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OBSERVATIONS ON SO-CALLED "WHITE MUSCLE DISEASE" IN RELATION TO ANALYTICAL DIFFERENCES BETWEEN PIG MUSCLES.

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During the last six years increasing reference has been made by Danish^{1,2,3} and French^{4,5} investigators to a dystrophic condition in the muscles of pigs which is superficially recognised by a pale, exudative appearance of the flesh and which is referred to as "muskeldegeneration" and "la myopathie exsudative dépigmentaire du porc" respectively. An apparently related condition has been found in the United Kingdom.⁶ Some further observations on such phenomena seem not untimely.

"Muskeldegeneration" is characterized biochemically by a low initial pH (i.e. at $\frac{3}{4}$ hour post mortem³) and by a very fast rate of pH fall during post mortem glycolysis^{5,7}; yet, although the pH may fall to 5.1 in the first $1\frac{1}{2}$ to 2 hours, it subsequently rises to attain a normal ultimate pH value of about 5.5⁷. On the other hand, in "la myopathie exsudative dépigmentaire du porc" muscles have a normal initial pH, but a slightly sub-normal ultimate pH (about 5.2)⁵. In the meat showing the so-called "white muscle disease" which we have examined, an exceptionally low ultimate pH is almost invariably found (it may attain 4.8)⁶; the latter is always accompanied by exudation and pale colour. Nevertheless, marked exudation has been encountered in normally pigmented rectus femoris muscles of pigs at an ultimate pH of 5.9⁶.

While no abnormal histological findings were reported by Wismer-Pedersen³, we have noted some unusual microscopic features, e.g. an alternate array of severely contracted and adjacent passively corrugated muscle fibres (similar to the appearance presented by normal muscle when the onset of rigor mortis has been swift: J. R. Bendall, personal communication). Very occasionally internal rowing of nuclei and areas of "coagulation necrosis" have been seen, but these latter features are non-specific and occur in many types of dystrophic muscles, whether the cause is ischaemia,⁹ virus infections,¹⁰ or vitamin E deficiency¹¹. According to Blaxter¹² hyaline nodes and proliferation of the sarcolemma arise with the latter condition; these have not been seen even in the most severely exudative musculature we have examined.

More in accord with Danish findings are the data obtained in solubility studies. Thus, in exudative muscles - those having a high "loose-water" (L.W.) number - Wismer-Pedersen³ reported that 50% of the total muscle nitrogen is insoluble in 0.6 M KCl, whereas only 24% fails to dissolve in this medium when the L.W. number is low. We have applied the procedure of Helander¹³ to longissimus dorsi muscles (at the level of the 4th, 5th and 6th lumbar vertebrae) from affected

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and normal pigs. In this procedure that fraction of the total nitrogen which is soluble in 1.1 M KI, but insoluble in 0.03 M phosphate buffer, is regarded as myofibrillar. It will be seen from Table 1 that, as the ultimate pH falls below

Table 1. Ultimate pH and myofibrillar nitrogen (as % of total nitrogen) in longissimus dorsi muscles (level of 4th, 5th and 6th lumbar vertebrae) from Landrace pigs

Ultimate pH	Myofibrillar nitrogen, %
5.80	52
5.56	52
5.46	40
5.42	43
5.31	26
5.29	26
5.28	22
5.19	29
5.19	22
5.05	20

about 5.5 (i.e. as the severity of exudation increases³) the percentage of myofibrillar nitrogen decreases from about 50% of the total nitrogen to 20% at an ultimate pH of 5.05. Concomitantly, the percentage of so-called stroma (or insoluble) nitrogen increases. Nevertheless it seems that ultimate pH is not entirely responsible for diminished solubility of myofibrillar nitrogen in exudative muscle, since in a sample of longissimus dorsi having an ultimate pH of 5.9 - but which was exudative - we found that only 30% of the total nitrogen registered as myofibrillar. As we have indicated earlier, an abnormally low pH is always associated with exudation; but the converse is not invariably true. Helander¹³, reporting on atrophies caused in rabbit muscles by denervation, tenotomy or prolonged immobilisation, showed that, in these conditions, myofibrillar nitrogen decreased from a normal value of about 56% of the total nitrogen to 48%, while stroma nitrogen increased from 8% to 16% of the total nitrogen

In this work it was obviously desirable to limit the influence of inter-animal variability as far as possible. To this end investigations have been commenced using, as experimental material, pigs of accurately known history from a National Pig Progeny Testing Station. Moreover, since Landrace rather than Large White pigs appear to be affected by the so-called "white muscle disease", a comparison of ultimate pH values and colour ratings in allegedly normal pigs from these two breeds was indicated. The longissimus dorsi muscle was chosen for study as being both commercially important and especially involved in the dystrophic condition⁶. Again, since there are conflicting views on the relative susceptibility of lumbar and thoracic regions of the longissimus dorsi, the latter was sampled at various vertebra levels (5th, 7th, 9th, 11th, 13th and 15th thoracic, and 1st, 3rd, 5th and 6th lumbar). The muscles were derived from 20 pure bred

pigs of Large White and Landrace breeds (13 hogs and 7 gilts in each case) which had been reared at a Progeny Testing Station from the age of 75 days. At the time of slaughter the average age of the Large White group was 183 days and that of the Landrace group 176 days. All pigs were of approximately the same carcass weight (153-154 lbs). Mean data are represented in Figure 1. It will be seen that the mean ultimate pH at all 10 locations in Landrace longissimus dorsi muscles is invariably lower than at corresponding locations in those from Large White pigs, the difference being minimal at the level of the 15th thoracic vertebra. Statistically the overall difference was highly significant ($P < .001$). In both breeds the mean ultimate pH at the levels of the 5th thoracic and 6th lumbar vertebrae were significantly higher ($.001 < p < .01$) than those at any of the other locations: values reached a minimum at the level of the 3rd lumbar vertebra. The scatter of ultimate pH values was also markedly different between the breeds, being greater at the levels of the 5th thoracic and 6th lumbar vertebrae, and less at the levels of the 9th thoracic and 1st lumbar vertebrae, in Large White pigs than in those of Landrace breed.

The mean colour ratings at all locations except 1st and 5th lumbar vertebrae were higher in Longissimus dorsi muscles from Large White pigs than in those from Landrace breed: the difference was especially marked at the level of the 5th thoracic vertebra. Again, at the same locations as with ultimate pH (namely, the levels of the 5th thoracic and 6th lumbar vertebrae) colour ratings of both breeds were higher than elsewhere in the longissimus dorsi. Nevertheless only in the longissimus dorsi muscles from Landrace pigs were there significant correlations between ultimate pH and colour (at the levels of the 7th and 15th thoracic and of the 1st and 3rd lumbar vertebrae).

The above inter-location differences in ultimate pH and colour may well reflect functional phenomena, the high values for these parameters at each end of the longissimus dorsi possibly indicating the need for a more sustained type of muscular action than at intermediate levels. Since the correlation between ultimate pH and colour is significant at relatively few levels, however, it must be assumed that other factors are implicated. In seeking the reason for these breed differences in pH and colour, both normal and exudative longissimus dorsi muscles from Landrace and Large White pigs are being submitted to more detailed analysis. Preliminary data from apparently normal material do not reveal any striking difference in, for instance, nitrogen distribution (Table 2), although the somewhat lower content of myofibrillar nitrogen in Landrace pigs may prove to be significant as the work progresses.

Table 2. Nitrogen fractions in longissimus dorsi muscles of normal ultimate pH (5.5) from Landrace and Large White pigs

Breed	Nitrogen Fractions				
	Total	Non-Protein	Sarcoplasmic	Myofibrillar	Stroma
Landrace	3.72	0.46	1.06	1.86	0.34
Large White	3.73	0.45	1.01	2.03	0.24

The availability of strictly controlled material has revealed an interesting aspect of ultimate pH which has apparently been obscured hitherto by the magnitude of inter-animal variability. In Figure 2 ultimate pH values for longissimus dorsi muscles at the level of the 4th, 5th and 6th lumbar vertebrae, have been plotted against the percentage of total moisture on a fat-free basis. Muscles of low ultimate pH are seen to have a lower total content of moisture than those at high ultimate pH. That the water-holding capacity should vary directly with ultimate pH has, of course, been frequently demonstrated; but it would have been supposed that this would not have involved any variation in the overall amount of water present. The white muscles which we have examined, despite their exudative nature, thus have a lower water-content than normal: here again our findings on dystrophic muscles apparently differ from those of Wismer-Pedersen³, where a high L.W. number (i.e. a more exudative state) was associated with a higher content of water.

It will be evident that although the various conditions recognised by marked exudation from muscles may be superficially similar, they cannot be assumed at this stage to have a common aetiology. Both practical and theoretical considerations justify continuing investigation of these problems.

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Figure Captions

Fig. 1. The mean (20) ultimate pH and colour (arbitrary units) of longissimus dorsi muscles from Large White (●) and Landrace (○) pigs of similar carcase weight at various vertebral levels.

Fig. 2. Relationship between ultimate pH and % moisture (fat-free basis) in pig longissimus dorsi muscle (region of 4th, 5th and 6th lumbar vertebrae).

Summary

A comparison has been made between "muskeldegeneration", "la myopathie exsudative dépigmentaire du porc" and an exudative condition occasionally found in Landrace pigs in the United Kingdom. Even in apparently normal longissimus dorsi muscles from a uniform group of Landrace pigs, the mean ultimate pH is lower and the mean colour is less red at most points from the level of the 5th thoracic to the 6th lumbar vertebrae than at corresponding locations in a group of Large White pigs of similar age and weight. Only in Landrace pigs, and at some vertebral levels, were there positive and significant correlations between ultimate pH and degree of redness. More detailed analytical work designed to elucidate differences between the two breeds and between normal and exudative muscle is continuing.

Résumé

On a comparé "muskeldegeneration" et "la myopathie exsudative dépigmentaire du porc" avec une maladie exsudative du muscle qui se présente de temps en temps au Royaume-Uni et qu'attendent surtout les porcs d'élevage Landrace. Même parmi les muscles longissimus dorsi des porcs d'élevage Landrace qui semblent évidemment normaux, à la plupart des situations du région 5ème vertèbre thoracique au région 6ème vertèbre lombaire le moyen pH final est inférieur et la moyenne couleur est moins rouge que ceux aux situations comparables des porcs d'élevage Large White qu'ont l'âge similaire et le même poids. Il y avait des corrélations positives et significatives entre le pH final et la rougeur seulement avec les porcs d'élevage Landrace et seulement aux quelques situations vertèbres. On continue ces expériences analytiques avec l'intention d'expliquer les différences entre les deux élevages et entre des muscles normaux ou exsudatifs.

Zusammenfassung

Eine vergleichende Untersuchung wurde ausgeführt zwischen "Muskeldegeneration", "la myopathie exsudative dépigmentaire du porc" und einem exudativen Zustand der gelegentlich in Landrace Schweinen auftritt. Selbst in anscheinend normalen longissimus dorsi Muskeln von einer einheitlichen Gruppe von Landrace Schweinen ist zwischen dem 5. Brust- und dem 6. Lumbalwirbel das End-pH im Mittelwert niedriger und die Farbe weniger rot als an entsprechenden Stellen in einer Gruppe von Large White Schweinen von gleichem Alter und Gewicht. Nur in Landrace Schweinen bestand in gewissen Wirbelabschnitten eine positive und bezeichnende Beziehung zwischen pH und Intensität der roten Farbe. Weitere analytische Untersuchungen zur Aufklärung der Unterschiede zwischen den zwei Rassen und zwischen normalen und exudativen Muskeln sind im Gange.

FIG. 1

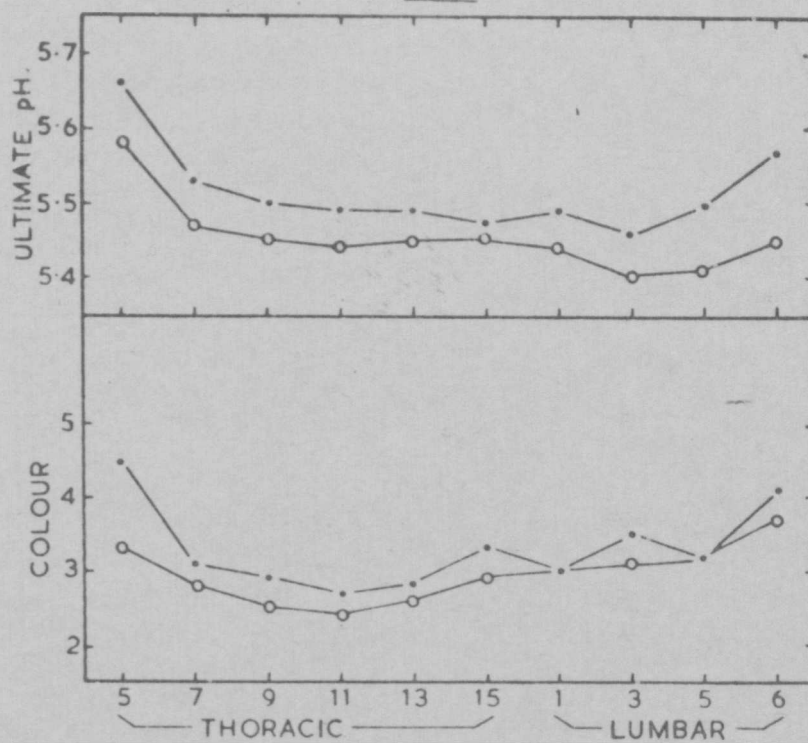


FIG. 2

