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THE pH_1 VALUES OF BRITISH PIGS

by

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Summary

Measurements of the pH of the leg muscle approximately 45 minutes after slaughter have been made in 4737 commercial pigs slaughtered at 8 factories in Great Britain. The values found lie on a single-peaked distribution curve with a maximum at pH 6.4 - 6.5. No evidence was obtained of any marked influence on pH$_1$ distribution due to sex, weight or period of lairage. Indications of watery muscle were observed in about 2 per 1000 of the pigs examined. The distribution of watery muscle between factories was very irregular, most of the watery carcases being observed in a single factory.

Zusammenfassung

Die Messung des pH von der Keulenmuskel, ungefähr 45 minuten nach dem Schlachten, wurde in 4737 handelsüblichen Schweinen ausgefuhrt, welche in 8 Fabriken in Grossbritannien geschlachtet wurden. Die gefundenen Werte liegen in einer einzigen zugespitzten Verteilungskurve mit einem maximalen pH von 6.4-6.5. Kein Beweis von irgendeinem merkbaren Einfluss in der pH-Verteilung, verursacht bei Geschlecht, Gewicht oder bei der Wartezeit bevor der Schlachtung wurde erhalten. Andeutung von wässrigen Muskeln wurde in ungefahr 2 pro 1000 untersuchten Schweinen beobachtet. Die Verteilung von wässrigen Muskeln zwischen den Fabriken war sehr unregelmässig, die wässrigen Kadaver wurden hauptsächlich in einer einzigen Fabrik beobachtet.

Resume

On a determiné le pH du muscle de la jambe de 4737 porcs de commerce approx. 45 minutes après l'abattage, à 8 abattoirs des usines en Grand-B retagne. Les valeurs observés se trouvent sur une courbe de distribution avec un seul maximum à pH 6.4-6.5. Il n'y a aucun èvidence d'une influence sur la distribution du pH dû à la sexe, le poids ou la dureè de stockage vivant. On a observé des temoins de muscle aqueuse en ca.2/1000 des porcs examinés. La distribution de cette muscle aqueuse parmi les abattoirs des usines était très irreguliére, la plupart des carcasses aqueuses se trouvant dans une seule usine.

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Introduction

There has in recent years been increasing interest in the incidence in pigs of a condition commonly referred to as 'watery muscle'. This condition, which affects particularly the longissimus dorsi or 'eye' muscle in the loin and the semi-membranosus muscle in the leg, [1,2] is characterised by an unusually pale colour and by the separation of free fluid from the tissue. The basic cause of the condition is not known, but it is associated with an unusually rapid fall in the pH of the muscle after death. The pH value 45 minutes after slaughter, referred to by Wismer-Pedersen[2] as the pH_1 value, has been used in Denmark as a criterion of potential watery muscle development. Using this criterion, a collaborative study of British pigs has been carried out by the Meat Research Institute of the Agricultural Research Council and the British Food Manufacturing Industries Research Association. In this study the Meat Research Institute has been concerned largely with progeny-tested pigs and the Research Association has made a background survey of run-of-the-mill commercial pigs slaughtered in the factories of Member firms. This Report presents the results of the B.F.M.I.R.A. work.

General plan of Work

Measurements were taken in 8 factories, located in the Home Counties, the West Country, the Midlands and Scotland, and covering a range of size from a kill of about 50 pigs per day to one of the order of 1000 per day. In most factories measurements were taken over a period of three successive days. All measurements were taken during the period June - September, 1964. Measurements of the ultimate pH (i.e. the final equilibrium pH value after overnight cooling) were made on some, but not all, of the experimental carcases. General observations on conditions of lairage and handling were made, and the ambient temperature during the working period was also noted.

Experimental. pH measurements were made using a Radiometer portable pH meter Model 24 (made by Radiometer, 72 Endrupvej, Copenhagen). This instrument was selected since it had already been used for similar work in Denmark. The instrument has separate glass and reference (calomel) electrodes, both designed as spear electrodes suitable for direct insertion into the muscle. In making measurements the electrodes were inserted and the reading noted; the glass electrode was then twice transferred to a new position, the reference electrode being left undisturbed, and the reading repeated

each time. The mean of the three readings was regarded as the pH of the muscle being tested. This triplicate reading procedure was occasionally relaxed to avoid hold up on the line, but was maintained for the great majority of the readings obtained. At the commencement of each day the meter was calibrated against a standard buffer of pH 6.5 (supplied in concentrated form by the manufacturers of the meter); the calibration was repeated routinely at intervals of approximately 15 minutes (or about every 50 pigs on the larger slaughter lines) and was also checked after any particularly unusual observation.

The conditions of measurement precluded any adequate control of temperature during the pH measurements. Attempts were made to determine the temperature of the muscle at the point of observation of the pH_1 values by inserting the bulb of a small mercury-in-glass thermometer into the cavity left by the removal of the glass electrode. It was, however, found that there was a substantial temperature gradient in the relevant region, which was near to the exposed surface of the cooling carcase, so that the indicated temperature varied appreciably with the depth of penetration of the thermometer bulb. The mean of 43 determinations with the bulb inserted to a depth of approximately one inch was 33°C; individual observations ranged from 27 to 38°C. Moreover, the repeated insertion and withdrawal of the glass electrode must have resulted in continual temperature fluctuations, the electrode tending to warm up during its periods of residence in the meat and to cool again during the intervening period. The working temperature of the electrode must, however, have been within the limits set by the temperature of the muscle and the ambient temperature. All the measurements were taken during the summer months and the ambient temperatures were recorded as lying between 17° and 27°C in all factories except one, where the ambient temperature at the point of measurement was 11-12°C. The reference electrode was so constructed that the calomel half-cell was always separated from the meat by a column of KCl solution; it must therefore have been operating predominantly at ambient temperature although repeated insertion into warm meat samples may have resulted in some temperature rise.

The Radiometer instrument is fitted with a temperature compensation device. This device, however, only compensates for variations arising from the temperature dependence of the relationship between the pH of the test sample and the actual difference of potential which the instrument measures; its validity is limited to measurements in which both electrodes are operating at the same constant temperature, the instrument being standardized with the electrodes immersed at the same temperature in a standard buffer of known pH value at that temperature. Since the experimental conditions precluded the proper use of the compensator, and in accordance with previous arrangements made with the Meat Research Institute, the temperature compensator

was maintained at an arbitrary setting of 20° throughout the whole of the pH_1 measurements, including the buffer standardisation.

In approximately 25% of the carcases measurements of the ultimate pH value (pH_2) were made after overnight cooling. In these measurements the temperature compensation device was adjusted to correspond with the ambient temperature at the time of measurement.

In making the pH_1 observations two departures from the experimental conditions used in the Danish measurements were necessitated by British factory practice:

(i) as already stated the term pH_1 refers to the pH value 45 minutes after slaughter and the Danish measurements were made after this interval. In some, but not all, of the factories visited in the present work the carcases entered the chill-room within 45 minutes of sticking and in this case readings were taken after a correspondingly shorter time. No readings were taken less than 35 minutes after slaughter and the variation in pH over the relevant period was examined in a range of carcases as a separate experiment.

(ii) the Danish measurements were made in the longissimus dorsi muscle, but it was found that in the British carcases access to this muscle was very difficult and was, in fact, impossible to achieve satisfactorily in the restricted time imposed by the progress of the slaughter line. All measurements were therefore taken in the ham muscles, the electrodes being inserted into the muscle face of the hind leg exposed by the splitting of the carcase. Again, a separate study was made in a number of carcases of the relation between the pH_1 value in the longissimus dorsi and in the leg muscles at the site of observation employed.

Results and Discussion

Temperature considerations. The pH value of meat, like that of any dilute aqueous buffer system, will depend upon temperature. Bendall, in a private communication, gives the temperature correction factor as - 0.028 pH unit per 10°C, the negative sign indicating a fall in pH with rising temperature. Over the range of temperature involved in the measurements (3°C to 38°C overall) the maximum variation in the true pH value would on this basis be about 0.09 pH unit. A pH meter is, however, a potential measuring device and it actually indicates a potential difference made up of two main contributions - the potential of the glass electrode with respect

to the test material and the potential of the reference electrode. Both of these potentials will be affected by temperature changes and the meter reading will therefore be temperature sensitive irrespective of any change in the true pH value of the test material. As already pointed out, the practical conditions of measurement were such that the working temperatures of the electrodes were not in fact known with certainty. It therefore seemed best to adopt an empirical approach and to study directly the variations in meter reading obtained using laboratory samples of meat maintained at defined temperatures.

These experiments indicated that, with the temperature compensator on the instrument maintained at the arbitrary setting of 20°C., pH values determined by observing the meter reading as soon as possible after the insertion of the electrodes tended to follow the anticipated pattern and to show a slight fall in the indicated pH reading with rising temperature of the meat, although in some experiments the magnitude of the variation was less than the theoretical value indicated by Bendall. It was, however, also shown that if the electrodes were left continually embedded in a block of meat which was slowly raised in temperature the effect was reversed, the indicated pH reading rising slightly with rising temperature. The actual conditions of measurement during the factory surveys, in which the electrodes were repeatedly and rapidly inserted and removed over a large number of successive observations, may well have resulted in a condition intermediate between the laboratory extremes and it therefore seems unlikely that any variations associated with temperature fluctuations during the survey would exceed the limits observed in the laboratory - approximately ± 0.05 pH unit over the maximum range of temperature concerned. No attempt has been made to apply any temperature correction to the observed values.

Systematic accuracy of Radiometer measurements

Laboratory comparisons were made of the readings of the Radiometer instrument against those of an E.I.L. Model 23A mains-operated pH meter; this was a high impedance instrument which had been in use in the laboratory for several years and was regarded as very reliable. Both instruments were standardised against the same buffer solution before use. The Radiometer instrument was standardised at ambient temperature and the temperature compensator was then set to 20°C; the E.I.L. instrument was standardised and set at ambient temperature. Measurements were made in muscle blocks, the electrodes of the two instruments being inserted alternately into the same cavities in the meat, and also in aqueous slurries, prepared by mixing the minced meat with three times its own weight of distilled water at room temperature. The Radiometer instrument

tended to give generally higher readings than the E.I.L., but the two instruments were in overall conformity to within about 0.05 pH unit.

Significance of deviations from 45 minute period between slaughter and measurement of pH_1

It has already been pointed out that in some of the factories visited the operating procedure made it necessary to take the pH_1 observations at less than 45 minutes after slaughter. Comparative measurements of pH at 35 and 45 minutes after sticking were made on the leg muscles of 55 carcases. The mean values were 6.57 at 35 minutes and 6.48 at 45 minutes, giving a mean fall in pH of 0.09 unit over the ten-minute period. In no case was the 45 minute reading higher than that at 35 minutes and of the individual differences observed 50 lay within the range zero to 0.2 pH unit. Of the measurements necessarily taken at less than 45 minutes after slaughter, 710 were taken after 35 minutes, 412 between 35 and 40 minutes and 612 after 40 minutes. On average, these observations are likely to be displaced to the extent of 0.05 to 0.09 pH unit in the direction of higher pH. As a direct check on the significance of this source of variation, the distribution curves have been separately plotted for the whole population of results (4737 observations) and for those taken after the prescribed 45 minute period (2973 observations). As expected, the distribution curve for the carcases measured after the full 45 minute period showed slight deviations in the direction of lower pH, but the general distribution of the results was not substantially altered (see Figs. 1A and 1B). The analysis of the results for the effect of factors such as sex, weight etc. has accordingly been based on the complete results.

Comparison of pH_1 measurements in the leg and in the longissimus dorsi muscle.

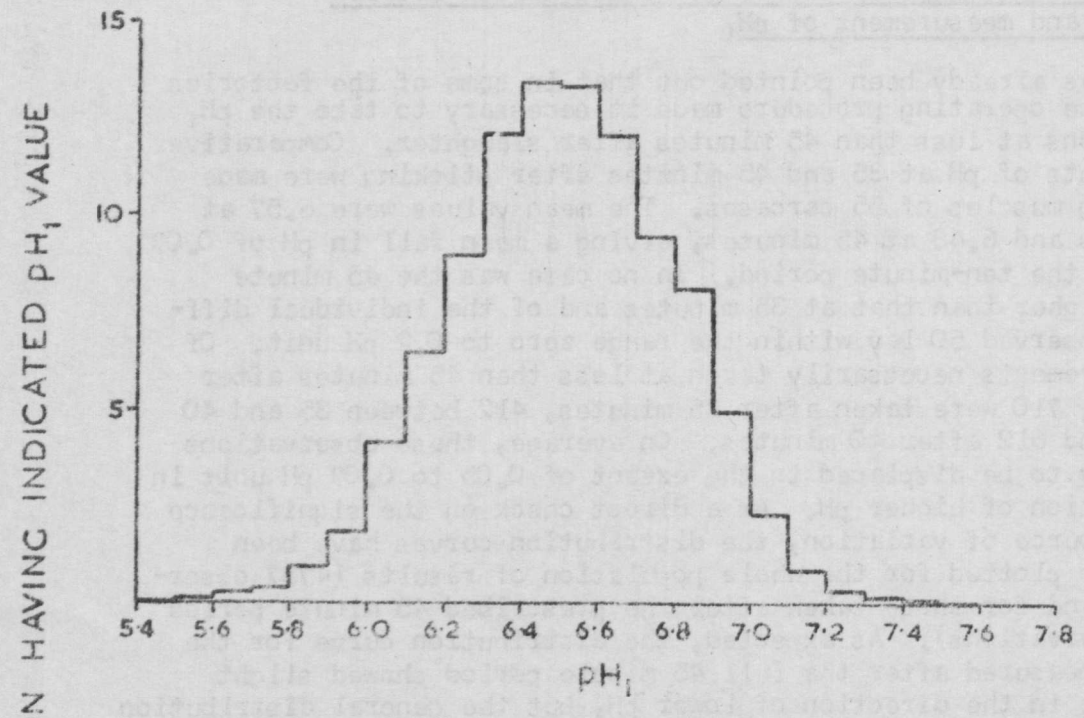
Comparative measurements of pH_1 in the leg and the longissimus dorsi muscle were made on 44 carcases. The difference observed in individual carcases ranged from nil to as much as 0.52 pH unit; the differences were, however, randomly distributed and the mean difference over all carcases was zero, the mean pH_1 value being 6.47 in both muscles. It therefore seems reasonable to conclude that, in an extended survey, the observations are unlikely to be systematically affected by this change in the site of observation.

Distribution and significance of pH_1 and pH_2 values.

Figure 1 shows the overall distribution of the pH_1 values in histogram form. Figure 1A shows the distribution for all carcases examined (including those in which the measurements were taken 35 and 40 minutes after slaughter); Figure 1B is restricted to carcases in which the pH_1 measurements were made after the stipulated interval of 45 minutes. Figure 2 shows the distribution of the pH_2 values.

FIG.1 OVERALL DISTRIBUTION OF pH_1 VALUES

A. ON ALL CARCASES EXAMINED - 4737 CARCASES



B. ON CARCASES EXAMINED AT 45 MINUTES AFTER SLAUGHTER

-2973 CARCASES

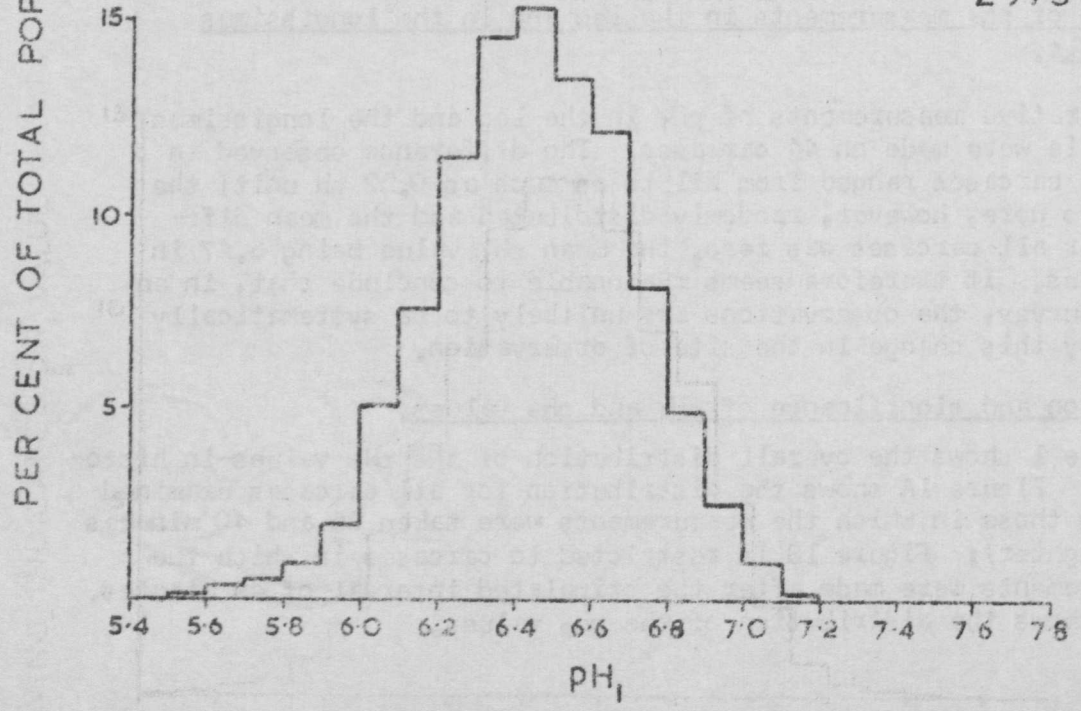
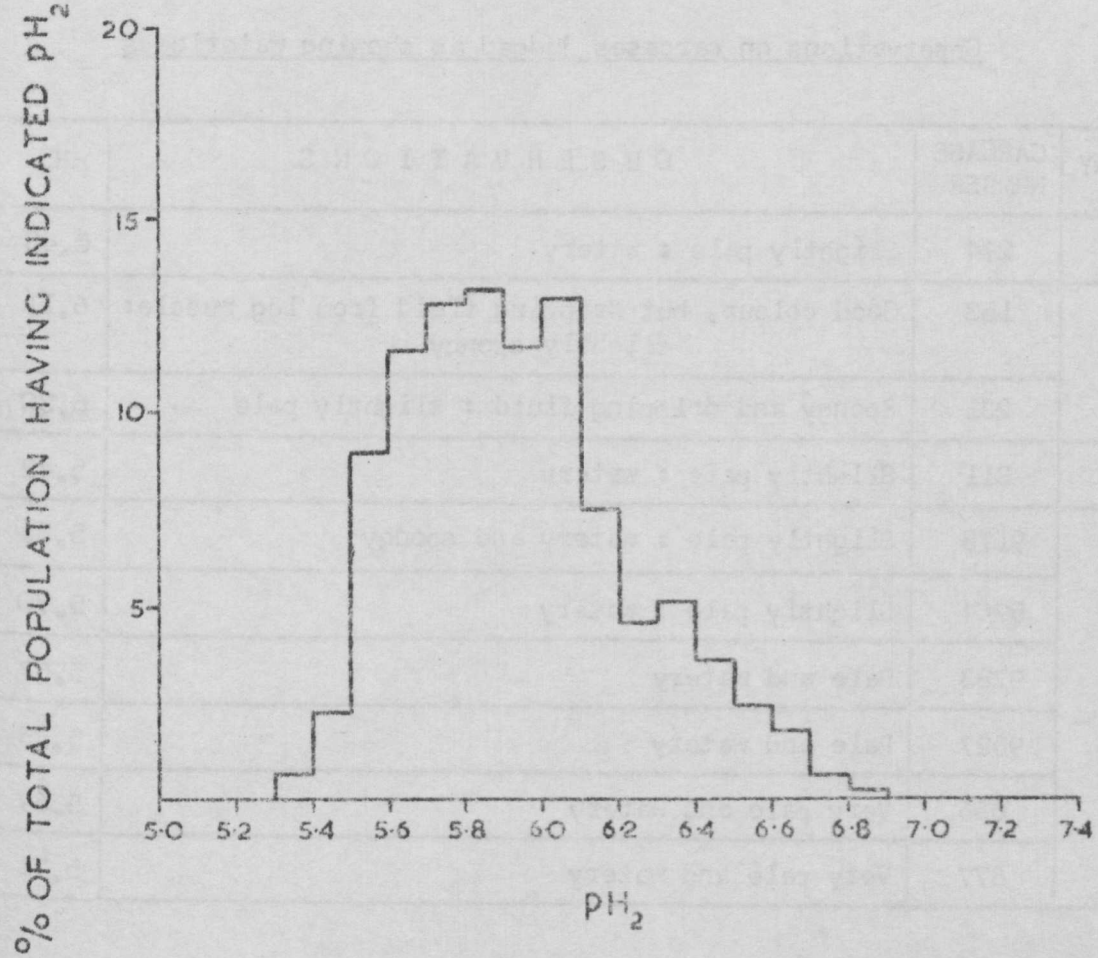


FIG. 2 OVERALL DISTRIBUTION OF pH_2 VALUES

1297 CARCASES



Both of the pH_1 curves show only a single maximum, and in both curves this maximum occurs at pH 6.4 - 6.5. The pH_2 distribution shows a flatter maximum, but over 75% of the recorded values were between 5.5 and 6.2.

During the course of the factory surveys the carcases were scrutinised for visual indications of pale or watery muscle. The observations were, however, necessarily made on relatively intact carcases and hence under conditions not particularly favourable for the detection of wateriness. It is moreover clear that there is scope for considerable personal variation in a judgement of this kind and that experience may well be an important factor. The observations summarised in Tables I and II must be interpreted with these limitations in mind.

TABLE I

Observations on carcases judged as showing wateriness

FACTORY	CARCASE NUMBER	O B S E R V A T I O N S	pH_1	pH_2
B	274	Slightly pale : watery	5.43	-
C	153	Good colour, but dripping fluid from leg muscle: slightly spongy	6.11	5.68
	231	Spongy and dripping fluid : slightly pale	6.30	5.58
D	311	Slightly pale : watery	5.42	-
G	9178	Slightly pale : watery and spongy	5.85	5.52
	9204	Slightly pale : watery	5.70	5.37
	9283	Pale and watery	5.67	5.50
	9527	Pale and watery	5.83	5.38
	666	Very pale and watery	5.67	-
	677	Very pale and watery	5.71	-

TABLE II

Observations on carcases noted as pale but not watery

FACTORY	PALE		SLIGHTLY PALE		VERY SLIGHTLY PALE	
	pH_1	pH_2	pH_1	pH_2	pH_1	pH_2
B			6.20	-		
F	5.65	5.76*			5.87	-
G	5.97	-	6.05	5.40	5.58	-
	5.70	-			6.39	-
H	5.57	-	5.59	-	5.90	-
			5.88	-	5.82	-
			5.96	-	5.73	-
			5.67	5.54	5.83	-
			5.75	-	5.87	-
			5.68	-	5.74	-
			5.64	-		

* good colour after overnight cooling: no indication of watery muscle.

The overall incidence of carcases judged as showing visual evidence of wateriness (Table I) amounted to about 2 per 1000 pigs, although in the factories in which the condition was observed the rate of incidence was somewhat higher. In particular, the rate of incidence in factory G was of the order of 5 per 1000 pigs. This factory appeared to be particularly susceptible to watery muscle and practical arrangements for dealing with watery carcases, by inspection and segregation of suspect carcases for special usage, were in force. In the experience of this factory the incidence of such carcases is found to be highest in spring and lowest in the autumn.

The two suspect pigs of factory C appear to be quite different from the remaining pigs of Table I in respect of their pH_1 values

and this fact, coupled with the observation that one at least was recorded as being of good colour, raises the possibility that these carcases may not have been exhibiting true watery muscle.

It is of interest to apply as far as possible to the present data the criteria which have been suggested elsewhere as indicative of potential wateriness. Bendall and Lawrie[3] report that for Danish pigs a pH_1 value of 6.1 or below has been found to be associated with watery meat; they emphasise, however, that the ultimate pH is also important and that their finding relates only to carcases having an ultimate pH value bwtween 5.7 and 5.2. Reference to Figure 2 shows that at least 75% of the British pigs had pH_2 values above the 5.2 - 5.7 range, suggesting that the general level of pH_2 values is higher in this country than in Denmark. Application of the main criterion is restricted by the fact that, out of a total of 386 carcases recorded as having pH_1 values of 6.1 or below, pH_2 measurements are available on 91 carcases only. 36 carcases had pH_2 values within the stipulated range and of these only four were noted as being watery (Table I) and two as being slightly pale (Table II). Four more of the watery carcases of Table I had pH_1 values below 6.1, but pH_2 values for these carcases are not available. Table II shows that most, but not all, of the carcases noted as pale had low pH_1 values, although it must be added that other carcases of similar pH_1 values were noted as being of good colour. Thus while it appears that, in general, pale colour and wateriness tended to be found in association with low values of pH_1, it certainly could not be said of the carcases covered by the present survey that if the pH_1 value of the carcases is below 6.1 the meat will be watery and pale, and this again points to a difference of behaviour between British and Danish animals.

An alternative criterion which has been suggested by Elliott, on the basis of results obtained on pigs in Northern Ireland, involves division into four groups:

(i) pH_1 above 6.0 : pH_2 less than pH_1

(ii) pH_1 above 6.0 : pH_2 greater than pH_1

(iii) pH_1 below 6.0 : pH_2 less than pH_1

(iv) pH_1 below 6.0 : pH_2 greater than pH_1

According to Elliott (private communication) watery muscle has been found in carcases of groups (iii) and (iv), but not of groups (i) and (ii). Application of this criterion to the present results is again restricted by limitations of the pH_2 data. Of the carcases on which pH_2 measurements were made only 46 had pH_1, values of 6.0

or below; sixteen fell into group (iv) and the remainder into group (iii). None of the group (iv) carcases was recorded as being watery; one was noted as being pale in colour at the time of the pH_1 measurement, but after overnight cooling it was of satisfactory colour and showed no sign of wateriness. Four of the group (iii) carcases were noted as being watery and are included in Table I; one is included among the carcases of Table II. In addition two carcases in this group were specifically noted as being of good colour, the remainder being passed without comment. Two of the carcases in Table I fall into group (i) in which, according to Elliott, watery muscle has not been observed; these are, however, the carcases from Factory C, which it has already been suggested may not have been truly watery.

Distribution of pH_1 values in individual factories

Figure 3 shows the distribution of pH_1 values for the individual factories visited, and Table III summarises the observations made on the particular conditions obtaining at these factories. Not unexpectedly, the individual distributions show some divergence, but it is difficult to say whether or not the differences are significant. Probably the most distinctive behaviour was that in Factory A, which showed a sharp cut-off below pH 6.1. This factory, which kills mainly heavy hogs, has a history of freedom from watery muscle: certainly no indication of the condition was seen in any of the carcases tested. Apart from this, there are no striking differences between factories B, D and G, in which watery muscle was observed, and factories E, F and H, where it was not. An unusual feature observed in Factory H was that in this factory the occurrence of low pH_1 values was associated with a tendency for rapid development of post-mortem rigidity, the carcases showing considerable stiffening at the time of the pH_1 measurements. This effect was not observed elsewhere, and it may be relevant to note that an appreciable number of carcases in this factory were noted as pale, although none was judged to be actually watery.

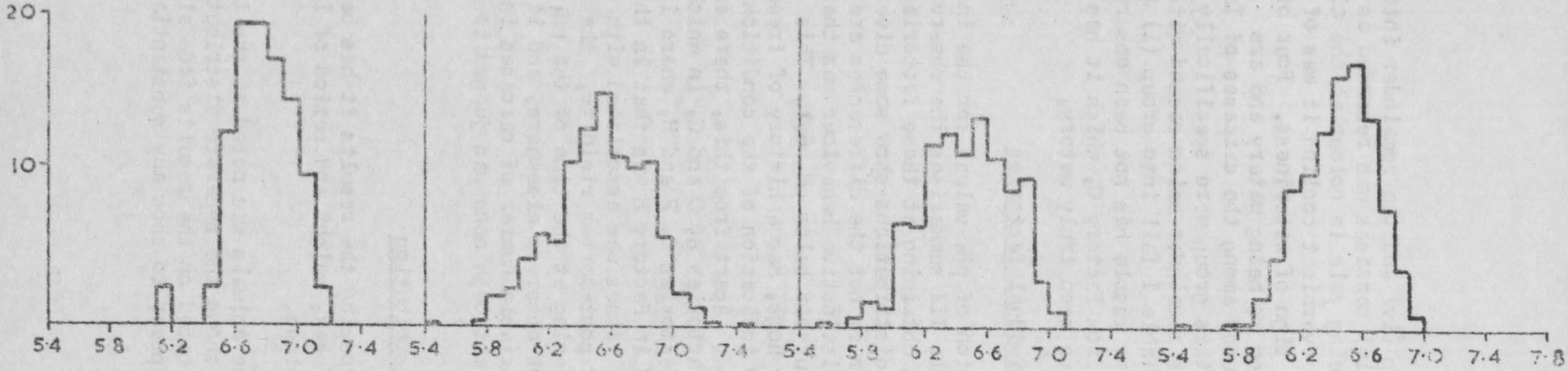
Effect of other factors on pH_1 distribution

By suitably selecting and grouping the results it has been possible to examine the effect of sex, weight and period of lairage on the distribution of the pH_1 values.

(a) Effect of sex. The sex of the animals was noted at the time of the pH measurement. Figure 4 shows the separate distribution curves for male and female pigs, based on the results from all factories. These curves do not appear to show any substantial difference.

FIG. 3 pH_1 VALUES AT INDIVIDUAL FACTORIES

FACTORY A 356 CARCASES. FACTORY B 727 CARCASES. FACTORY C 294 CARCASES. FACTORY D 305 CARCASES.



FACTORY E 372 CARCASES. FACTORY F 642 CARCASES. FACTORY G 1258 CARCASES. FACTORY H 803 CARCASES.

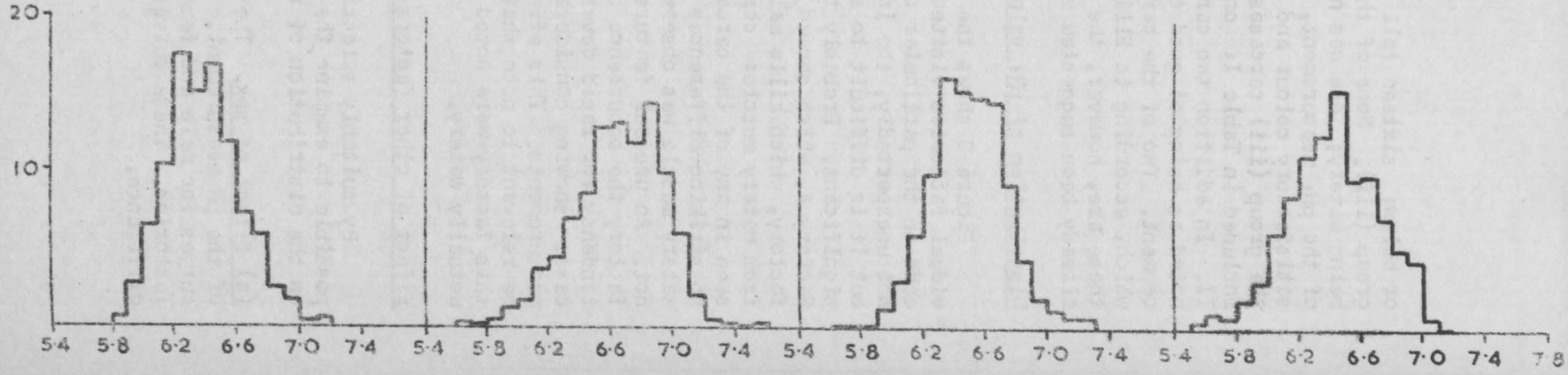


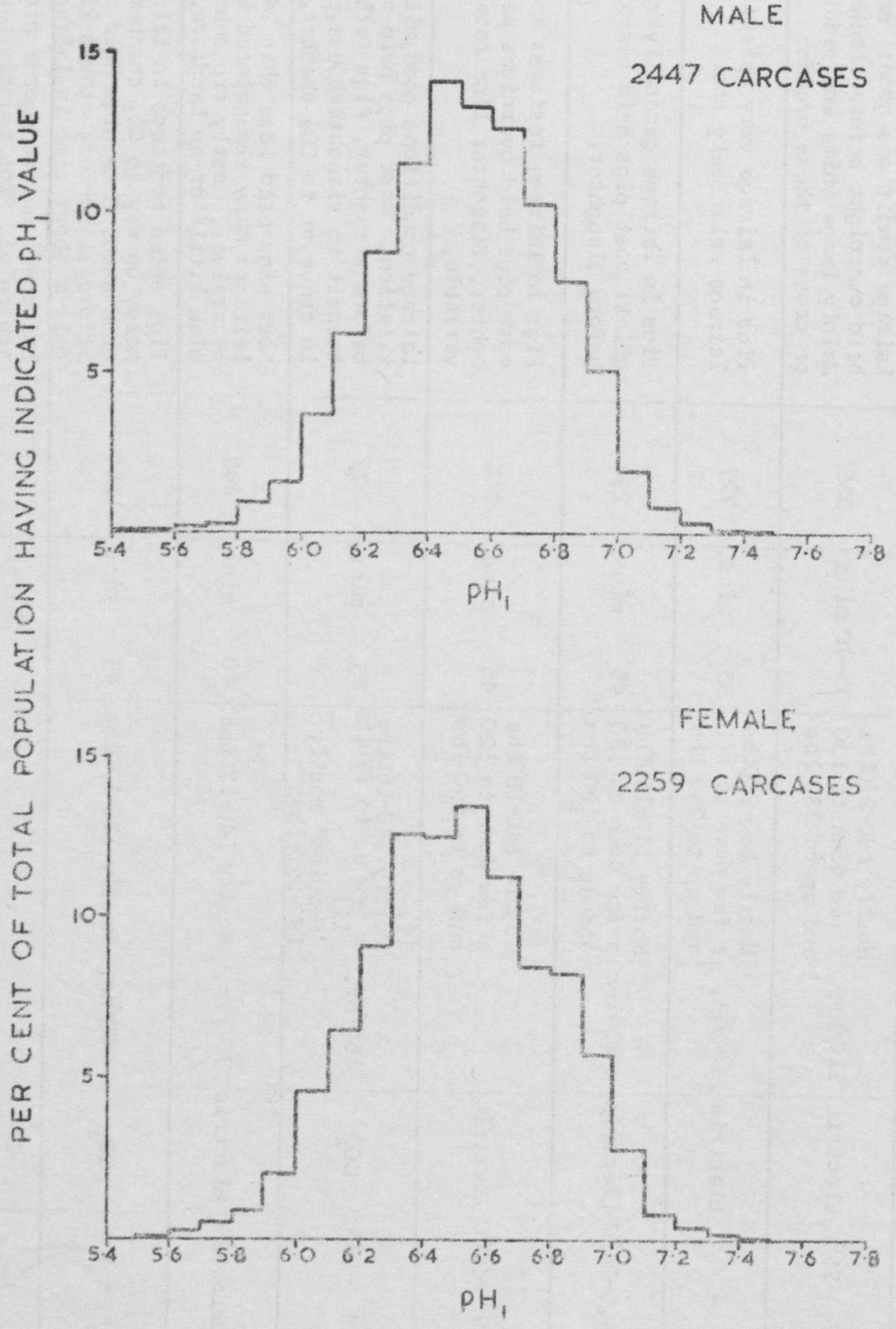
TABLE III

TABLE III

Notes on Individual Factories Visited

FACTORY	Dates of Measurements	Ambient Temperature		Method of Stunning	Killing Rate (approx.)	Carcase weights (cold)	interval between sticking and pH_1 measurement	Total number of carcases examined	REMARKS
		on Slaughterline	in Lairage						
A	1.9.64-3.9.64	approx. 20°C	17 -26°C	Electric	110/hr.	Mostly 180-240lbs a few down to 150 and up to 330 lbs	35-40 mins.	336	Lairage conditions good: most pigs held overnight before slaughter. Mainly large white and saddleback, or cross of these breeds.
B	29.6.64-2.7.64	20.5-22.5°C	-	Electric	180/hr.	Mostly 180-230lbs a few down to 140 and up to 260 lbs	35 mins.	727	Pigs in lairage very quiet: lairage relatively cool
C	21.7.64-23.7.64	20 - 21°C	14.5-24°C	Electric	50/day	Mostly 140-160lbs a few down to 130 and up to 180 lbs	45 mins.	294	Pigs in lairage generally very quiet: most pigs held overnight before slaughter.
D	22.6.64-24.6.64	19 - 20°C	19 -20°C	Electric	-	Mostly 140-180lbs a few down to 120 and up to 220 lbs	45 mins.	305	Pigs in lairage restless and noisy: most pigs held overnight before slaughter. Slaughter line rate rather variable.
E	8.7.64-10.7.64	18 - 19°C	15 -16°C	CO_2	160/hr.	(i) Mostly 140-160lbs a few up to 170lbs (ii) 'Heavies' mostly 180-220 lbs.	45 mins.	372	Lairage conditions good, with fan ventilation. Most pigs held overnight before slaughter. Pigs rather noisy in transit to slaughterhouse, particularly in conveyor to CO_2 chamber.
F	15.9.64-17.9.64	17 - 18°C	Below18°C	Electric	130/hr.	Mostly 140-170lbs	40 mins.	642	Most pigs held less than 24hrs. in lairage: many slaughtered within 1 hr. of arrival. Mostly cross-bred pigs with little or no Landrace.
G	27.7.64-29.7.64	18 - 24°C		CO_2	200/hr.	Mostly 130-170lbs	45 mins.	1258	Pigs often restless in lairage and noisy on way to CO_2 chamber; electric goad used. Some pigs held overnight before slaughter; others killed after only a short time in lairage.
H	13.7.64-16.7.64	24.5-27°C	1 or 2° above outside temp. when lairage full.	Electric	180/hr.	Mostly 140-170lbs	45 mins.	803	Lairage conditions good: pigs in lairage quiet. Pigs roughly handled and allowed to run about during unloading. Some pigs in lairage overnight, others slaughtered almost immediately on arrival.

FIG. 4 pH_1 DISTRIBUTION FOR MALE AND FEMALE PIGS



(b) Effect of carcase weight. Figure 5 shows the pH_1 distribution for groups of pigs weighing less than 150 lbs. and more than 160 lbs. respectively. These groups were selected as being roughly of equal size and representative of the lighter and heavier portions of the population respectively. There is some indication of a systematic difference between the groups, the distribution curve for the heavier group being generally slightly lower on the low pH_1 side and higher on the high pH_1 side. There may, however, well be an individual factory effect involved since the heavier pigs were derived largely from factories A and B, while the lighter pigs were mainly from factories F, G and H. A limited comparison between light and heavy pigs in the same factory (made possible in Factory E by the fact that the pigs examined there fell into two distinct and well-separated weight groups) did not in fact confirm the indication of the overall curve, tending if anything to show a displacement in the reverse direction (see Figure 6).

(c) Effect of Lairage Period. Opportunities arose in three factories to segregate groups of pigs on the basis of lairage period.

(i) In Factory A, where the majority of the pigs were held overnight in lairage, a group of 47 pigs was slaughtered after about an hour only in lairage.

(ii) In Factory G the pigs slaughtered on the first day had been held overnight in lairage, while those slaughtered on the two succeeding days had only a short lairage period.

(iii) In Factory H, where again the majority of the pigs were held overnight in lairage, a group of 110 pigs was slaughtered immediately on arrival at the factory.

The results for the three factories are spearately shown in Figure 7. The 'short lairage' curve for factory H shows a slight shoulder on the low pH_1 side, but there is no indication of a general tendency in this direction.

A further point which it would clearly be of interest to examine is the effect of the method of stunning, but although the factories visited covered both electrical and carbon dioxide stunning no direct comparison can be made on account of other possible sources of variation between individual factories. It can, however, be noted that of the two factories using carbon dioxide stunning, one was completely free from watery muscle at the time of observation, whereas the other appeared to be the most severely affected. Similarly one factory using electrical stunning had never experienced watery muscle, while instances were observed in other factories using this method.

/It does

FIG. 5 pH_1 DISTRIBUTION FOR LIGHT AND HEAVY PIGS

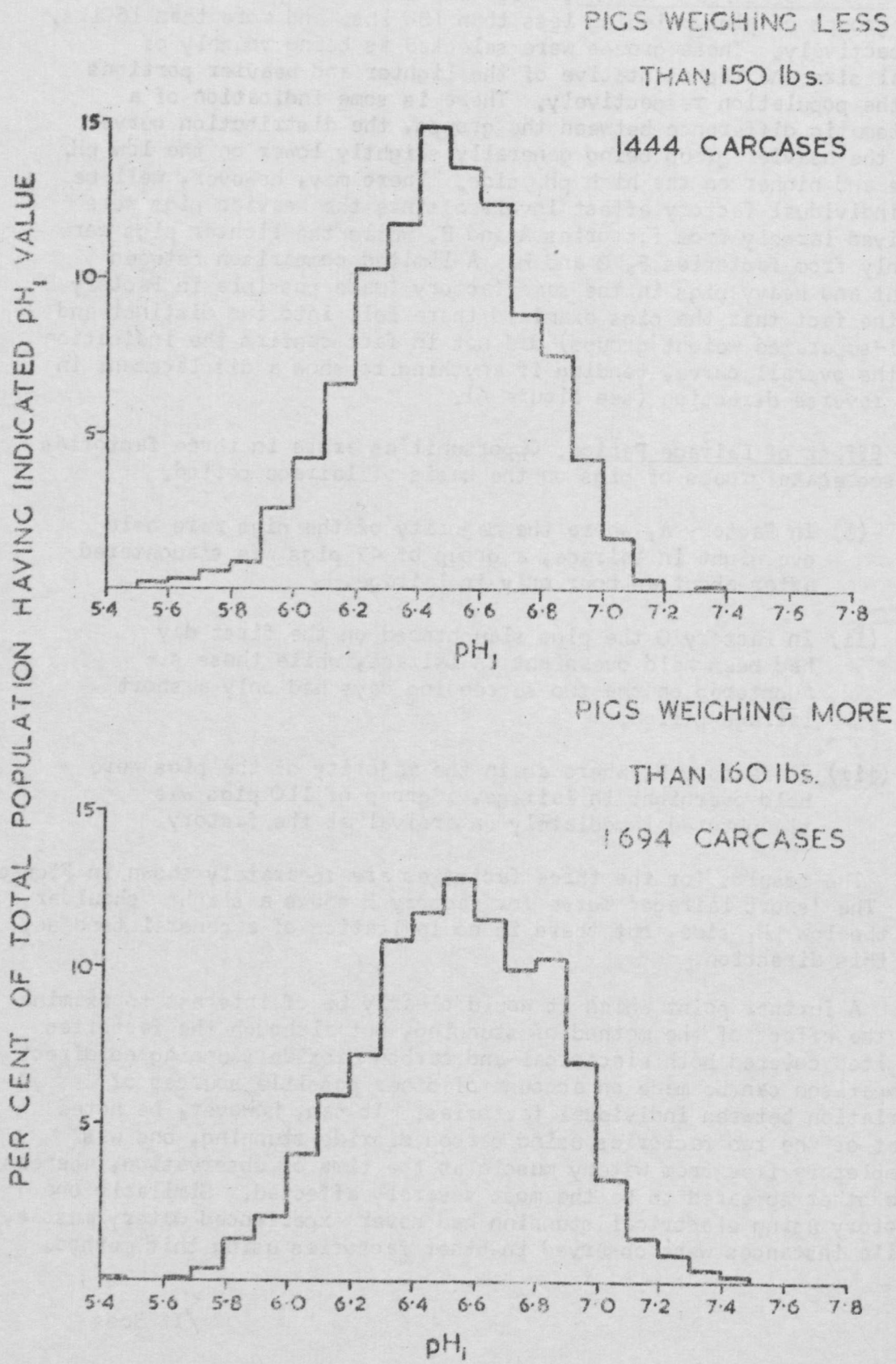


FIG 6 pH_1 DISTRIBUTION FOR LIGHT AND HEAVY PIGS IN FACTORY E -

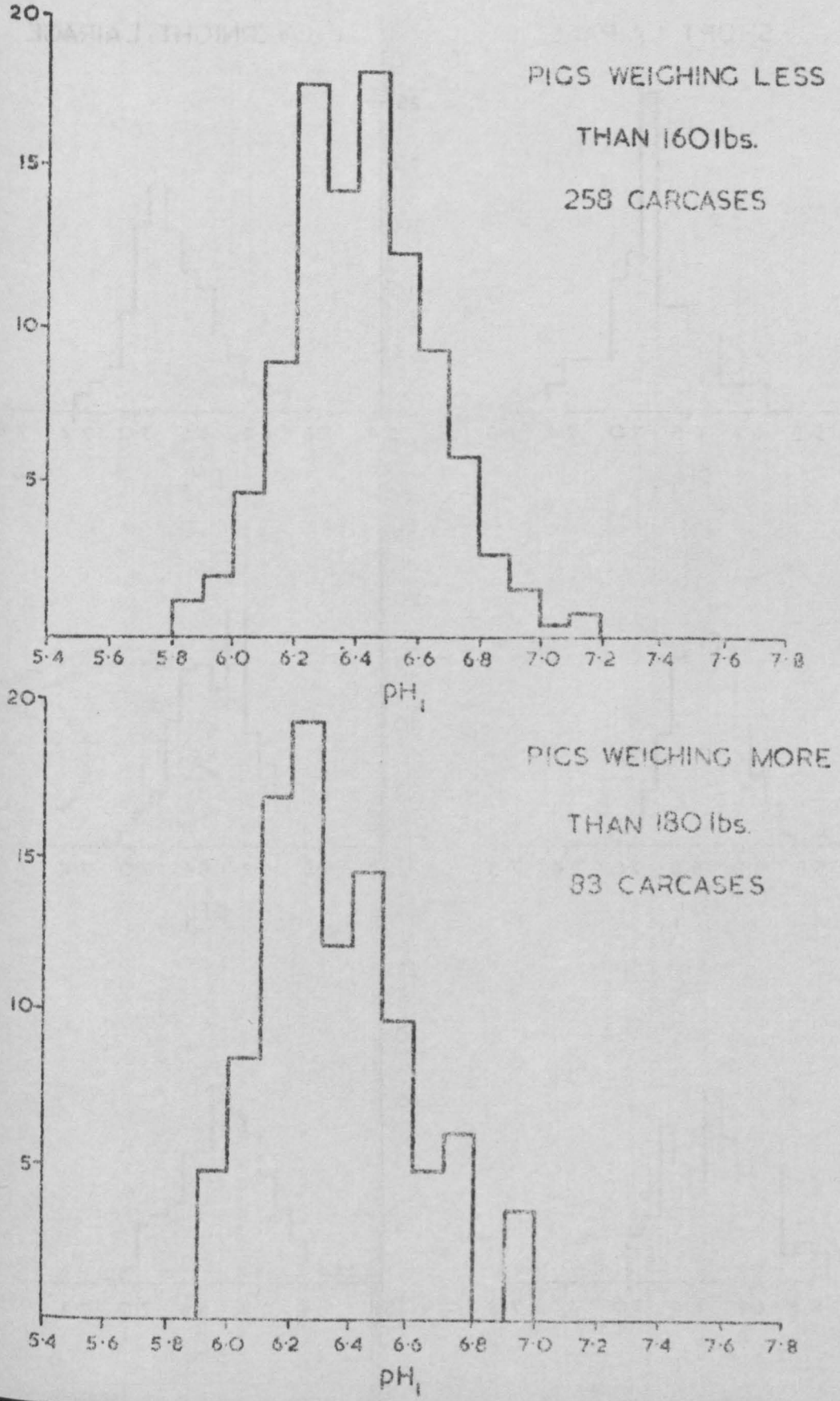
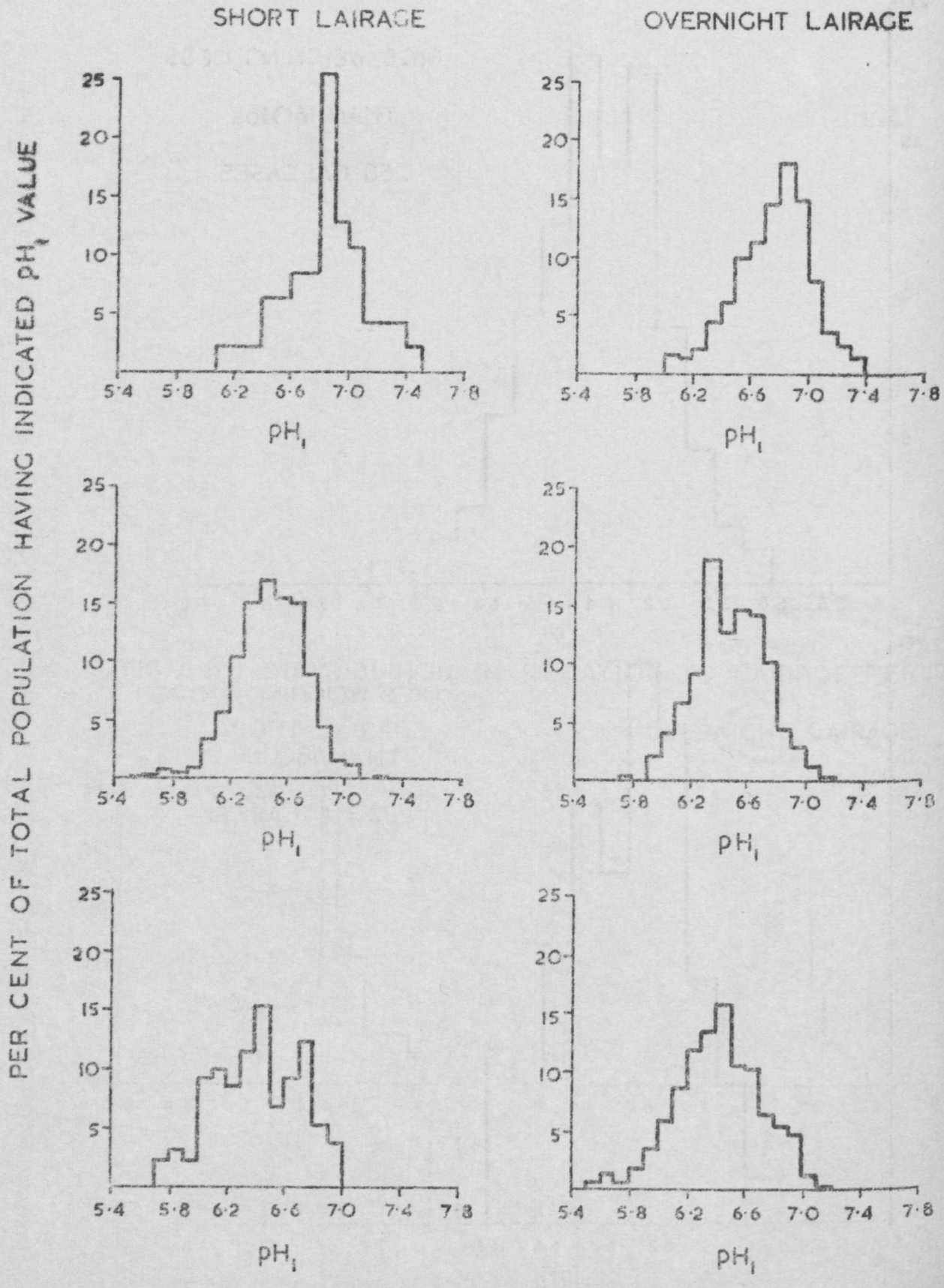


FIG.7 pH_1 DISTRIBUTION IN RELATION TO LAIRAGE PERIOD



It does not appear therefore that the method of stunning per se is a major factor in the incidence of watery muscle.

Significance of breed of animals

It became clear during the course of the work that information on the breed of pigs arriving at a factory for slaughter is often difficult to obtain and in view of the generally negative character of the observations this point was not normally pressed. It was, however, established that the pigs noted as watery in Factory G contained a high proportion of pure Landrace or Landrace/Large White crosses.

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