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Introduction

Phenomenon of pale, soft and exudative muscle is scientifically very interesting and economically important change of pork. The complexity and importance of that change is due to the fact that watery pork muscle is pale, soft and exudative and therefore unsuitable for use. According to Bendall and Lawrie /2/ the commercial setback of watery muscle is that such meat is unsightly, because hams made from it frequently have a two-toned appearance, and yield excessive amounts of jelly.

If we mention that this change was established in 18 % of approximately 15.000 suveyed hams in USA/7/, and in 22,7 % of 1.198 carcasses of pigs, surveyed in Holland /15/, one can see much better economical effect of this phenomenon.

Because of the character of the change in watery pork muscle, as well as of its economical importance, this problem has been widely investigated. That is reason why there are so many works dealing with watery pork.

It is characteristic that watery pork coincide with fast and significant pH decreases immediately post-mortem /1, 2, 3, 4, 14, 15, 17/.

pH of watery pork muscle decreases for 3o-45 min. post-mortem below 6,o . Bendall, Hallund and Wismer-Pedersen /1/ have found that in Danish Landrace pigs, with more or less severe changes due to watery muscles, pH decrease for 1,o4 units/hours post-mortem /while in the other group of pigs of the same race, without incidence of watery muscles, pH falls for max. 0,65 units/hours/. In some pig carcasses, with watery muscles, of the former group, rigor mortis was developed in 16o min. Wismer-Pedersen writes, in an earlier paper/17/, that glycolysis is completed in some pigs of the same race, in 1 hour post-mortem.

pH of watery pork muscle falls, ordinary below 5,5 /6/ or 5,6 /15/. However, extremly low registered pH of watery pork muscle are 4,78 and 4,6 /14, 1/.

According to some authors, glycolytic rate is a major factor which determine the ultimate pH and water holding capacity of post-mortem musculature /12/. Briskey /3/ and Kastenschmidt, Briskey and Hoekstra /12/ have found that watery pork muscle with low pH is more pale than normal muscle. Borchert and Briskey have come to similar results /6/, while investigating the possibilities of how to prevent the incidence of watery pork using low temperature. Bendall and Lawrie /2/ point to the contradiction in the results cocerning the total pigments in watery pork, writing that Lawrie has found less pigment in watery muscles than in normal muscles of pigs of English races, while Wismer-Pedersen didn't get analogical results investigating the colour in muscles in Danish

Landrace pigs.

It has been already mentioned that in canned hams, produced of pale, soft and exudative muscles there is much jelly /2/, which indirectly shows that the WHC of these muscles is low. There are many published data about the influence of pH on WHC /9, lo/. It should be noted that in more papers /3, 5, 13, 16, 17/, dealing with post-mortal biochemical changes in pork muscle, was reported that muscle tissue with low pH is, also, of low WHC.

Pale, soft and exudative porcine muscle is of some interest for our meat industry, too. This importance could be better demonstrated if the frequecy of appearance of watery pork in white pigs in our breedings is statisticaly shown, Table 1. /unpublished data/.

As watery pork is becoming more interesting and important problem for our meat industry, we have decided to examine what is /a/ a relation between total pigments in watery and normal porcine muscles, as well as /b/ the moisture content, WHC and pH of watery muscles and relations of these values.

Experiments

In the first part of this research we have determined colour /as transmittance/ of mm. semitendineus, semimembranaceus, rectus femoris and adductor from lo pig hams, as well as from lo m. longissimus dorsi.

In the second part of our research we determined the colour, also as transmittance, moisture content, WHC and pH of the mentioned pork muscles from lo pig hams and 13 m. long. dorsi.

On mm. semitendineus and semimembranaceus we have examined all these characteristics in brighter /outer/ and darker /inner/ layers.

Material. We have taken samples needed for our examination from the carcasses of pigs in type of Land-race and Large White, of live weight from loo to 11o kg. Carcasses had been chilled before the samples were taken, for about 24 to 48 hours, under uniform and ordinary conditions.

We have selected all samples during the cutting of the carcasses. So, we were able to take the samples with desired charactaristics.

From every ham we have taken already mentioned muscles, of which m. adductor served as control.

The samples of m. long. dorsi we have used were of different intensity of changes, as well as normal muscles.

The examination was conducted in April and first half of May of this year. All samples were taken in the plant "Industry of Meat and Meat Products - Venac", Novi Sad.

Methods. We have determined the colour by measuring the transmittance of total pigmets in meat extract on wave length 64o mμ. Pigments were extracted with 8o% aceton/water solution, as described by Hornsey /11/. The transmittance of filtered extract was determined with Standard Model Spectronic 2o Colorimeter, Bausch and Lomb; 1-inch cell was used.

pH was detected in aqueous extract of meat, prepared as described by Andriewski, by means of pH-meter.

"Radiometer", model 24, with electrodes G 2o2 C and K 4o1.

WHC was measured by the filter-paper moisture-absorption technique, as described by Grau and Hamm /8/, using Schleicher und Schüll, No 589², blau band filter-paper.

WHC was expressed in cm^2, calculated so that from the total wet surface was abstracted the surface covered with the film of compressed muscle.

Results and discussion

Colour. The results obtained by measurement of the transmittance of the total pigments in meat extract /Fig. 1./, in first part of this research show, that m. rectus femoris, outer /brighter/ layer of mm. semitendineus and semimembranaceus, as well as m. long. dorsi contain less pigments than m. adductor and inner /darker/ layer of mm. semitendineus and semimembranaceus. These results coincide with the scores of the colour of these muscles, as it is shown in Table 2.

The average value of transmittance of samples scored with 1 is higher than that of the samples scored with 2. Some results of individual measurement of samples scored with 1 were the same as the results of individualy measured samples scored with 2. The average values of the transmittance of other scored groups of samples are significantly different, and the lowest as well as highest values of the individual measurement of the samples are not overlaped.

Table 2. Comparison of subjective scores with transmittance of chilled muscles

Scores	Transmittance in %
1 /extremly pale, soft and exudative muscle/	95,3 /94-97/
2 /moderately pale, soft and exudative muscle/	94,o /92-96/
3 /moderately dark, firm and dry muscle/	89,o /87-91,5/
4 /very dark, firm and dry muscle/	85,o /82-86/

The results of the examination of transmittance of the total pigments of meat extract are very similar in the first and the second part of this research work /Fig. 2./. We emphasize the interesting result that there is almost no difference in content of the total pigments between normal and watery samples of m. long. dorsi.

It should be noticed that in samples of mm. rectus femoris, semitendineus and semimembranaceus the typical characteristics of the watery porcine muscle were not expressed. So, in mm. semitendineus and semimembranaceus the pale colour of outer layer was typical, but softness and wateriness could hardly be detected. However, all characteristic changes of the watery samples of m. long. dorsi were intensive.

Moisture. It was found that in the brighter layer of the samples of mm. semitendineus and semimembranaceus, as well as in m. long. dorsi /regardless the colour/ there is less content of moisture than in the samples of m. adductor and in darker layer of samples of these two mentioned muscles /Fig. 3./.

Correlation between transmittance of total pigments of meat extract and moisture content is shown in Fig. 4. Therefore, muscles with higher percentage of moisture contain more pigments and are darker than muscles with lower content of moisture.

Water holding capacity. It can be noticed on the basis of the results of examination of chilled samples of muscles that the WHC is the highest in m. adductor and normal m. long. dorsi, lower in m. rectus femoris and in the darker layers of mm. semitendineus and semimembranaceus and the lowest in bright layers of the same two muscles, as well as in the samples of watery m. long. dorsi /Fig. 5./.

The difference in WHC between brighter and darker layers of mm. semitendineus and semimembranaceus was not significant. However, this difference between watery and normal samples of m. long. dorsi was highly expressed.

Comparing results shown in Figers 2. and 5., one can see that muscles with brighter colour have, also, lower WHC, except m. long. dorsi. In this case there is almost no difference in colour between normal and watery muscles, while the WHC of normal muscle is evidently higher than WHC of watery one.

Relation between WHC and moisture content is shown in Fig. 6., and one can see that there is no correlation between these two characteristics in examined samples.

pH. Analysing pH values of chilled muscles /Fig. 7./ it can be noticed that higher pH is found in darker muscles, and lower in brighter ones. If one compares pH of samples of brighter layer of mm. semitendineus and semimembranaceus, as well as of watery m. long. dorsi with darker layer of correspondent muscles, respectively with pH of normal samples of m. long. dorsi, then the evidently expressed differences can be detected. However, when is compared pH, for example, of brighter layer of samples of m. semitendineus with pH of darker layer of samples of m. semimembranaceus and normal m. long. dorsi, then one can see that pH of brighter tissue is higher than pH of darker tissue /dark layer of m. semimembranaceus and normal m. long. dorsi/. It is interesting, also, to emphasize that pH of brighter layer of m. semitendineus is lower only by 0,01 unit than pH of m. adductor, inspite of the fact that this muscle is very dark and is used as a standard for determination of the degree of changes of watery muscles. In Fig. 8. expressed positive correlation between WHC and pH of chilled muscles is shown.

Summary

Colour, moisture content, WHC and pH in watery porcine muscles were studied in this paper. Examinations were done on four muscles of pork ham /mm. adductor, rectus femoris, semitendineus, semimembranaceus/ as well as in m. long. dorsi. M. adductor and normal m. long. dorsi were used as controls. Outer, brighter

and inner, darker layers were always examined in mm. semitendineus and semimembranaceus.

Colour of muscles has been examined in two groups of pigs. In the first group the examination was carried out in 10 carcasses / 10 hams and 10 m. long. dorsi/ and in the second group in 10 hams and 13 m. long. dorsi. All previously mentioned characteristics of muscles were examined in all samples from the second group of pigs.

The samples were taken from the carcasses of pigs of types of Landrace and Large White, of live weight from 100 to 110 kg.

From the results obtained in this research work it can be seen that extract of total pigments of darker muscles shows lower transmittance than extract of brighter ones. Similar results were obtained with pigs from both groups /Fig. 1. and 2./. Lower moisture content was found in brighter muscles than in darker ones. The difference in moisture content between watery and normal samples was not found in m. long. dorsi /containing less moisture/, /Fig. 3./. A negative correlation between moisture content and transmittance is expressed /Fig. 4./. WHC is the highest in m. adductor and normal m. long. dorsi, lower in m. rectus femoris and in darker layers of mm. semitendineus and semimembranaceus, and the lowest in the brigh layers of these two muscles and in the watery samples of m. long. dorsi /Fig. 5./.

There is no correlation between WHC and moisture content/Fig. 6./. Higher pH was found in darker muscles and lower in brighter ones. However, in darker layer of m. semitendineus it was found higher pH than in m. adductor, inspite of the fact that this muscle is very dark and was used as a standard for determination of the degree of changes of watery muscles /Fig. 7./. It is evidently expressed positive correlation between WHC and pH /Fig. 8./.

Résumé

On a étudié dans ce travail la couleur, l'humidité, le pouvoir de rétention d'eau et le pH des muscles exsudatifs du porc. On a examiné dans ce but quatre muscles du jambon /m. adductor, rectus femoris, semitendineus et semimembranaceus/ et le muscle longissimus dorsi. Les muscles adductor et long. dorsi servaient d'éléments-contrôle. Pour les muscles semitendineus et semimembranaceus, on a examiné la couche externe, plus pâle, et la couche interne, plus foncée.

On a examiné la couleur sur du matériel obtenu dans deux groupes de porcs, utilisant dix jambons et dix muscles long. dorsi du premier groupe et dix jambons et treize muscles long. dorsi du second groupe. On a étudié également les autres caractéristiques des muscles du second groupe.

Le matériel examiné provient de porcs de races landrace et yorkshire, d'un poids de loo à llo kg.

Les résultats obtenus montrent que les muscles de couleur plus foncée présentent une transparence de l'extrait des pigments musculaire plus faible que les muscles plus pâles. Par conséquent, les muscles plus pâles contiennent moins de pigment. Des résultats

semblables ont été obtenus dans les deux groupes examinés /Fig. 1 et 2/. On a établi que les muscles de couleur plus pâle continnent moins d'humidité que ceux de couleur plus foncée. Pour les muscles long. dorsi, on n'a pas trouvé de différence en ce qui concerne la quantité d'eau, entre les muscles exsudatifs et les muscles normaux /ils contiennent moins d'eau/ /Fig. 3/.

Une corrélation négative se manifeste entre la quantité d'eau et la transparence de l'extrait musculaire /Fig. 4/.

Le muscle adductor et le muscle long. dorsi normal présentent un pouvoir de rétention d'eau plus fort, alors qu'il est moindre pour le muscle rect. femoris et les couches plus foncées des muscles semitendineus et seminenbranaceus, et le plus faible pour la couche plus pâle de ces duex muscles et pour les muscles long. dorsi exsudatifs /Fig. 5/. Il n'y a pas de corrélation entre le pouvoir de rétention d'eau et la quantité d'eau /Fig. 6/. La valeur du pH des muscles plus foncés est plus élevée que celle des muscles plus pâles. Cependant on a trouvé un pH supérieur dans la couche plus foncée du muscle semitendineus que dans le muscle adductor, bien que ce muscle de couleur foncée ait servi d'élément-contrôle pour déterminer le degré de myopathie exsudative des autres muscles /Fig.7/. Une corrélation positive entre le pouvoir de rétention d'eau et le pH se manifest avec évidence /Fig. 8/.

Abrevations used

WHC - water holding capacity
Ad. - m. adductor
Rec. - m. rectus femoris
ST_1 - m. semitendineus, brighter layer
ST_2 - m. semitendineus, darker layer
SM_1 - m. semimembranaceus, brighter layer
SM_2 - m. semimembranaceus, darker layer
L.d.w. - m. long. dorsi, watery
L.d.n. - m. long. dorsi, normal

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Table 1. The frequency of watery porcine muscles in our breedings of pigs in types Landrace and Large White

Group No.	Race and provenance of pigs	No. of surveyed carcasses	Muscles												
			M. rect. fem.			M. semitend.			M. semimembr.			M. long. dorsi			
			Subjective scores												
			1	2	3	1	2	3	1	2	3	1	2	3	4
1	LR AE	126	4,8	16,7	78,5	23,8	18,3	57,9	24,8	21,4	53,8	1,6	12,6	43,7	42,1
2	LR AC	47	2,0	17,0	81,0	12,8	42,6	44,6	21,2	51,1	27,7	-	2,0	35,5	62,5
3	LW AE	165	7,8	35,2	57,0	23,0	43,0	34,0	17,0	29,7	53,3	2,2	4,6	43,7	49,5
4	LW AC	62	22,6	45,1	32,3	71,0	27,4	1,6	54,8	40,3	4,9	12,3	21,5	49,2	17,0
5	W AC	217	13,3	52,6	34,1	21,1	56,4	22,5	26,0	49,6	24,4	1,7	3,8	54,5	40,0

LR = Landrace
LW = Large White
W = White

AE = Agricultural economy
AC = Agricultural community

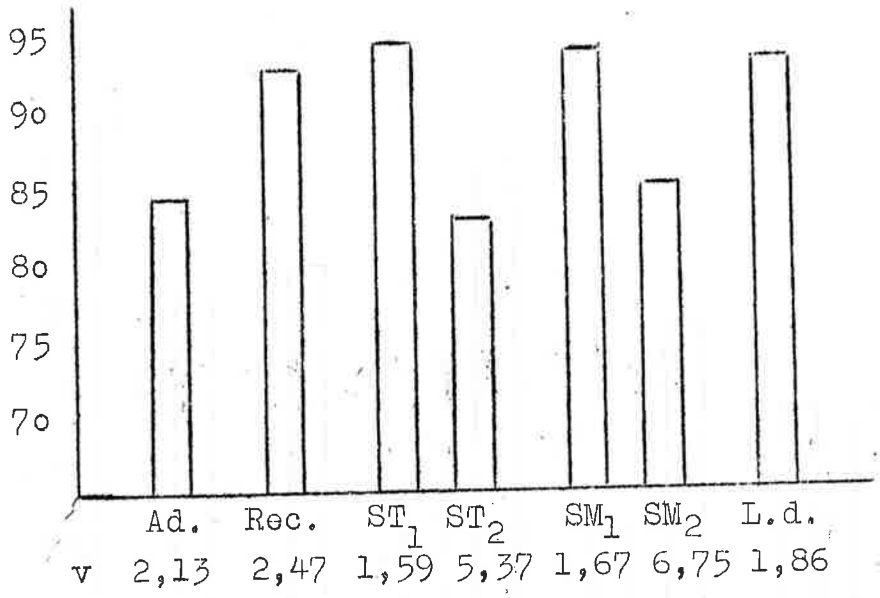


Fig. 1. Results of the measurement of transmittance of total pigments in meat extract (I experiment)

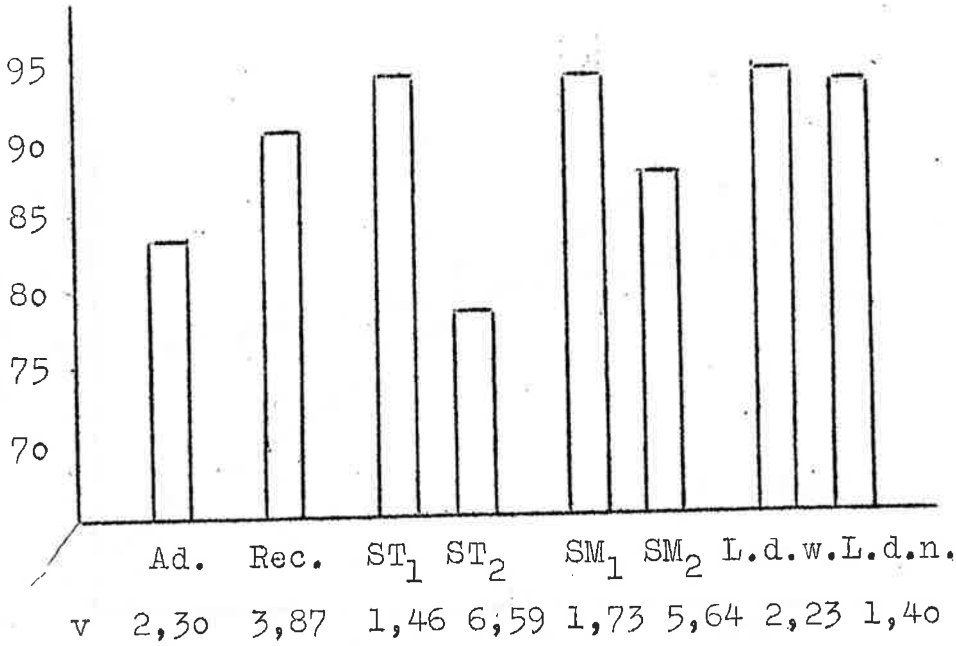


Fig. 2. Results of the measurement of transmittance of total pigments in meat extract(II experiment)

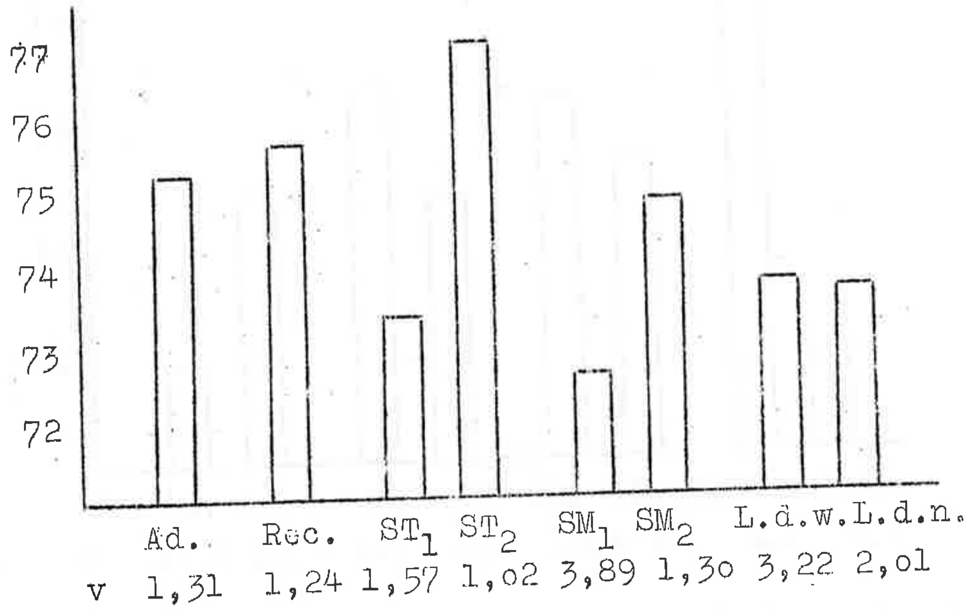
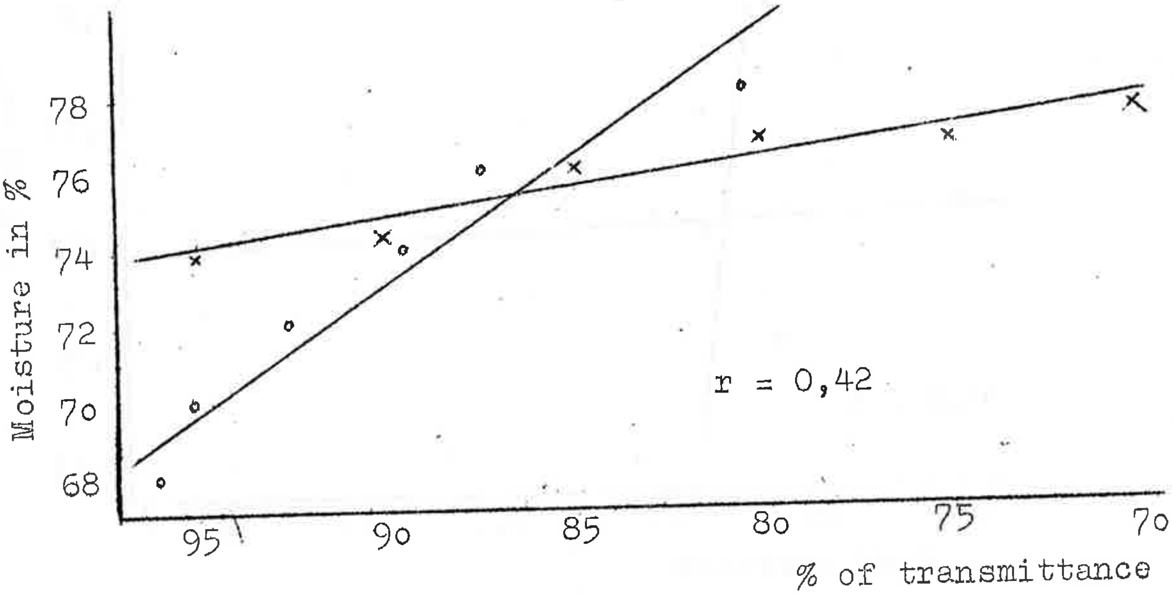


Fig. 3. Moisture content of the chilled muscles



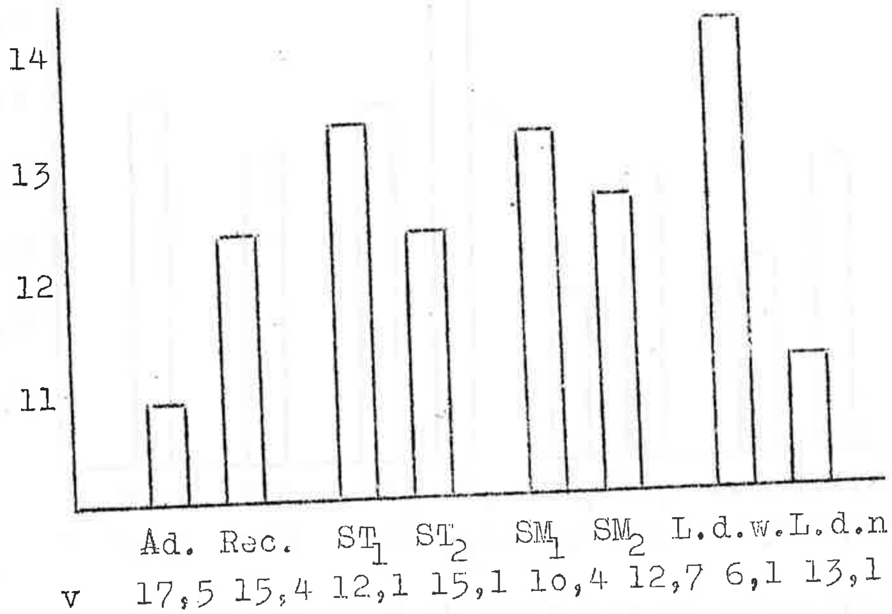


Fig. 5. Water holding capacity of chilled muscles

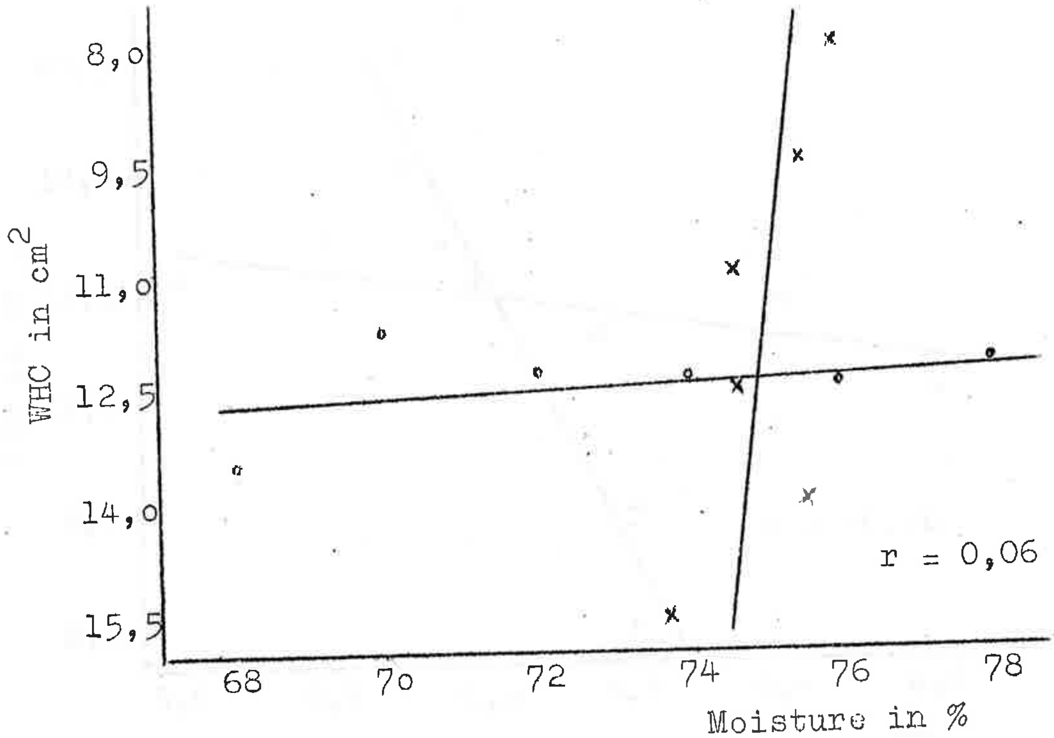


Fig. 6. Correlation between moisture content and water holding capacity

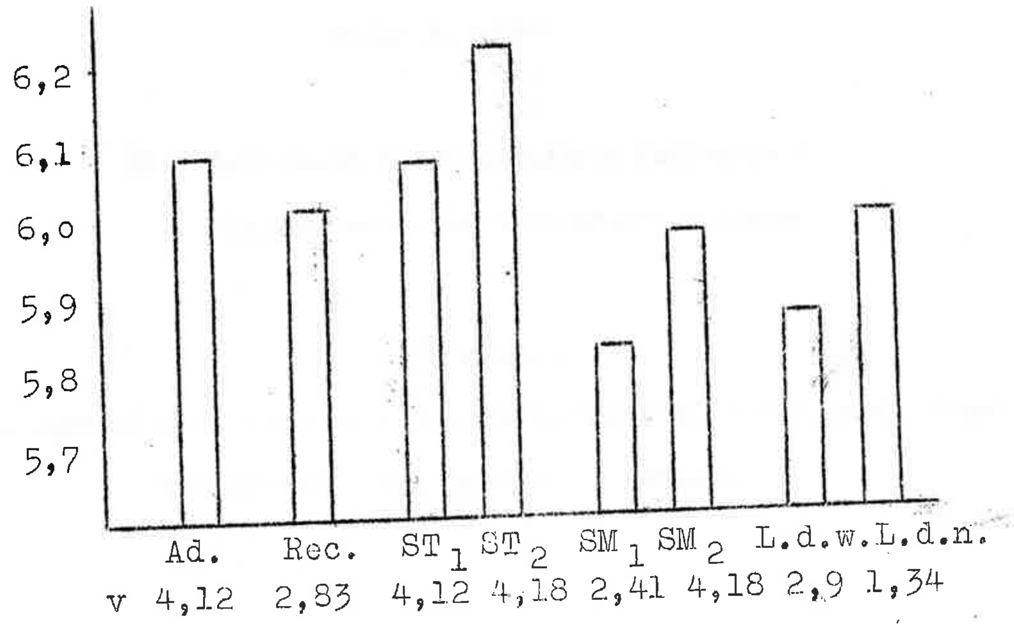


Fig. 7. Results of pH measurement of chilled muscles

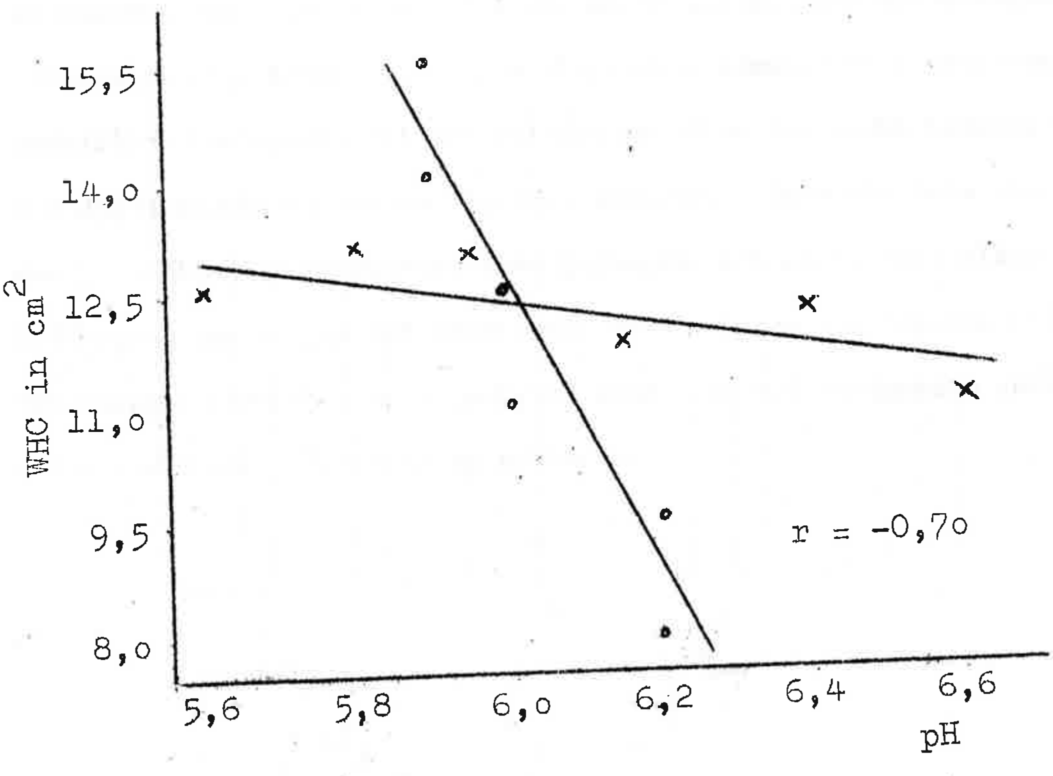


Fig. 8. Correlation between water holding capacity and pH of chilled muscles