Techniques for the Accurate Measurement of Ultimate pH of Meat

G.V. PETERSEN.

Department of Veterinary Pathology and Public Health, Massey University, New Zealand.

INTRODUCTION

It has become customary to use the M.longissimus dorsi (LD) as an indicator muscle for detecting carcases with a high ultimate pH (Munns and Burrell,1965, 1966; MacDougall and Rhodes,1972; Poulanne and Aalto,1980; Tarrant and Sherington,1980). Such a procedure appears to be justified because of the high commercial value of the LD, its tendency to develop high pH, and the greater range of pH values of this muscle compared with others (Tarrant and Sherington,1980). However, there appears to be little information about the precision of ultimate pH measurements in the LD of meat animals taken during commercial slaughter and dressing operations. As pH measurements of the LD are used in both commercially and scientific studies to assess certain parameters of meat quality, it is important that the most accurate and practical methods are chosen for such tests. It was with these criteria in mind that the following work was undertaken.

MATERIALS AND METHODS

1. Effect of chilling on pH decline

Samples were obtained from the LD from beef carcases which had been subjected to a commercial chilling process resulting in deep bone temperatures declining to approximately 7°C within 24 hours after slaughter. Immediately after sampling, two grams of muscle tissue was homogenised in 20 ml of 5mM iodoacetate solution and the pH measured with a combination glass electrode. Duplicate samples were incubated under liquid paraffin for a further 24 hours at room temperature and the pH of these were then measured in a similar manner.

2. Plug sampling

A modified surgical biopsy instrument which has previously been described (Petersen, 1982) was used to obtain 2g plug samples from the LD of culled breeding ewes condemned during regulatory post mortem inspection at local meat export works.

The plug samples were obtained approximately one hour after slaughter and immediately overlaid with liquid paraffin before being taken to the laboratory. After removal of the plug sample, a 10-15cm long, full transverse section of the LD at the site where the plug sample was taken, was also removed. After an incubation period of 24 hours at 20-22°C, the pH values of plug samples and of 2g samples from muscle sections were obtained in a similar manner to that of the previous experiment.

3. Comparison of different solutions for homogenisation of samples

A 10-15cm section of the LD was removed from one side of four sheep carcases within one hour of slaughter. The muscle sections were incubated for 24 hours at room temperature after which period, surface tissue was removed from the muscles (2-3mm) and the remainder of each muscle was ground in a household mincer and then mixed thoroughly in a polythene bag. From each homogenised muscle section, ten samples of between 1-2.5g were taken. These ten samples were divided into two groups of five ensuring that the distribution of sample weights was similar in both groups. All the samples from one sample group were homogenised in 20ml 5mM iodoacetate/water solution whereas the samples from the other group were homogenised in 20ml 5mM iodoacetate/ 0.15M potassium chloride solution. The pH values of all solutions were obtained with a combination glass electrode within 30 min. of homogenisation.

4. Effect of sample location

In the first part of this study, the major part of the LD was removed from both sides of 13 sheep shortly after slaughter. After incubation for 24 hours, the muscles were divided into five approximately equal sized sections and the pH of a 2g sample from each section was determined. In another study, samples were obtained from the LD of 24 beef carcases. A 2g sample was removed from a medial, central and lateral location in the muscle adjacent to the 12th rib. The pH values of these samples were determined after 24 hours incubation.

RESULTS AND DISCUSSION

1. Effect of chilling on pH decline

In Table 1, a comparison is made between mean pH values of the LD from beef carcases at the end of the chilling period and the mean ultimate pH values obtained after incubation of samples for a further 24 hours. When carcases are subjected to only an overnight holding period prior to boning and packaging, there is a considerable difference between the two values, whereas mean pH values are the same when prolonged chilling periods are used (weekend holding).

It is well established that the time required for a muscle to reach the ultimate pH is temperature dependant (Bate-Smith and Bendall, 1949) and it has also been suggested that with efficient cooling systems, a period of 26 to 36 hours may be required for completion of all glycolytic changes in the LD of beef animals (Marsh, 1954). More recently Tarrant and Mothersill (1977) reported that the time required for the pH to fall to 6.0 in some major muscles of beef chilled at 3°C ranged from 2.2 to 13.6 hours, varying with the muscle examined and its depth in the carcase.

These observations and the results of the present study clearly indicates the danger of relying on pH values obtained at the end of a 24 hour chilling period as an accurate assessment of ultimate pH values. The use of such methods are likely to provide misleading results, particularly when comparisons of such assumed ultimate pH values are made between groups of animals of different grades and weights (Munns and Burrell,1966; Poulanne and Aalto, 1980). Although such investigations have indicated that high pH may be more prevalent

In the leaner grades, it must also be appreciated that the LD of animals in these grades have faster cooling rates because of the reduced fat cover. If the pH of the LD in such animals is measured within 24 hours, it is likely that glycolytic changes will not be complete and pH values will be falsely high because they have not reached their ultimate. It would thus appear that for accurate assessment of ultimate pH values under commercial conditions, a sample must be removed from the LD and subjected to a further incubation period before pH is measured.

2. Plug sampling

It can be seen in Table 2 that when plug samples weighing approximately 2g are incubated under liquid paraffin for 24 hours, there is a high degree of correlation between their pH values and those obtained from intact muscle sections. It will also be noted that the relative "within animal" variation is no greater for this method as compared to methods where greater parts of the muscle is excised. Some of our earlier investigations indicated that the precision of this method depends both on the sample size which preferably should be at least one gram as well as the avoidance of aerobic glycolysis which can dramatically affect the amount of lactic acid in the surface layers of tissue samples (Leet and Locker, 1973).

With some experience it is possible to obtain 50-100 samples per hour, without mutilation of carcases and the method has been further improved by the use of a Colworth Stomacher* for homogenisation of samples. It is therefore believed that this technique could be a valuable tool in investigating causes of high pH meat.

3. Comparison of different solutions for homogenisation of samples

In Table 3 a comparison is made between the pH values obtained from using either an iodoacetate/water mixture or an iodoacetate/potassium chloride mixture as solutions in which the muscle was homogenised. It can be seen that the relative variability within muscles is slightly higher when using the latter solution. Thus, it would appear that the addition of potassium chloride to the iodoacetate solution does not increase the precision of pH measurements when different suspensions of muscle ranging from 1:8 to 1:20 are used. However, it will also be noted that the pH values obtained after homogenisation in the iodoacetate/potassium chloride solution were generally lower than those obtained after homogenisation in the iodoacetate/water solution. This problem was further investigated by comparying ultimate pH values obtained by the two different methods from a further 14 muscles from sheep and the relationship between the two sets of values is shown in Figure 1. The data confirm to the following relationship :

$$pH\ (\text{iodoacetate/KCL}) = 0.97\ pH\ (\text{iodoacetate/}H_2O) + 0.16$$
$$r = 0.993.$$

In a previous survey Bendall (1973) reported on 14 pairs of values from M.sterno mandibularis from beef in which the correlation coefficient (r) was 0.978.

It is thus possible to accurately adjust for the slightly lower iodoacetate/potassium chloride values compared with the iodoacetate/water chloride values but as there appears to be no difference in the precision of the two methods, it seems sensible to use the latter method as it is the most commonly accepted method.

4. Effect of sample location

The mean ultimate pH values in different locations of the LD are shown in Table 4. It will be noted that there are only small differences between these values and none of these differences were statistically significant. Table 5 indicates that mean ultimate pH values obtained from three different locations of beef LD in an area adjacent to the 12th rib were very similar and these differences were also statistically non-significant.

The observed differences between different sites within the LD of both sheep and cattle would thus appear to occur at random and are probably caused by both real randomly distributed differences between actual muscle tissue as well as a randomly distributed error associated with sampling, homogenisation and measurements of pH values. Although it is possible to obtain a better estimate of the true mean pH value of the LD by taking more samples, these results also indicate that there is no advantage in sampling this muscle over a wider area or in any particular location.

CONCLUSIONS

With the use of modern refrigerating practices, it would appear that in most cases the identity of carcases will be lost before the LD reaches its ultimate pH levels. Investigations of high pH meat can therefore only be carried out if samples are obtained prior to cutting, packaging and freezing. Adequate plug samples can be obtained with a modified surgical biopsy instrument without mutilation of carcases and if such samples are incubated under liquid paraffin for 24 hours at room temperature, the pH values obtained from these are an accurate measure of the ultimate pH of the LD. The precision of such measurements was not increased by using an iodoacetate/potassium chloride solution for homogenisation of samples. However, it is possible to predict accurately the slightly lower iodoacetate/potassium chloride values from the iodoacetate/water values. Although differences were observed in pH values between different sites within the LD of both sheep and cattle, it was shown that such differences appear to occur at random and therefore the site of sampling of this muscle is of little importance in relation to the precision of the test.

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* A.J.Seward, UAC House, Blackfriars Rd., London SE1 9UG, U.K.

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Table 1 : Effect of chilling on pH decline

Grade	Chilling Period	Mean (n=21) pH_c	± S.E. pH_u
Prime Ox	24 hours	5.88 ±0.021	5.71 ** ±0.024
Boner Cow	24 hours	5.90 ±0.019	5.71 ** ±0.027
Boner Cow	72 hours	5.76 ±0.017	5.75 ±0.024

pH_c = pH at time of cutting and packaging
pH_u = ultimate pH (24 hours later)
** = Differences between means are significiant at the 1% level.

Table 2 : Comparison of ultimate pH between plug samples in liquid paraffin and muscle section samples from 12 sheep (two samples per animal)

	Muscle section	Plug sample
Sample weights (g)		
Mean		1.87
Range		0.83 - 2.76
pH		
Mean	5.93	5.90
Range	5.60 - 7.04	5.59 - 6.93
Variance Components (%)		
Among animals	96.0	97.1
Within animals	4.0	2.9
r	0.99 (P<0.01)	

Table 3 : Mean ultimate pH values of five samples weighing from 1.0g to 2.5g from M.longissimus dorsi from four sheep.

Animal	Iodoacetate/H_2O Mean	± S.E.	Iodoacetate/KCL Mean	± S.E.
1	5.76	0.008	5.70	0.009
2	5.88	0.011	5.84	0.016
3	6.04	0.015	5.95	0.027
4	6.37	0.007	6.25	0.014
Components of variance %				
Among muscles	98.6		96.47	
Among samples	1.04		3.53	

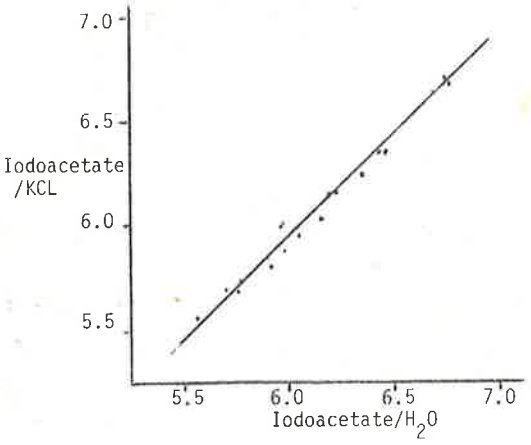
Table 4 : Mean ultimate pH values from 10 locations from 13 sheep.

Location	Left Side	Right Side
1	5.83	5.81
2	5.82	5.80
3	5.82	5.81
4	5.78	5.79
5	5.81	5.78
	5.81	5.80

Table 5 : Mean ultimate pH values from 3 different locations in 24 cattle.

Medial	5.80 ± 0.051
Central	5.79 ± 0.053
Lateral	5.78 ± 0.052

Figure 1 : Relationship between muscle pH measured after homogenisation in iodoacetate/H_2O or iodoacetate/KCL.



FEATURES OF THE FERMENTED SAUSAGE CURVE

BEFORE DELETION						
N	$\bar{X}$ MAN	$\bar{X}$ IA	S MAN	S IA	S_E	R
150	31.76	31.70	5.31	5.31	1.13	0.957
150	42.12	42.28	6.08	5.87	1.28	0.958
150	20.72	20.69	4.44	4.37	0.73	0.975
150	5.10	5.03	1.09	0.97	0.31	0.923
150	18.50	18.68	4.27	4.26	0.91	0.957
150	99.73	99.70	0.89	0.64	--	---

N = NUMBER OF VALUES

$\bar{X}$ = MEANS OF THE CONSTITUENTS

S = STANDARD DEVIATION

S_E = STANDARD ERROR

MAN = MANUAL VALUE

IA = INFRA ALYZER 400 VALUE

R = MULTIPLE CORRELATION COEFFICIENT

The Use of Infra-Red Reflection Analysis in Quick Determination of Value Determining Portions of Meat and Meat Products

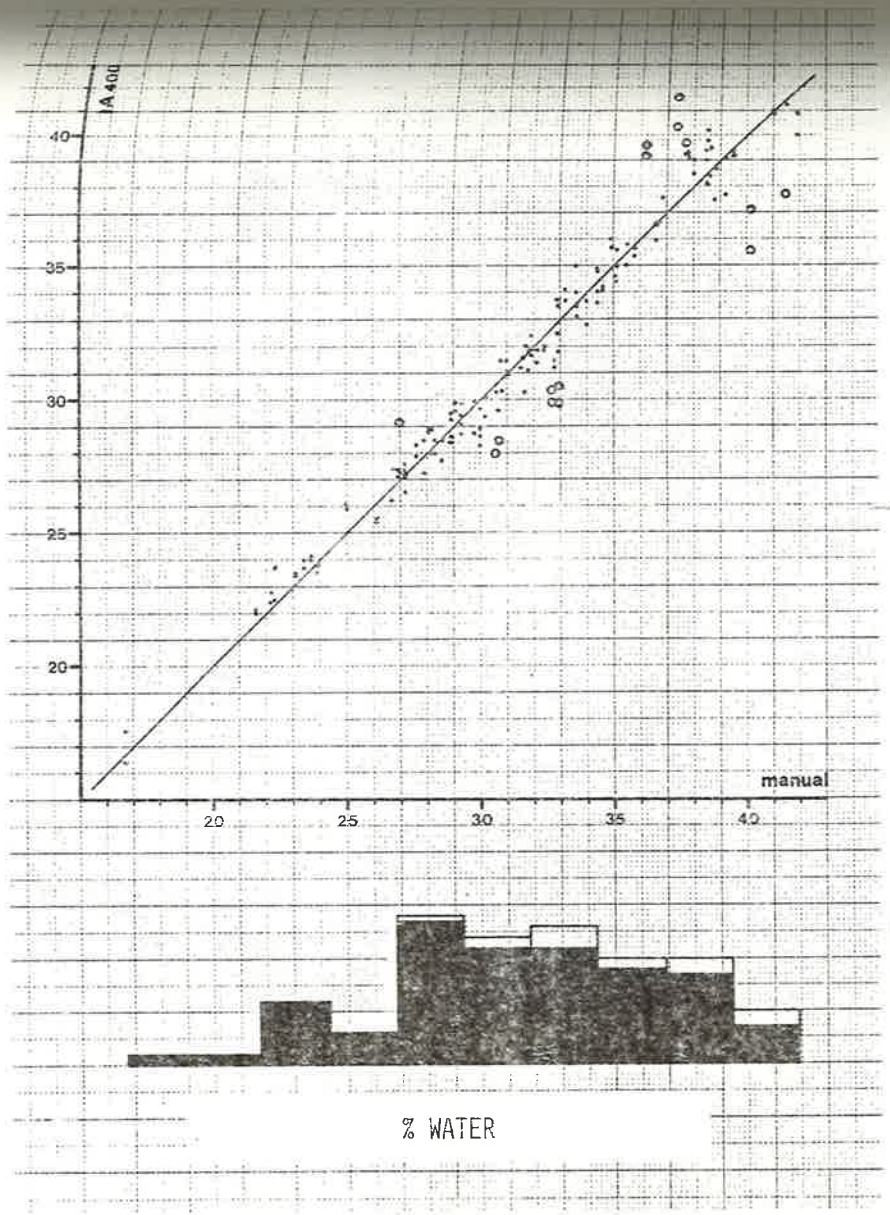
U. WEBER, B. ZESIGER, AND E. HAUSER

Swiss Federal Veterinary Office, Berne (Switzerland)
(Director: Prof. Dr. H. Keller)

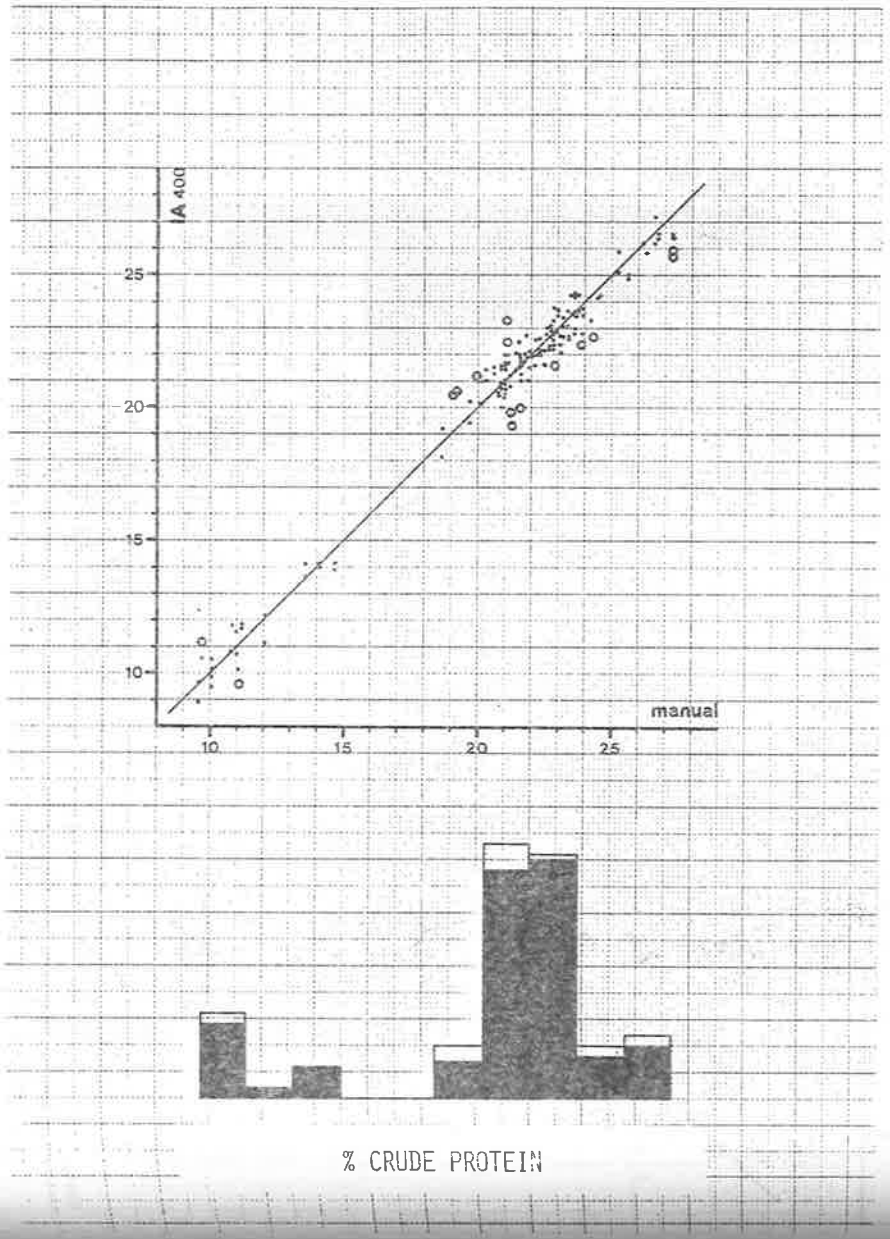
CONSTITUENT
WATER
FAT
CRUDE PROTEIN
ASH
COLLAGEN FREE PROTEIN
BALANCE

THE REGRESSION CURVE WAS ESTABLISHED ON THE BASIS OF THE FOLLOWING KINDS OF SWISS MEAT PRODUCTS :

- ITALIAN TYPE SALAMI (N = 24)
- ITALIAN TYPE SALAMI, COARSE CUTTING (N = 42)
- ITALIAN TYPE SALAMI, FINE CUTTING (N = 48)
- LANDJAEGER (FERMENTED SMOKED BEEF SAUSAGE, N = 10)
- METTWURST (N = 24)
- FERMENTED BEEF/PORK SAUSAGE (N = 2)



AFTER DELETION						
N	$\bar{X}$ MAN	$\bar{X}$ IA	S MAN	S IA	S_E	R
135	31.39	31.40	5.31	5.25	0.75	0.981
135	42.36	42.36	6.01	5.94	0.97	0.975
135	20.72	20.72	4.40	4.37	0.57	0.984
135	4.98	4.98	0.94	0.92	0.20	0.956
135	18.52	18.52	4.48	4.44	0.62	0.982
109	99.73	99.72	0.82	0.60	--	---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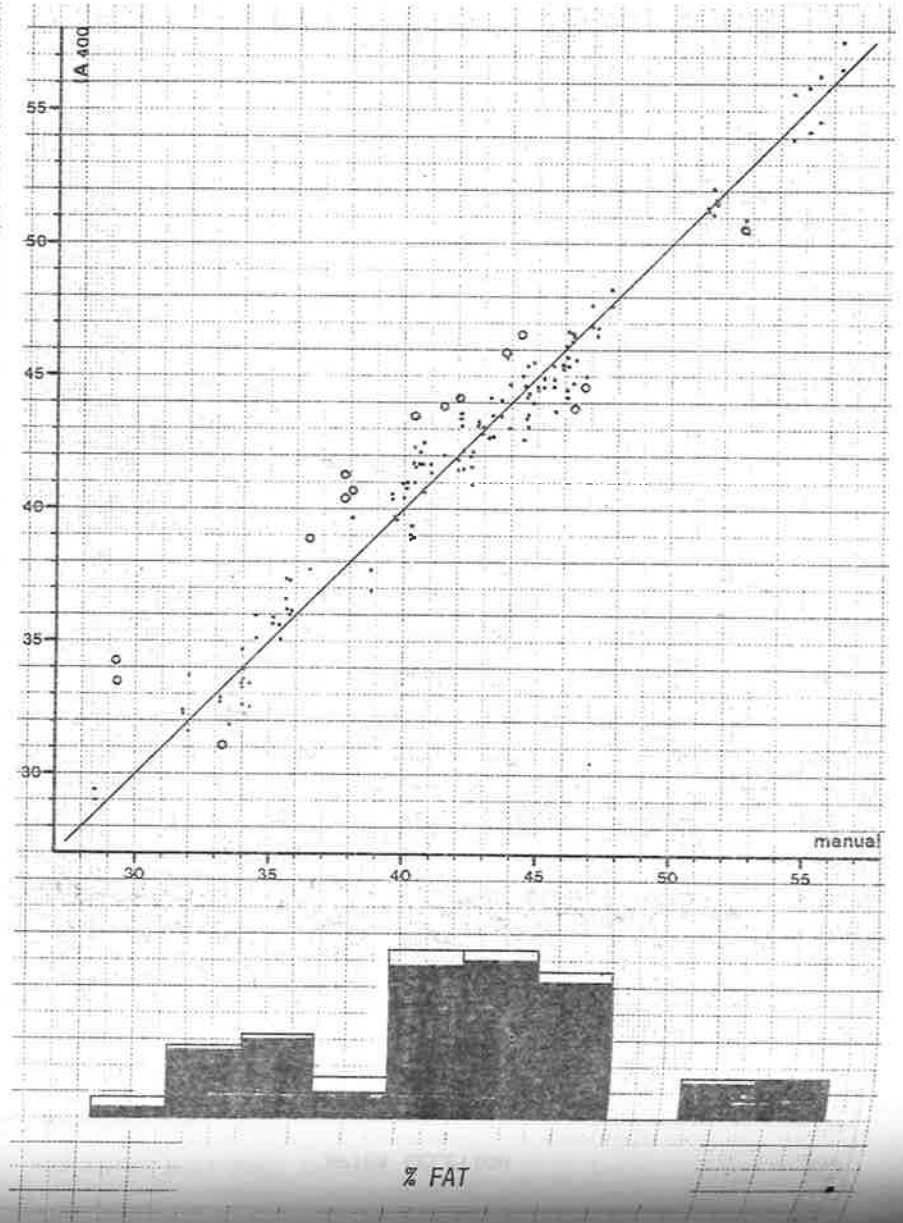
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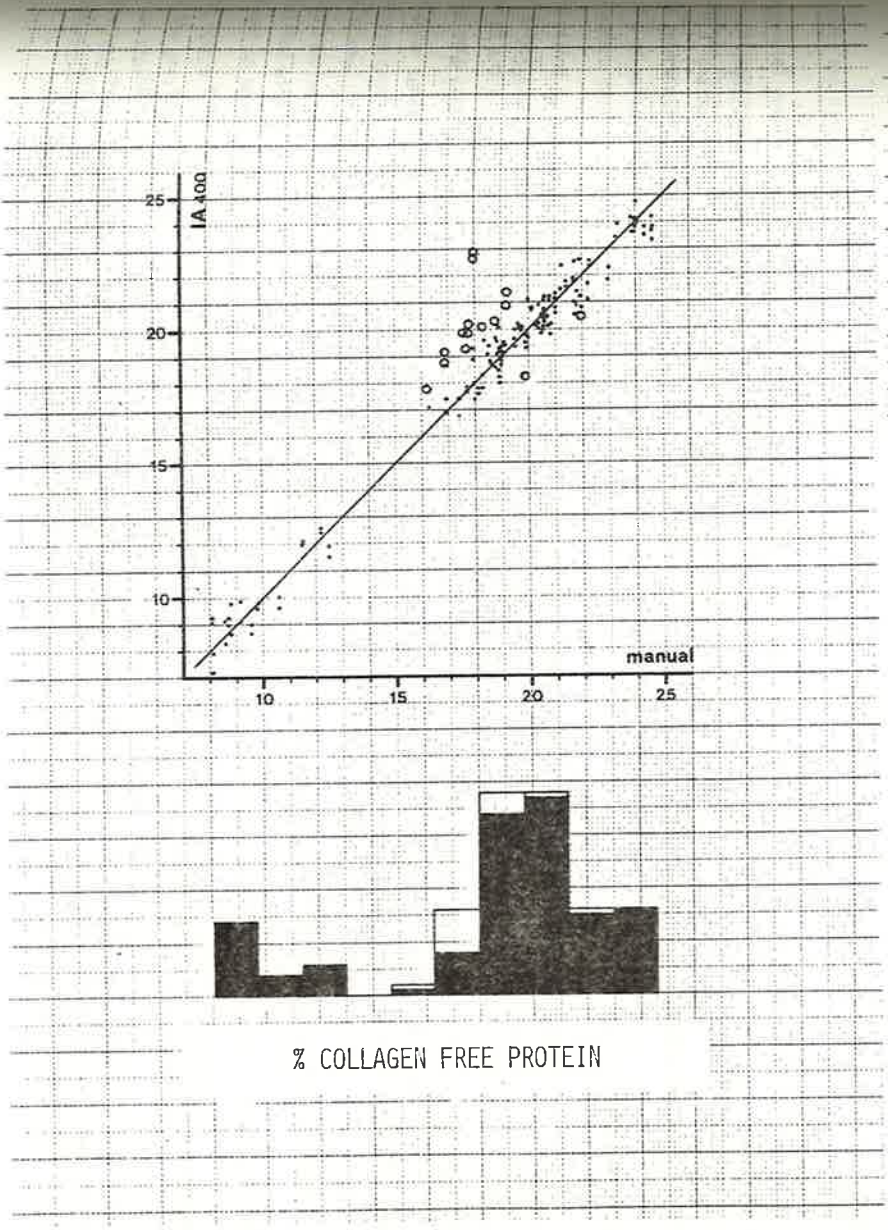

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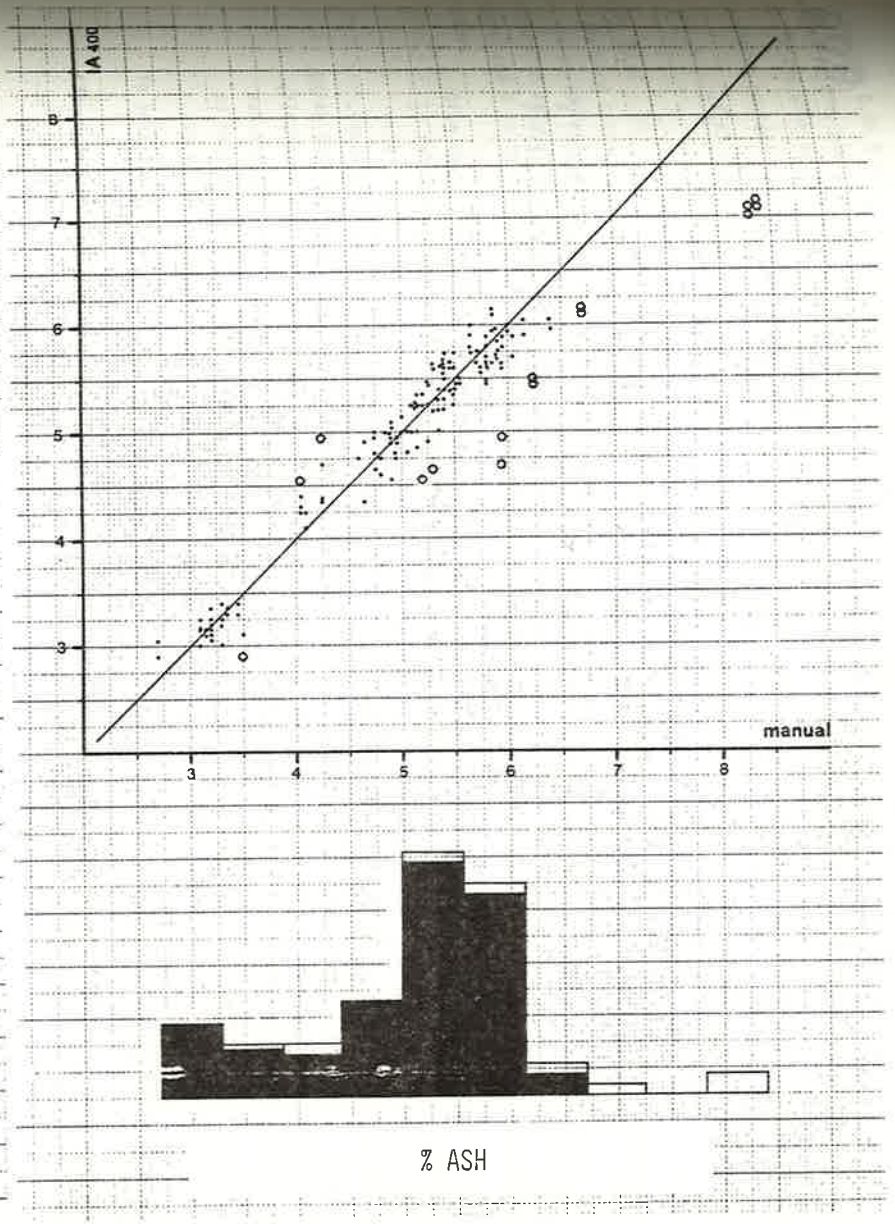

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