small differences in the difficulty of chewing.

Measurement of marbling fat

The within-block correlation between chemically determined intramuscular fat and the total subjective scores for marbling fat by a panel of six was 0.85. The total score had an average of 17.9, ranging from 6 to 27 for individual loins. Intramuscular fat averaged 3.45% on fresh weight basis, ranging from 1.1% to 7.4%.

Although the loin chosen in a particular block as "marbled" always had a marbling score no lower than the other, "deficient" loin, the difference in the score among the 18 blocks ranged from 0 to 17. The mean difference between marbled and deficient loins was 7.4 on this 30 point scale. The mean difference in intramuscular fat was 2.83% which was also highly significant.

Relation of tenderness to marbling

Shear values showed a significant difference of 1.3 lb. between the two types of loin, the "marbled" loins being the more tender. Some 38% of the variation in shear values was explained by the amount of intramuscular fat (r = -0.62); an increase of 1% in intramuscular fat caused, on average, an improvement of 0.42 lb. in shear value. The correlation of shear value with marbling score was -0.61 within blocks.

Table 3 shows, for each taster, the mean chew counts for the loins classified as relatively well marbled and relatively poorly marbled. The analysis showed that each taster was able to detect differences in tenderness between loins by this method, although the marbled loins were significantly more tender for only four of the six tasters; taster B failed to detect a significant difference on average between the two series. The extent of the difference varied from taster to taster and, of course, from block to block.

Table 4 shows how the chew counts were related to two measures of marbling (regression of chew count on marbling score and intramuscular fat %). Some 45% of the variation in the panel average chew count was explained by the marbling score (reduced to 35% when the extreme block was omitted), and some 33% by the percentage of intramuscular fat (reduced to 22%). Marbling score and intramuscular fat percentage together explained 44% of the variation in the panel average chew count within blocks of loins. An increase of 1% in the intramuscular fat corresponded to a decrease in chew count of about 1½ on average. Taster B was again exceptional in showing no significant relationship between chew counts and marbling.

These results give support to the contention that pork loins with low levels of intramuscular fat tend to be somewhat tougher on average, when prepared and eaten in this manner, than those with more intramuscular fat, although the relationship was not sufficiently close to be used for predictive purposes. Selection programmes aimed at improving the lean meat content of pig carcasses should therefore keep a careful check on the changes that are occurring in the eating qualities of this lean meat as the level of fatness of the carcass is reduced. Shearing samples of cooked pork with apparatus of the Warner-Bratzler type seems the most practicable way of making regular evaluations of tenderness in pigs from progeny testing stations etc.; periodic comparisons with chew count evaluations by a small trained panel would be desirable, however, to ensure that the shearing method continues to reflect differences in the difficulty of chewing as selection alters the chemical and physical composition of the meat.

SUMMARY

1. The "chew count" was studied as a method of evaluating the tenderness of pork chops. Some tasters were more repeatable than others in making the count and were able to discriminate more between loins of varying tenderness.

2. Mean chew counts by a panel of six tasters for 36 loins ranged from 25.3 to 47.0, with one exceptional value at 60.0.

These showed a high correlation with mean shear values based on 10 shears per loin. On average, an increase of 1 lb. in shear value corresponded to an increase of 4 in the chew count in this experiment.

. Mean chew counts and shear values both showed significant correlations with two measures of marbling fat made on the 36 loins, namely visual scores and intramuscular fat contents, the less marbled loins being somewhat tougher. On average, an increase of 1% in intramuscular fat corresponded to a decrease of about 1.5 in the chew count or 0.4 lb. in shear value.

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Figure 1. Allocation of duplicate samples to plates according to Method 1, used for the first three sessions, and Method 2, used for the remaining sessions. A and B form the first block of two loins and so on, three blocks being compared at each session.

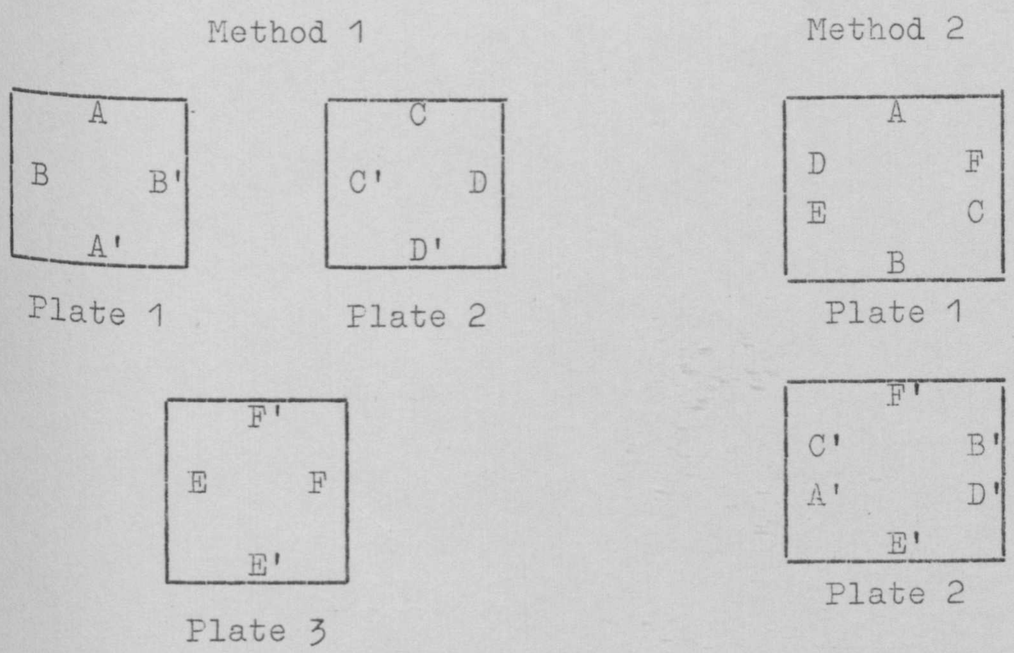

Table 1. Repeatability and discrimination in the main experiment

Standard errors of repeated chew counts when tasting was by methods 1 and 2 (each on 18 degrees of freedom), and over the whole experiment (on 36), together with the F value (ratio of mean squares "between" and "within loins in the same block" on 18 and 36 degrees of freedom) and the intraclass correlation as a percentage.

Taster	Method 1	Method 2	Overall	F	Intraclass correlation
A	3.9	2.7	3.4	3.3	54
B	7.5	5.3	6.5	4.8	66
C	2.6	3.7	3.2	6.2	73
D	4.1	2.5	3.4	4.6	65
E	5.3	6.4	5.9	8.4	79
F	4.3	4.3	4.3	5.8	70
Pooled	4.9	4.4	4.6	-	-

Table 2. Subjective and objective tenderness measurements

The relation between mean chew counts and shear values for each taster and for the panel average. These have been calculated on a within block basis.

Taster	Regression coefficient ± standard error (chews)	Correlation coefficient
A	2.6±0.3	0.89***
B	5.0±1.2	0.72***
C	3.0±0.6	0.79***
D	2.5±0.6	0.69**
E	7.4±0.9	0.90***
F	4.2±0.7	0.83***
Panel average	4.1±0.4	0.92***

** 0.01>p>0.001

*** 0.001>p

Table 3. Differences between loins within blocks

The mean chew counts for the loins classified as relatively well marbled and relatively poorly marbled for each taster, together with the significance of the difference (F, based on 1 and 17 degrees of freedom).

Taster	Mean of well marbled loins	Mean of poorly marbled loins	Difference	F
A	36.4	41.3	4.9	28.2***
B	40.6	43.8	3.2	<1
C	34.5	38.1	3.6	4.3
D	20.8	24.8	4.0	7.2*
E	33.4	43.5	10.1	9.3**
F	36.0	42.0	6.0	8.7**

* 0.05>p>0.01

** 0.01>p>0.001

*** p<0.001

Table 4. Subjective tenderness measurements in relation to marbling fat

The relation between mean chew counts and measures of marbling fat for each taster and for the panel average. These have been calculated on a within block basis.

Taster	Marbling score: Regression coefficient (chews)	Marbling score: Correlation coefficient	Intramuscular %: Regression coefficient (chews)	Intramuscular %: Correlation coefficient
A	-0.47	-0.71***	-1.53	-0.77***
B	-0.56	-0.35	-1.06	-0.23
C	-0.51	-0.59**	-1.19	-0.46*
D	-0.60	-0.74***	-1.31	-0.55*
E	-1.19	-0.64**	-3.31	-0.60**
F	-0.71	-0.64**	-1.95	-0.58**
Panel average	-0.67	-0.67**	-1.73	-0.57*

* $0.05>p>0.01$

** $0.01>p>0.001$

*** $0.001>p$