

## The effect on digestibility of methods commonly used to increase the tenderness of lean meat

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(Received 12 September 1955)

During the course of an investigation into the effect of chewing on the digestibility of certain foods (Farrell, 1956) it became apparent that some foods often leave large undigested residues in the faeces if they are not masticated. The most nutritionally important of these foods are the lean meats, some of which leave undigested residues of up to 85% of their original weight. The amount of mastication necessary for maximum absorption of lean meat was also investigated and found to be slight; many people, however, do not trouble to chew their food—even though they may have excellent dentitions—and swallow much of it in lumps, thereby incurring nutritional losses which are greatest in lean meats.

There are, however, a number of factors which might be expected to reduce these losses by increasing the digestibility of meat, and among them are various methods commonly employed to make it more tender. It was thought that an investigation of the effect of these 'tenderizing' methods on digestibility would be of interest.

### EXPERIMENTAL

The method adopted was similar to that used in the previous work and is described below.

*Meat.* The food used in all the experiments was fried beef-steak, and each piece was selected as being likely to be slightly tougher than the best cuts. In each test before the meat was cooked it was divided into two portions as similar as possible, each measuring roughly  $3 \times 3 \times \frac{1}{2}$  in. One of these portions was then treated in one of the ways described below, and the other was left untreated as a control (or treated in a different way if it was desired to test the relative merits of two methods).

*Tenderizing methods.* (1) The pH was changed by soaking the meat for 12 h in diluted vinegar. The concentration of acetic acid in the resulting fluid was between 4 and 6%, such as is present in marinades.

(2) The meat was treated with papain, salt and sugar in the form of a proprietary meat tenderizer. The one used was Meatendra (Ulvir Ltd, Boreham Wood, Herts), which, according to the manufacturer's statement, contains 'salt, dextrose and dried Papaya melon juice'. One level teaspoonful of Meatendra for each pound of meat, the amount recommended, was sprinkled evenly on all sides.

(3) The meat was beaten with a rolling pin or with a spiked hammer. These were selected as being typical of blunt and sharp instruments used for this purpose in ordinary households. The spiked hammer (Taylor Law Ltd, Stourbridge, Worcs) has

two faces, one having sixteen pyramidal and sharp-pointed projections, the other thirty-six smaller ones. With it each side of the meat received fifteen blows from each face; with the rolling pin thirty blows were given on each side of the meat with a force as nearly as possible equal to that used when wielding the spiked hammer.

(4) The meat was beaten with the spiked hammer and then treated with Meatendra.

*Cooking.* When two portions of meat had been cut and treated as previously described, they were fried together in the same pan, turned at the same time and finally removed together, so that they were equally cooked.

*Digestibility test.* The specimens were cut into cube-shaped pieces, their volume being about 1 cm<sup>3</sup> and their weight about 1 g. They were weighed to the nearest 0.01 g. The weights of the two specimens used in an experiment were always within 0.05 g of each other; this accuracy was sufficient, as the weights of the pieces, after passage through the intestine, were expressed as percentages of the weights recorded before swallowing. Too much cutting of the specimens was avoided for fear of tearing them and so increasing their surface area. Each specimen was then sewn into a cotton-mesh bag, and the pair of bags was tied together and swallowed as part of an ordinary meal. The mesh of the material used for the bags was 1.5 mm<sup>2</sup>. A ball-bearing was enclosed in the bag with each specimen to make it possible, if necessary, to follow its progress radiographically. The ball-bearings were of different sizes and so served to differentiate between the two bags on recovery from the faeces.

The swallowing, which was quite easy after a little practice, was usually done just before or just after the daily motion so that the bags had every chance of being voided in 24 h time. The subjects ate normal meals while the bags were in passage and made notes of the food consumed at the meal which preceded the swallowing and at those meals eaten before the collection from the faeces was made. In addition to their normal food all the subjects, except one\*, took two teaspoonfuls of Normacol (a preparation of vegetable mucin, Norgine Pharmaceutical Products Ltd, 19 Manchester Square London, W. 1) at least 8 h after the swallowing. Normacol was used because it had been found previously in some of the subjects that the bags occasionally took a long time in passage and then tended to be empty when voided. Radiographic evidence indicated that they were delayed in the large bowel, where presumably digestion, probably mainly bacterial, was taking place. Incubation of food with faeces confirmed that such digestion can occur, and as no significant absorption takes place from the large intestine it was thought desirable to hasten the passage of the bags after they had passed the ileocolic valve. Normacol was found to do it satisfactorily, and a comparison of the results of those experiments in which it was used with those in which it was not showed no evidence that it had any action other than that intended. The times of passage in the fifty-eight experiments in this investigation ranged from 19 to 37 h, the average being 25.

When the bags had been collected from the faeces they were gently washed and opened, and their contents were examined and weighed. There was no difficulty in distinguishing between undigested meat and faeces because the bags collapsed as they emptied, so that faeces neither entered nor formed inside them.

\* In this subject the bags passed through quite quickly even when Normacol was not taken.

The standard deviation of the method was calculated in the previous investigation (Farrell, 1956) and found to be 3.5%.

In this investigation and in the previous one the procedure was carried out 439 times. No subject (out of a total of ten) complained of any discomfort, and it is the author's opinion, having been the subject on more than half of those occasions, that the method is without serious difficulty and is safe.

*Subjects.* Six subjects (five male and one female) took part in this particular investigation. All were adults in good health who had never suffered from any gastrointestinal disturbance likely to have an effect on their suitability for the purpose. Their ages at the time of the experiments ranged from 24 to 33 years.

#### RESULTS

The results, summarized in Table 1, show that two of the methods tested—soaking in a vinegar solution and beating with a rolling pin—had no significant effect on the digestibility of meat, but that the others increased it considerably. The spiked hammer was very effective, increasing the digestibility by 28% ( $P < 0.001$ ), and the Meatendra, with a corresponding figure of 16% ( $P < 0.01$ ), also gave a good result, but it was not until the two methods were combined that the maximum effect was obtained (37%,  $P < 0.001$ ).

Table 1. *Effect of various tenderizing procedures on the digestibility of lean meat*

Series	Procedure		No. of experiments	Mean weight of residue after passage through the intestine (as percentage of original weight of specimen)			Significance of difference
	First specimen	Second specimen		First specimen	Second specimen	Difference	
1	Soaking in diluted vinegar	None	10	53	59	6	Not significant
2	Treating with Meatendra*	None	10	44	60	16	$P < 0.01$
3	Beating with a rolling pin	None	10	38	44	6	Not significant
4	Beating with a spiked hammer	None	10	24	52	28	$P < 0.001$
5	Beating with a spiked hammer and treating with Meatendra*	None	8	12	49	37	$P < 0.001$
6	Beating with a spiked hammer and treating with Meatendra*	Beating with a spiked hammer	10	28	54	26	$P < 0.01$

\* A proprietary meat tenderizer containing salt, dextrose and Papaya melon juice (Ulvir Ltd, Boreham Wood, Herts).

The last series of experiments recorded in Table 1 was carried out to confirm the fact that the use of Meatendra with the spiked hammer gives results significantly better than those obtained when the spiked hammer is used by itself. It was not necessary to do further experiments in order to compare the efficacy of the spiked hammer and the Meatendra because a calculation based on the percentage residues of specimens taken from meat treated by the two methods showed a mean difference of 24% ( $P < 0.02$ ) in favour of the spiked hammer.

It has therefore been possible to grade the methods in descending order of efficacy according to the magnitude of the effect they have on the digestibility of meat:

(1) Beating the meat with a spiked hammer and treating it with Meatendra, or a similar preparation.

- (2) Beating the meat with a spiked hammer.
  - (3) Treating the meat with Meatendra, or a similar preparation.
- The other two methods had no significant effect.

#### DISCUSSION

It seems probable that the increase in digestibility brought about by the spiked hammer is due to the extra surface area afforded by the penetration of its sharp points, and that the failure of the rolling pin is caused by its bluntness. The effect of the hammer is thus analogous to chewing with the teeth. The effectiveness of the tenderizing preparation may be due to some extent to predigestion of muscle fibres, but macroscopic examination of meat treated with it showed that it seems to attack the connective tissue between the fasciculi and elsewhere, splitting the meat into little islands of muscle fibres and so materially increasing its surface area.

If it is true that the reason for the success of these tenderizing methods in increasing the digestibility of meat is that they enlarge its surface area, it becomes of interest to compare the results reported here with those obtained in the previous investigation (Farrell, 1956) when the effect of chewing was examined. Fried beef-steak was one of the foods tested, and chewing was found to increase its digestibility in ten experiments by an average of 32% ( $P < 0.01$ ), a figure of the same order as those obtained by using the spiked hammer and the Meatendra together (37%) and by using the former by itself (28%). The closeness of these figures is striking, despite the fact that chewing obviously increases the surface area to a degree far in excess of anything that the tenderizing methods can achieve, so that it might be expected to produce not similar but vastly better results. It was, however, also established in the previous investigation that the amount of chewing necessary for maximum digestion is slight; in other words, a relatively small increase in surface area can turn the scale between the leaving of large undigested residues and the leaving of little or none. In addition, therefore, to any intrinsic value that the results of these experiments may have, they may also be interpreted as giving support to the conclusions drawn from the experiments that tested the effect of chewing on digestibility.

No serious attempt has been made to test the efficiencies of the methods solely as means of making meat more tender, but it is the author's very definite impression that tenderness and digestibility go together.

#### SUMMARY

1. A method for studying the effect of tenderizing methods on the digestibility of lean meat is described. In each of fifty-eight experiments two weighed portions of fried beef-steak—taken from similar portions of meat treated differently—were sewn into separate cotton-mesh bags which were then tied together and swallowed; on recovery from the faeces the residues (if any) contained in the bags were examined and their weights compared.

2. Five methods which may be used to improve the tenderness of meat were tested, and it was found that three of them (beating with a spiked hammer, treating with

Meatendra or both) increased digestibility considerably (by from 16 to 37%), but that two had no significant effect.

3. It is suggested that the effectiveness of some of these methods in influencing digestibility is due to their ability to increase the surface area of the meat.

The author wishes to acknowledge much valuable guidance and assistance given by Professor R. V. Bradlaw, Dr G. N. Jenkins and Mr D. J. Newell. Thanks are also due to Dr J. H. Bushill of J. Lyons and Company Ltd, Mrs M. V. Jackson of the Northern Counties Training College of Cookery and Domestic Science and Mrs I. Alderson of the Good Housekeeping Institute for their advice on various aspects of the inquiry; to the subjects for their uncomplaining co-operation; and to Willing's Press Service Limited for a gift of Meatendra.

#### REFERENCE

Farrell, J. H. (1956). *Brit. dent. J.* **100**, 149.

## **The rate of passage of foodstuffs through the alimentary tract of the goat**

### **2. Studies on growing kids**

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(Received 21 October 1955)

It has been shown that the passage of a stained marker through the alimentary tract follows a fairly constant pattern in adult sheep (Lenkeit, 1930, 1932), cattle (Balch, 1950) and goats (Castle, 1956).

The relative sizes of the four compartments of the ruminant stomach alter from birth until the age of about 4 months, after which time the proportions remain almost constant. For example, at birth the abomasum is the largest compartment and is more than twice the size of the rumen, whereas in the adult the rumen is about ten times as large as the abomasum (Sisson, 1953). The length of the intestine also increases as the animal grows. It would not therefore be surprising if these changes were reflected in alterations in the pattern of excretion of the food. It is well known that in the suckling ruminant milk passes directly into the abomasum by means of the oesophageal groove and only small amounts enter the rumen. The course of solid foods in young ruminants has not been extensively investigated.

Lenkeit & Columbus (1934) found that chopped rye straw given in milk, water or oatmeal gruel, either as a drench or by stomach tube, was excreted more rapidly in lambs than in adult sheep. Since the straw was given in a fluid, however, its course