SOME OBSERVATIONS ON THE pH OF PORK UNDER VARIOUS CONDITIONS

by

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INTRODUCTION

Man has always realized that the nature of the meat that we eat is affected by a complicated chain of factors stretching from the breeding herd of the producing country to the plate of the consumer. It is clear that the life history of a meat animal may influence both the quantity and quality of the meat we eat.

The role which the pH, the negative common logarithm of the hydrogen ion activity, of meat plays affords a useful plane to which the complicated events which take place in the carcass can be related, and upon which they can be oriented. Under many circumstances the scale of change in pH is a far more useful reference than the scale of time.

Equipped, as most laboratories are, with a glass electrode pH meter, the determination of pH presents little more difficulty than the determination of temperature. The results of a greater knowledge on the pH are likely to be of importance in studying the effect of various treatment of slaughterhouse animals on the properties of meat. It is known that adjustment of the pH of meat influences certain of its properties, especially the extent to which frozen meat drips after thawing (2,6). In unfrozen meat, the best keeping quality is shown by meat having a low pH. Ingram (8), in working with controlled hams, found that pH had a marked effect on the growth of bacteria.

In this dissertation, the term pH is used throughout to

replace the cumbersome term, hydrogen-ion activity, which is really measured and spoken of as hydrogen-ion concentration or degree of active acidity or pH.

Since the pH value varies inversely as the hydrogen-ion concentration, the use of both terms must be confusing. The use of only one, pH, the more convenient and popular term, avoids the mental gymnastics and discipline required for the continual conversion of opposing terms.

REVIEW OF LITERATURE

The major factor affecting pH in meat is the formation of lactic acid from glycogen in the tissue. In terms of elementary chemistry this reaction requires no more than the addition of water to glycogen, $(C_6H_{10}O_5)n+nH_2O \rightarrow 2nC_3H_6O_3$, but between the initial and final states an extremely complicated series of transformations is interposed.

The precise pH of the muscle immediately prior to cessation of the circulation depends on the recent history of muscular activity (2). Evidence indicates the pH of the live tissue with a minimum amount of lactic acid to be in the neighborhood of 7.4 (13). A resting muscle has a neutral reaction and normally contains a considerable amount of glycogen. After death the pH decreases with the production of lactic acid. According to Bates-Smith (2), there are two factors which have the effect of decreasing the fall of pH: the liberation of carbon dioxide from bicarbonate and break down of creative phosphate.

The change in pH has at various times been regarded as the actual cause of rigor mortis. But one fact alone is sufficient to dispel an idea that rigor mortis is due to porduction of lactic acid, that is, that rigor mortis sets in at times without any change in acidity whatsoever. Nevertheless, it is interesting to note that, when sufficient lactic acid is produced, rigor mortis always sets in when the muscle reaches a certain pH (2).

It has already been mentioned that the amount of glycogen in the muscle tissue is dependent upon the muscular activity prior to slaughter. Callow (4), found that carcasses from fatigued pigs have muscular tissue with a higher pH than those from well rested animals. Moreover, resting before slaughter progressively diminishes the after-effects of fatigue, and yields muscular tissue with a progressively lower pH.

The results of fatigue and resting can best be explained in terms of physiological changes of muscle following death. The pH of muscle represents a balance, between the buffering power of a group of substances which alone give a pH near neutrality and acidic substances of which the most important is lactic acid. The amount of lactic acid in a muscle varies greatly. In life, the lactic acid formed from muscular glycogen during exercise is removed by way of the blood. After death, the glycogen reserve is gradually broken down to lactic acid during rigor mortis, but because of the cessation of the circulation the acid cannot be removed and accumulates in the muscle. If the muscle is fatigued

shortly before death its glycogen reserve is depleted, therefore less lactic acid formation is possible during rigor mortis and the flesh is ultimately less acid. If the muscle is not fatigued there will be a full reserve of glycogen and a greater amount of acid can be formed resulting in a lower pH.

Bates-Smith (1), found that if animals are not fed during the rest period, replenishment of the glycogen in the muscle takes place very slowly from the liver. If the animals are fed, the glycogen is supplied from the blood and the replacement is more rapid and the supply from the liver is not needed. Replenishment is particularly rapid if sugar or a high sugar content feed is used.

If the muscles have been completely inert and well supplied with oxygen for a relatively long period before death, say sixteen to twenty-four hours, metabolism will be completely aerobic and the lactic acid content will be very low.

The immediate effect of exercise on a muscle is the decrease in its glycogen content. However, if the work is light, and nutrients are available the glycogen is replenished as the work proceeds. In a well nourished animal, recovery of glycogen after exercise is usually quite rapid.

Bates-Smith (1), is of the opinion that struggling on the slaughtering floor should be reduced to a minimum because the loss of glycogen from the muscle is particularly heavy during exertion of short duration and while the animal is alive the glycogen passes

directly into the blood and is lost during bleeding.

Callow (5), found that feeding was necessary to increase muscle glycogen after exercise. In his experiments, hogs were shipped one mile by truck and then walked a quarter of a mile before slaughter. The ultimate pH in the Psoas major of a group which was rested over night, but not fed, averaged 5.80 as against 5.79 for the unrested; whereas a group which was both rested and fed had an average pH of 5.58 as against 5.87 for the unrested control groups. Previous work by Callow (3), indicates " 'resting' must, in fact, be resting in order to be effective." Pigs tend to fight when strange groups are mixed together in pens and under these circumstances no recovery of glycogen takes place.

A second example by Callow (4), is of a group of pigs which although rested after their journey for periods from 2½ to 17 hours, were walked ½ mile to the slaughter house and had average ultimate pH values of 6.00 to 6.18. Similar groups carried the short distance by truck had average pH values of 5.75 to 5.83. These differences appear surprisingly large for such apparently small differences in handling.

Kidd (9), has reported that the length of the delay before the onset of rigor is determined by (a) the pH of the muscle at the moment of death and (b) the glycogen content of the muscle. Since the activity of the animal just before death affects both these factors, it is now confirmed that this activity is the most important single factor influencing the post mortem behavior of the muscles.

With recent improvements in the glass electrodes changes in the pH of muscle can now be followed by means of a fine spear shaped electrode. The value recorded is, of course, that of the fluid in the intercellular spaces which in the living animal, must differ from that of the cell contents (7).

However, at some stage in the dying muscle equilibrium is reached between these two phases. In life, the membranes have the ability to repell the diffussion of ions but upon death there is a free diffussion of ions through the previously impermeable membranes which result in a rapid equilization of pH throughout the tissue. This was shown by Bates-Smith (1) where the value recorded by the spear electrode was identical with that of the minced and ground tissue.

Madsen (10), by the use of sugar in the feed for two days before slaughter compared to feeds with normal amounts or no sugar, found the average pH of the Psoas major to be 5.50 in the animals given sugar compared to 5.87 in the animals held off feed completely. Particularly important was the keeping quality of the pork of the two different groups. The test showed that there was far more influence on the appearance of the fresh pork than the addition of sugar to the meat. If the pork from the animals fed sugar was stored in a cool and dry place it had a more satisfactory surface condition than the pork from the animals held off feed. There was also a substantial difference in the odor of the fresh pork. The odor of the pork from the unfed pigs became rank, whereas

that from the sugar fed pigs was pleasantly sweet.

In salted pork, the surface of the cured sides from the unfed group were in a slimy condition eleven days after removal from the curing tank, while those of the fed group took twenty-one days to reach the same onditions. The surface condition was accompanied by a considerably better surface color which gave it a fresher and more appetizing appearance. Thus the pH of the mass of the muscular tissue may affect the microbiological spoilage not only in the interior as Callow showed but also on the surface of the carcass.

The methods in use prior to 1930 for the determinations of pH resulted in a most extraordinary variation in the recorded values. Ritchie (11), quotes values from the literature up to 10.0 for the pH of muscle. Since then the use of the glass electrode has become widespread and the quoted values can be regarded as more reliable.

Several authors have mentioned the variation they have observed between different muscles of the same animal and in the same muscle of different animals. However, they agree that there is much less variation in beef than in pork. Callow (4,5), also showed that muscles vary in their sensitivity to fatigue. In his determinations, the pH for the Psoas major was 5.72 while a pH of 5.48 was obtained for the Longissimus dorsi. Callow (5), also suggests that the proximity to bone may be one reason for this variation. Neutralization of lactic acid by calcium carbonate in the bone is one factor that could cause a rise in pH. Bates-Smith (2) believes it is more likely that the variation in ratio

of connective tissue to muscle tissue is the determining factor. As the muscle narrows towards its insertion the ratio decreases. Therefore, the production of lactic acid in the tissue decreases and a fall in the pH results. Bates-Smith (2) believes freezing has little, or no, effect on pH.

In this review the author has endeavored to gather past research pertaining ot the pH of meat and its effect in actual practice and theory in the handling of meat. A common factor in all aspects of the subject is the influence of the acidity of the meat on its immediate properties and its future behavior.

A review of the literature pertaining to the pH of fresh meat indicates that there is a need for further information pertaining to this subject. With this in mind this study was undertaken.

It was decided to make pH readings on all animals slaughtered in the Meats Laboratory at Kansas State College during the school year, 1950-1951. Circumstances made it impossible to collect the data according to a time schedule. However, it was endeavored to make the readings according to some schedule.

Some determinations were made on beef, but because of the limited number, these determinations were not included in this paper.

METHODS AND PROCEDURE

This study was undertaken to secure additional information on effects of pH on pork under various conditions.

Determinations were made under five conditions:

1) Hams, by inserting the electrode directly into the hams while on the carcass.
2) Hams, by removing a portion of the ham and determing the pH while not in contact with with carcass.
3) Psoas major, by removing Psoas major from the carcass immediately after slaughter.
4), Longissimus dorsi, the effects of repeated freezing and thawing on the pH of loin roasts.
5) Pork Sausage, the effect of the pH of repeated freezing and thawing on the pH of pork sausage under three types of packaging.

The equipment consisted essentially of a Beckman Model H-2 glass electrode pH meter, sensitive to 0.03 pH unit. (Plates I and II). With this pH meter calibrations were only to 0.1 units, therefore, the combined error of the pH meter and the interpretation of the operator made the accuracy generally obtained to 0.1 units.

In the first work with this meter it was not found practical to work in the cooler, due to inaccuracy under those conditions. Therefore, all readings in this study were made at room temperature. The meat used was kept in the cooler until the equipment was ready and then taken out. Under these conditions the reading

appeared to be accurate or at least could be duplicated.

A glass electrode, Beckman glass electrode number 8990 with a temperature range of -5 to 50°, specially constructed for material of a semi-solid nature was used in conjunction with a saturated potassium chloride calomel reference electrode, Beckman calomel electrode number 4970 with a temperature range of -5 to 60°C. The advantages of this electrode are primarily the speed in which a wide range of determinations can be made over a short period of time. However, some care must be used in its application to meat. The electrodes must be carefully rinsed with distilled water and wiped with cotton or some other soft material which will remove all residue from the previous reading and at the same time not cause damage to the glass. Ordinarily, two to three minutes appears to suffice for the attainment of equilibrium, however, in a few cases, the length of time before equilibrium was reached was as long as fifteen minutes. It was found that equilibrium was reached quicker and a more accurate reading was obtained if the electrodes were wet when inserted into the tissue. It appeared that the fat did not adhere to the electrode when wet. Therefore giving a reading of muscle tissue rather than becoming coated with fat when passing through fat tissue and influencing the reading by the presence of fat on the electrodes.

It was also found that a relatively large hole should be made into the tissue before insertion of the electrode. At first, a sharping steel approximately one-half inch in diameter, the same as the electrodes was used. In later work, a small cut was made.

EXPLANATION OF PLATE I

The Beckman Model H-2 pH meter used in this study. The distilled water and thermometer are needed for making pH determinations.

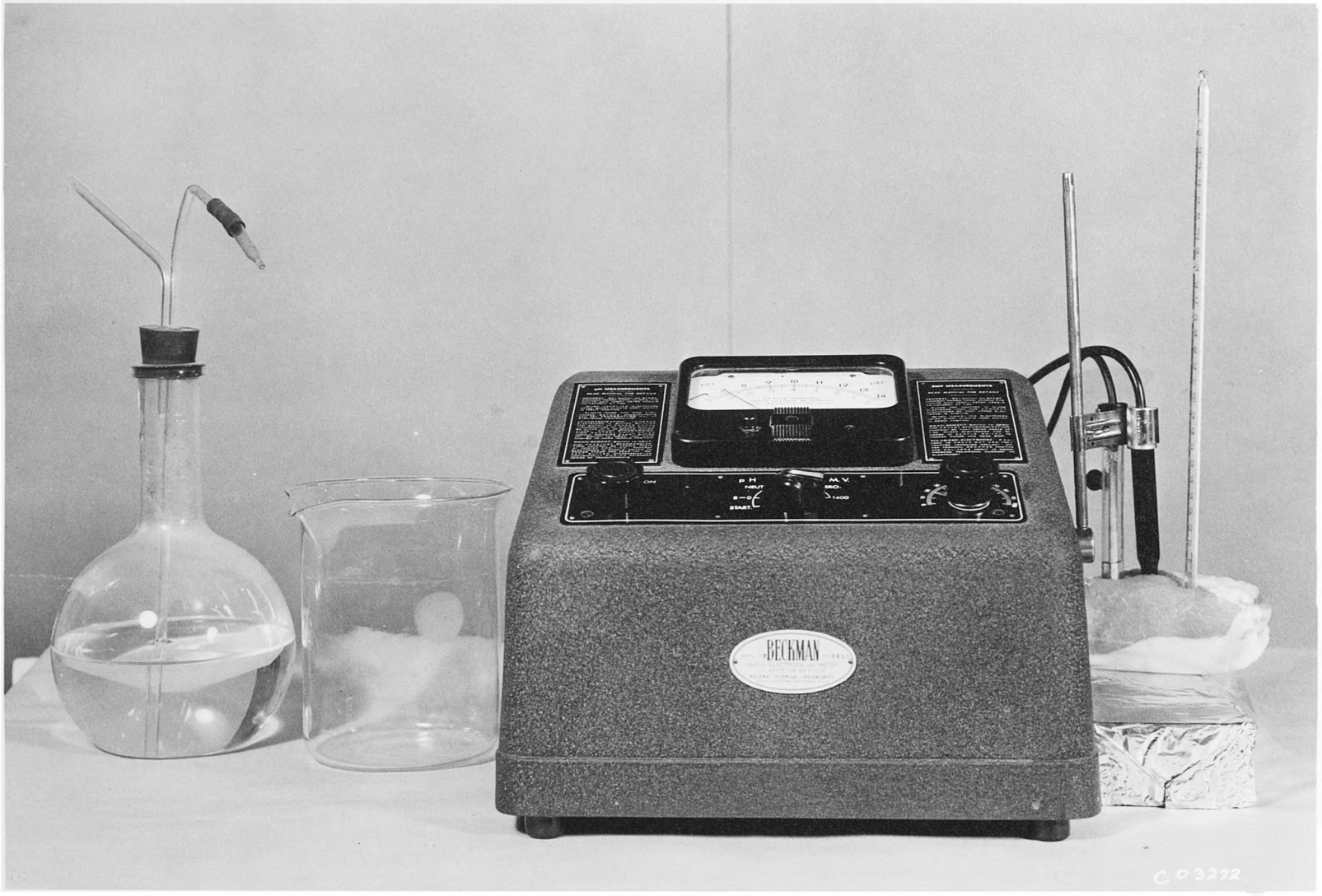

Plate I

EXPLANATION OF PLATE II

Close-up of pH meter used in this study, showing top of instrument containing standardization control, pH selector range control, temperature range control, and dial with calebration to 0.1 units.


A. J. GRINER COMPANY
Laboratory Supplies
NEW AND REBUILT MICROSCOPES
Scientific Instruments
pH MEASUREMENTS
READ MANUAL FOR DETAILS
GENERAL: SET SWITCH ON START. CONNECT POWER CORD, DURING FIVE MINUTE WAIT VERIFY METER NEEDLE ADJUSTMENT AT 7.00.
WHEN HANDLING ELECTRODES AFTER START ALWAYS KEEP SWITCH IN NEUT POSITION.
ALWAYS RINSE AND WIPE ELECTRODES BEFORE MEASUREMENTS AND SET TEMPERATURE DIAL AT ELECTRODE TEMPERATURE.
STANDARDIZATION: IMMERSE ELECTRODES IN BUFFER SOLUTION AND SWITCH TO PROPER RANGE (TEMPERATURE OF BUFFER SHOULD BE WITHIN 10° C. OF SAMPLE TEMPERATURE). ADJUST STANDARDIZATION CONTROL UNTIL METER NEEDLE INDICATES EXACT BUFFER PH. SWITCH TO NEUT. AND MOVE POINTER TO MARK NEEDLE POSITION.
MEASUREMENT: SWITCH TO NEUT. AND READJUST STANDARDIZATION CONTROL SO NEEDLE RESTS AT POINTER POSITION. IMMERSE ELECTRODES IN SAMPLE, SWITCH TO PROPER RANGE AND READ PH. REPEAT BUFFER STANDARDIZATION OCCASIONALLY DURING EXTENDED SERIES OF MEASUREMENTS.
NATIONAL TECHNICAL LABS. SOUTH PASADENA, CALIFORNIA, U.S.A.
pH 7 6 5 4 3 2 1 0 8 9 10 11 12 13 14 pH
TO READ MILLIVOLTS SWITCH TO EITHER MV POSITION AND MULTIPLY READING BY 100
BECKMAN pH METER
EMF MEASUREMENTS
READ MANUAL FOR DETAILS
GENERAL: SET SWITCH ON START. CONNECT POWER CORD, DURING FIVE MINUTE WAIT VERIFY METER NEEDLE ADJUSTMENT AT 7.00.
PLACE 700 ADAPTER IN GLASS ELECTRODE JACK AND CONNECT ELECTRODES SO THAT UPPER ELECTRODE IS POSITIVE.
WHEN HANDLING ELECTRODES AFTER START ALWAYS KEEP SWITCH IN ZERO POSITION.
MEASUREMENT: SWITCH TO ZERO AND ADJUST STANDARDIZATION CONTROL SO THAT METER RESTS AT 0.00. CLEAN ELECTRODES AND IMMERSE IN SAMPLE SWITCH TO PROPER RANGE AND READ EMF.
POLARIZED ELECTRODES: PROCEED AS ABOVE BUT USE 700-1 ADAPTER (GROOVED COLLAR). UPPER TERMINAL BECOMES POSITIVE AND DELIVERS ABOUT 10 MICROAMPERES POLARIZING CURRENT TO ELECTRODES.
STA ZATION
pH 6–14 800 M.V.
NEUT.
ZERO.
8–0
1400
START.
TEMP. ° C.
BECKMAN
MODEL H2 SER 2511
GLASS ELECTRODE pH METER
115 VOLTS, 50-60 CYCLE
NATIONAL TECHNICAL LABORATORIES
SOUTH PASADENA, CALIFORNIA, U.S.A.
C03273

Plate II

It was found that equilibrium was obtained quicker this way. The probable reason for this was that the electrodes were in contact with the tissue and at the same time they did not have the internal pressure of the meat against the sides, causing a moving or settling of the tissue against the sides of the electrodes.

When planning this study, the question of the accuracy of the readings made by inserting the electrodes directly into the muscle tissue was discussed. Bates-Smith (2) states that the fulids in the intercellular spaces have a different pH than the cell contents in life, but soon after death there is an equilization of pH throughout the tissue. Some preliminary observations were made to compare the readings secured by inserting the electrodes directly into the muscle tissue, with those readings made of minced tissue distributed into distilled water. These observations are summarized in Table 1. The similiarity of the readings procured by these two methods seems to have justified determining pH values by inserting the electrodes directly into the muscle tissue and therefore, all observations were made by this method.

Table 1. Summary of pH readings comparing minced ham in water to direct reading in ham.

	Hours after slaughter		
	$18\frac{1}{2}$	42	140
	pH	pH	pH
Direct into ham	5.88	5.85	6.00
Minced in water	5.80	5.85	5.90

The determinations in the hams (Table 2) were made beginning shortly after slaughter and continued as long as possible under the conditions present. In many cases the carcasses were cut and packaged after a forty-eight hour chill, making further readings impossible. These determinations were made by inserting the electrodes into the hams, posterior to the aitch bone, with care being taken so as to avoid contact with any bone. These readings were made from a cart which could be moved to any location in the laboratory. The pH meter was equipped with electrodes which had ten foot leads to permit easy handling. (Plate III).

In the second group of observations, which were made, on slices removed from the ham (Table 4) a portion of each ham was removed and a series of determinations were made to study the effect of tissue removed from the carcass.

The Psoas major was removed from the carcass immediately following slaughter and pH readings were made for a peirod of forty-eight hours after slaughter. (Table 3).

Pork Loins (Table 4) were boned and cut into three roasts of approximately equal lengths. All readings were made from the posterior end. Each reading was made by removing a chop or slice approximately three-fourths of an inch thick from the posterior end of a roast and this slice was used for the pH determination. The remainder was frozen on a plate freezer at -10 degrees, Farenheit. The package was then removed and placed in a 34° to 36° F. cooler for a period of twenty-four hours, at which time another

EXPLANATION OF PLATE III

Cart used in this study with pH meter, with ten feet electrodes, saturated potassium chloride solution for a calomel electrode, concentrated buffer solution, and cotton used for cleaning electrodes after pH determinations.

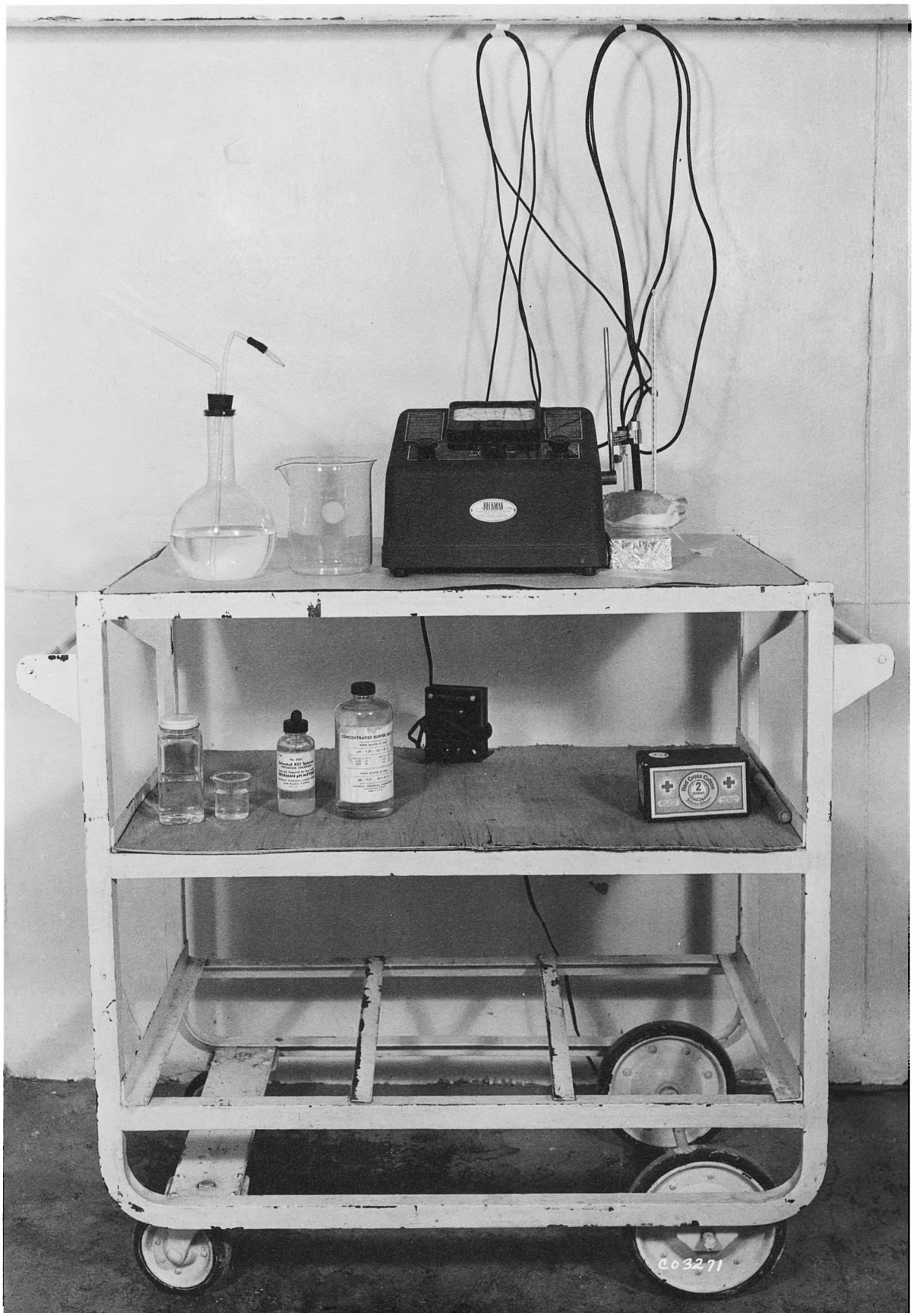

Plate III

sample was taken from which the pH determination was made. This was continued until the entire roast was used.

The pork sausage (Table 6) used in this experiment was made to a ratio of approximately twenty-five percent fat and seventy-five percent lean, and seasoned with one pound of salt, two ounces of pepper, and two ounces of sage per fifty pounds of meat. The trimmings were ground first through a three-quarter inch plate followed by a grinding through three-eight inch plate and then a one-eight inch plate. The sausage was then cooled in a 34° to 36° degree cooler for twenty-four hours and packaged as follows:

A) Two pound package wrapped in cellophane with "Tite."*

B) Two pound package wrapped in "Tite."

C) Package twelve inches by twelve inches by two inches wrapped in "Tite."

In all three cases the confectioners type of wrapping was used.

OBSERVATIONS AND DISCUSSION

A summary of all pH readings made by inserting the electrodes directly into the ham appears in tabular form in Table 2. Four. of these pH readings made by inserting the electrodes directly into the ham are graphically illustrated in Figs. 1,2,3, and 4. Figure 1, illustrates graphically the pH curve that would be expected if the breakdown from glycogen to lactic acid, was the determining factor and no other force was present to affect the pH.

* "Tite." A commercial glassine laminated paper for wrapping frozen food

Figure 2 illustrates a slight increase in the pH which appeared in many cases approximately forty-eight hours after slaughter. Figure 3 indicates there is a rise in the pH following slaughter which usually terminates approximately six hours after slaughter. This increase was found to appear in many, though not in all, hams. Figure 4 illustrates both the rise in pH at approximately six hours and the rise which appears at approximately forty-eight hours after slaughter.

The variation of pH, by inserting the electrodes directly into the ham muscle was found to range from 4.8 to 6.5.

A summary of all readings made on the Psoas major muscle of pork carcasses is in tabular form in Table 3. Four samples of various pH readings of the Psoas major, starting shortly after death and continuing for forty-eight hours, are graphically illustrated in Figs. 5,6,7, and 8.

In the Psoas major, as in the ham muscle, it was found there existed certain characteristics. The rise in pH terminating at approximately six hours after death and the rise at approximately forty-eight hours following slaughter were both observed in many cases.

During the past year Kansas State College conducted an experiment in which eight hogs were shipped thirty-six miles by truck. After this, the hogs were treated as follows; two hogs (no.35 & 37) were given feed and water, two hogs (no.34 & 36) were rested two hours and given only water, two hogs (No.38 & 40)

rested sixteen hours and given feed and water. Figures 5,6,7, and 8 graphically illustrate the pH of these hogs under these four conditions. The pH curve of Hog No. 36 which was given two hours rest and water only is shown in Fig.5. There was a very slight increase in the pH of the Psoas major muscle. The increase was less than 0.1 units, therefore the significance of this increase is not certain, however, there was very little, if any change. This may be due to the absence of glycogen in the muscle at time of slaughter. This is in accordance with Callow (4 & 5).

Figure 6 illustrates hog number 35, which was given two hours rest with feed and water. There was a slight decrease here which may have been due to the increased glycogen in the blood from the feed. After slaughter, this glycogen could have formed lactic acid to lower the pH.

The pH of hog number 39, which was given sixteen hours rest with water only is represented in Fig.7.

Figure 8 illustrates the pH of hog number 39, given sixteen hours rest, feed and water. In both hogs (numbers 39 & 41) given feed and water with a sixteen hour rest period there was a greater increase in the pH soon after slaughter than in the hogs (numbers 38 & 40) given only water during the sixteen hour rest period.

In all four of the hogs given sixteen hours rest there appeared an increase in the pH soon after salughter. This increase was not found in the animals given a two hour rest period. In general it was noted that the pH of the Psoas major had a tendency to have

a higher ultimate pH than the pH from the hams made by the direct insertion of the electrodes.

A summary of all pH determinations on a portion of the ham removed from the carcass is contained in Table 4. Figure 9,10, 11, and 12 illustrate four pH curves obtained by this method. There appeared to be very little, if any difference in the pH of the ham by removing it from the carcass.

Because of this finding, future work can possibly be based on inserting the electrodes directly into the carcass. This would facilitate large scale pH determinations with no resulting economic loss due to damaging of the meat.

The summary of the pH determination of the loin roasts which were frozen on a -10^{0} F. plate freezer and then thawed for twenty-four hours in a 34^{0} to 36^{0} F. cooler is contained on Table 5. The loin was removed at the third rib and at the hip bone. It was cut into three roasts of equal length. Each pH determination was made by removing a chop or slice approximately three-fourths of an inch thick from the posterior end of the roast. The roast was then frozen and thawed and the process was repeated. Figures 13, 14, and 15 represent pH curves from one of the loins.

The observations noted were the difference in pH between the roasts. In almost all cases the blade end roast had a higher pH than either the center or loin end roasts. The loin end roast appeared to have the lowest pH in most cases. It appears likely that the pH of a pork loin decreases from blade end to loin end.

Table 6 contains the summary of pH determinations on pork

sausage packaged by three methods. The pH determinations are illustrated in Figs. 16, 17, and 18. Figure 16 represents the two pound package wrapped in cellophane with a "Tite" protective covering. Figure 17 graphically illustrates the two pound package wrapped in "Tite." Figure 18 illustrates the twelve inch by twelve inch by two inch package wrapped in "Tite." Because of the small number of packages, the author feels there can be no comments made concerning the effects of different wraps and methods of packaging on the pH of the sausage.

Table 2. Summary of pH readings on hams. Hogs number 1 to 46.

Hog Number:	Hours after slaughter																	
	1	2½	4	6	8	19	24	28	30	44	48	50	56	68	75	95	116	
1			6.16	5.96	5.75	5.65												
2			6.55	6.02	5.78	5.72	5.60											
3	6.2	5.6				5.75		5.90										
4	6.1	5.8		5.7		5.77		5.65										
5	5.8	5.8		5.9		6.1		6.1			6.2							
6		5.85				5.80												
7			5.55															
8			5.95			6.15												
9		5.25		5.50	5.52						5.6					5.6		
10	5.32			5.55	5.80						5.8					6.15		
11			5.60				5.77								5.92			
12							5.78								5.90			
13					5.88				5.81				6.32	6.00				
14					5.33				5.75				6.02	5.79				
15					5.65				5.73				5.80	5.82				
16					5.49				5.72				6.05	5.80	5.88	5.98		
17			5.05	5.18	5.70		5.88			5.69		5.79		5.63			5.57	
18			5.02	5.88	5.63		5.82			5.70		5.86		5.34			5.50	
19	5.28			5.88	5.85		6.02			5.89		6.02		5.86			5.65	
20	5.17			5.55	5.70		5.90			5.79		5.82		5.55			5.48	
21	5.28			5.63	5.64		5.80			5.70		5.78		5.43			5.48	
22					5.88					5.85							6.00	

Table 2. (Concl.)

Hog Number	Hours after slaughter								
	1	6	8	12	24	28	30	34	39	48
23		5.75		5.70		5.82			5.50	5.68
24		5.72		5.72		5.59			5.57	5.43
25		5.85		5.75		5.68			5.61	5.48
26		5.62		5.65		5.65			5.45	5.52
27		5.77		5.70		5.70			5.43	5.70
28		5.57		6.05		6.09		6.17	6.22	6.22
29		5.49		5.75		5.89		6.02	5.93	5.90
30		5.72		6.03		6.10		6.18	6.13	6.08
31		5.50		5.88		5.78		5.97	6.00	5.82
32		5.78		6.08		5.95		6.03	6.11	6.10
33		5.78		6.05		5.85		5.97	5.90	5.90
34					4.95					
35					5.50					
36					5.48					
37					4.78					
38			5.79							
39			5.53							
40			5.61							
41			5.18							
42		5.9		5.8			4.9			
43		5.6		5.7			5.0			
44		5.7		5.4			5.0			
45		5.75		5.5			5.0			
46		5.3		5.7			5.3			

Table 3. Summary of pH readings on Psoas major. Hogs number 23 to 41

Hog number :	Hours after slaughter								
	: 1	2½	6	8	12	28	33	39	48
23	5.57		5.92		5.98	5.80		5.78	
24		5.62	5.75		5.68	5.85		5.60	
25		5.67	5.73		6.10	5.80		5.65	
26		5.65	5.70		5.85	5.78		5.65	
27		5.60	5.75		5.76	5.80		5.65	
28	5.80			5.90	5.80	5.89	5.71	5.77	5.85
29	5.60			5.72	5.65	5.72	5.70	5.68	5.70
30	5.79			5.95	5.85	5.85	5.90	5.85	5.90
31	6.12		5.87		5.82	5.80	5.85	5.75	5.89
32	6.05		6.32		6.05	6.05	6.20	6.25	6.11
33	5.82		5.95		.5.80	5.83	5.85	5.85	5.95
34	5.78					6.07			6.02
35	5.85					5.62			5.60
36	5.62					5.70			5.75
37	5.59					5.62			5.57
38		5.73		5.80			5.68		
39		5.00		5.62			5.52		
40		5.62		5.81			5.68		
41		5.19		5.79			5.73		

Table 4. Summary of pH readings of portion removed from ham. Hogs number 23 to 33.

Slice of ham	Hours after slaughter					
	5½	14	29	34	39	48
23	5.95	5.49	5.78		5.55	
24	5.90	5.83	5.85		5.65	
25	5.58	5.75	5.70		5.60	
26	5.92	5.95	5.68		5.57	
27	5.50	5.55	5.49		5.42	
28		5.92	6.01	6.00	6.00	6.05
29		5.65	5.83	5.82	5.87	5.88
30		5.90	5.98	6.00	6.00	6.05
31		5.78	5.72	5.62	5.68	5.68
32		5.85	5.98	5.93	6.00	6.05
33			5.70	5.82	5.78	5.80

Table 5. Summary of pH readings on loins.

	Initial Reading	Number of times frozen and thawed 1	2	3	4	5	6
Hog 16 Rt. loin							
Loin end	5.7	5.95	5.65	5.50	5.75		
Center	5.45	6.15	6.47	5.60	5.70		
Blade end	5.9	6.0	5.9	5.79	5.68		
Hog 41 Rt. loin							
Loin end		5.60	5.59	5.60	5.55		
Center		5.70	5.60	5.68	5.48	5.60	5.95
Blade end		5.70	5.78		5.71	6.10	
Hog 41 Lt.loin							
Loin end		5.90	5.77	5.60	5.62	5.73	5.72
Center		5.70	5.65	5.58	5.60	5.75	5.68
Blade end		5.85	5.70	5.85	5.71	6.00	5.85
Hog 55 Lt.loin							
Loin end	5.68	5.55	5.68	5.48	5.65	5.55	5.69
Center	5.58	5.50	5.68	5.62	5.63	5.48	5.81
Blade end	5.59	5.49	5.73	5.69	5.67	5.51	5.81
Hog 55 Lt.loin							
Loin end	5.61	5.63	5.65	5.72	5.65	5.39	5.78
Center	5.67	5.62	5.65	5.82	5.77	5.50	5.69
Blade end	5.58	5.68	5.72	5.85	5.75	5.50	5.79
Hog 58 Rt.loin							
Loin end	5.65	5.40	5.61	5.40	5.41	5.48	5.35
Center	5.58	5.35	5.53	5.35	5.43	5.65	5.35
Blade end	5.58	5.48	5.70	5.41	5.72	5.70	
Hog 58 Lt.loin							
Loin end	5.70	5.63	5.45	5.20	5.45	5.53	
Center	5.62	5.55	5.57	5.47	5.59	5.68	5.67
Blade end	5.65	5.75	5.70	5.42	5.63	5.76	

Table 6. Summary of pH readings on sausage.

Package :	Number of times frozen and thawed					
:	1	2	3	4	5	6
A	6.2	6.35	6.45	6.52	6.28	6.23
B	5.7	6.3	6.41	6.25	6.21	6.20
C	6.10	6.25	6.40	6.39	6.24	6.18

The pH determinations of hams made by direct insertion of electrodes

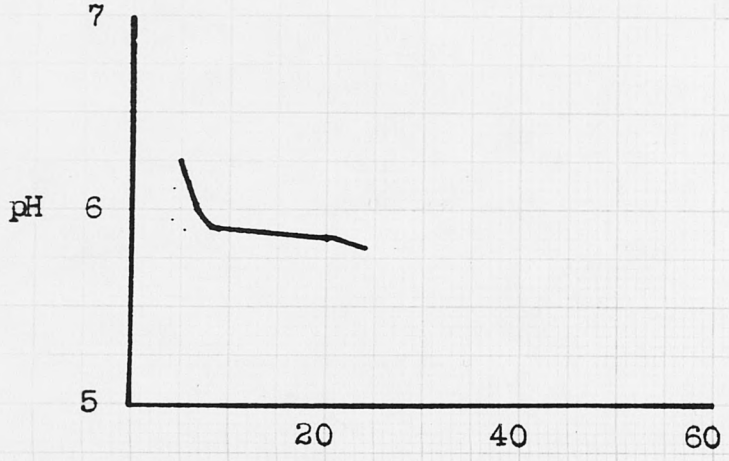

Fig.1. Hours after slaughter

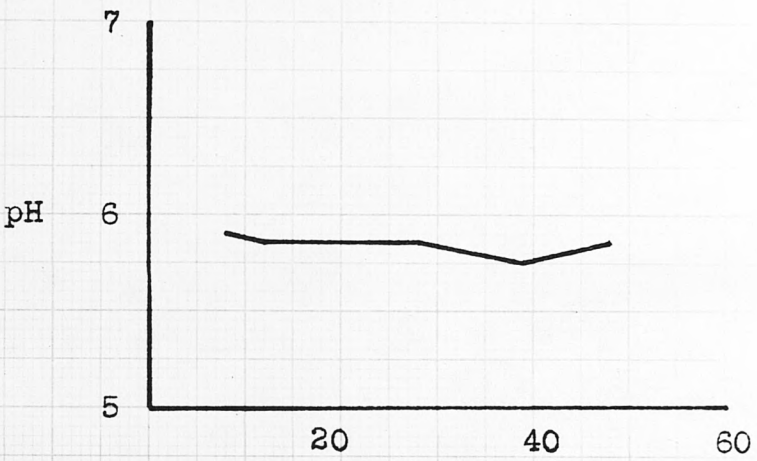

Fig.2. Hours after slaughter

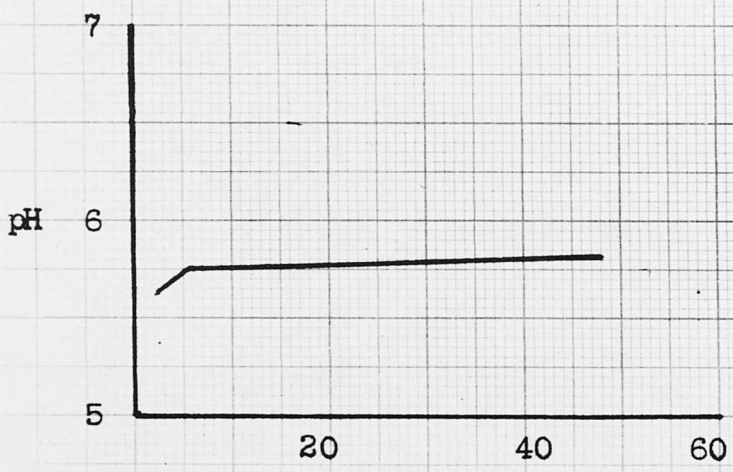

Fig.3. Hours after slaughter

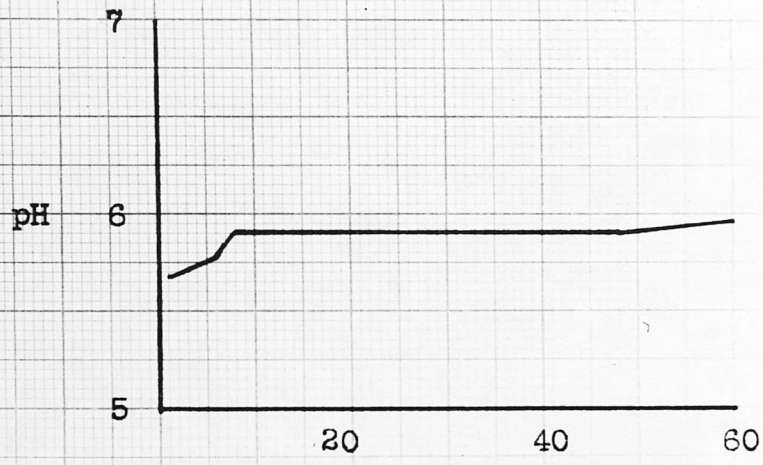

Fig.4. Hours after slaughter

The pH determinations of the Psoas major

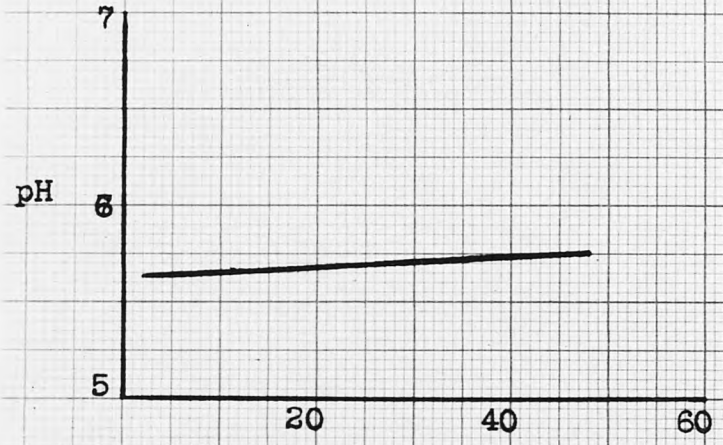

Fig.5. Hours after slaughter

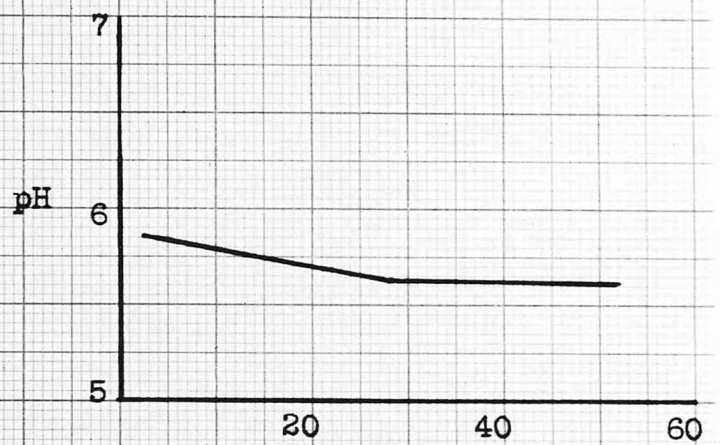

Fig.6. Hours after slaughter

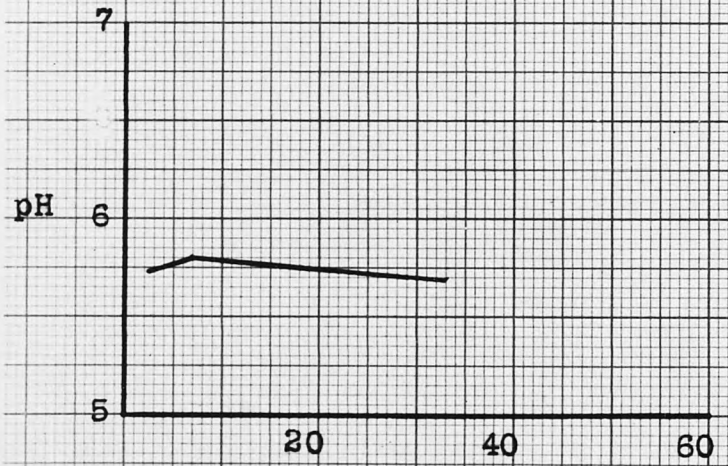

Fig.7. Hours after slaughter

Fig.8. Hours after slaughter

The pH determinations of the slice off the ham

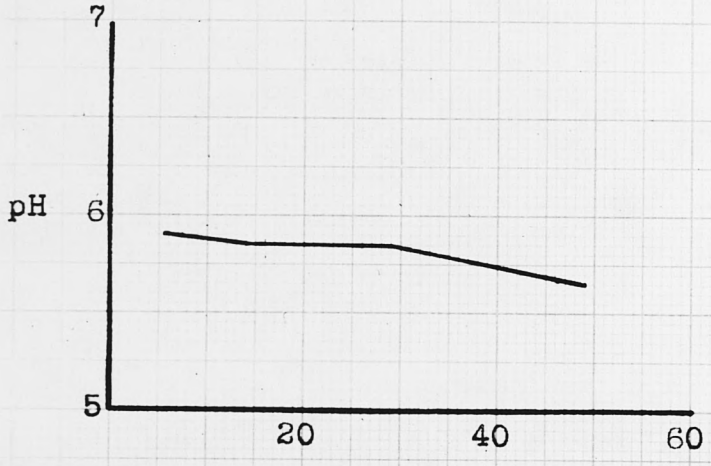

Fig.9. Hours after slaughter

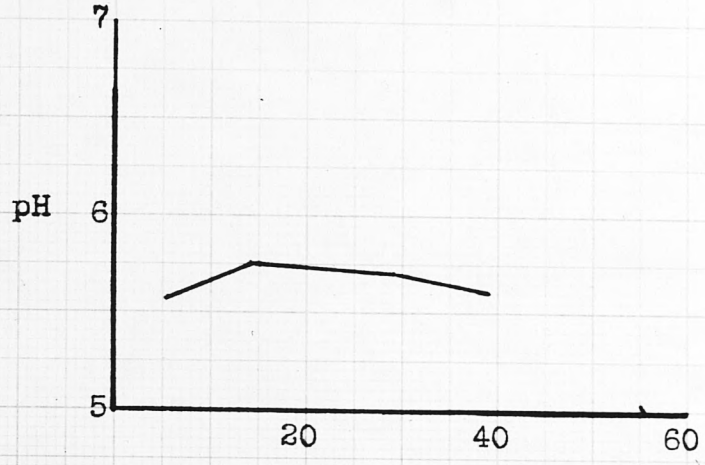

Fig.10. Hours after slaughter

Fig.11. Hours after slaughter

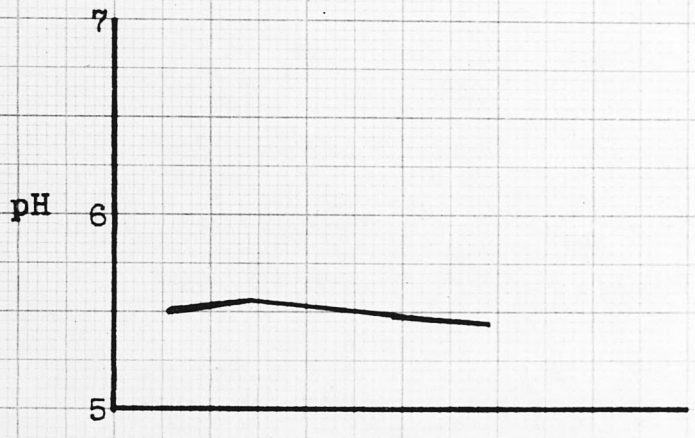

Fig.12. Hours after slaughter

pH determinations of loins during repeated freezing and thawing

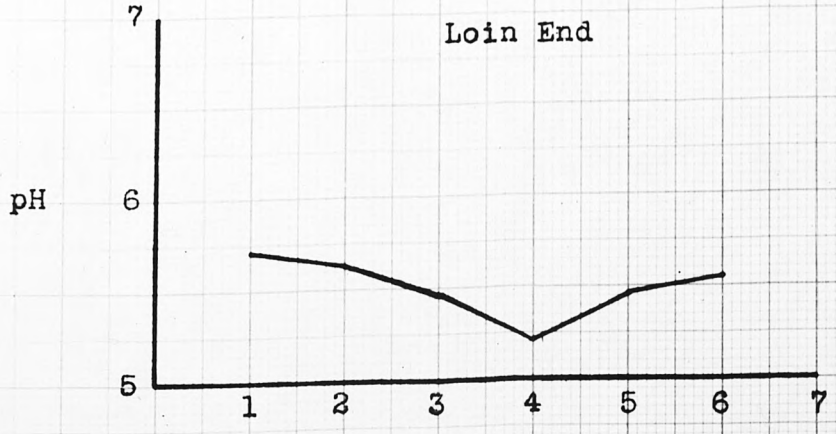

Fig.13. Number of times frozen and thawed

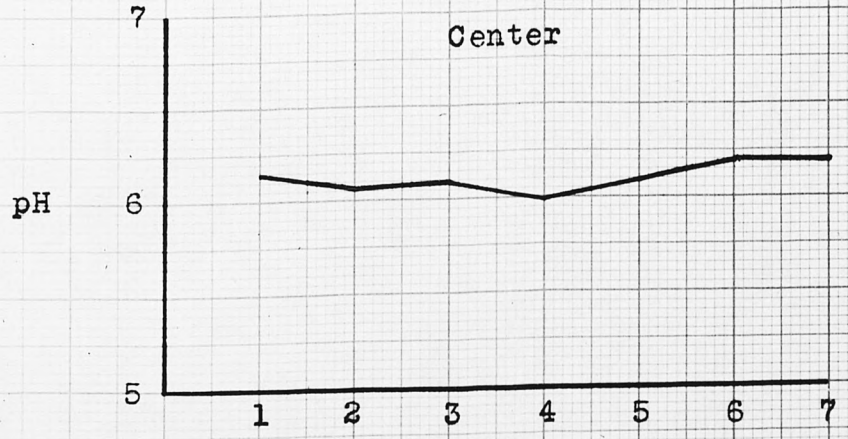

Fig.14. Number of times frozen and thawed

Fig.15. Number of times frozen and thawed

pH determinations of sausage during repeated freezing and thawing

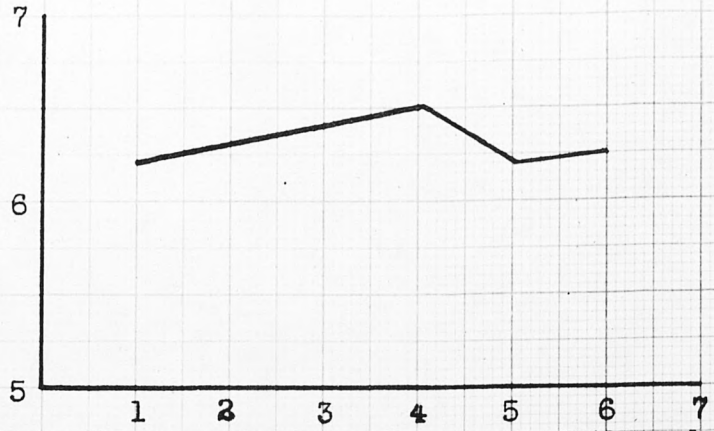

Fig.16. Number of times frozen and thawed

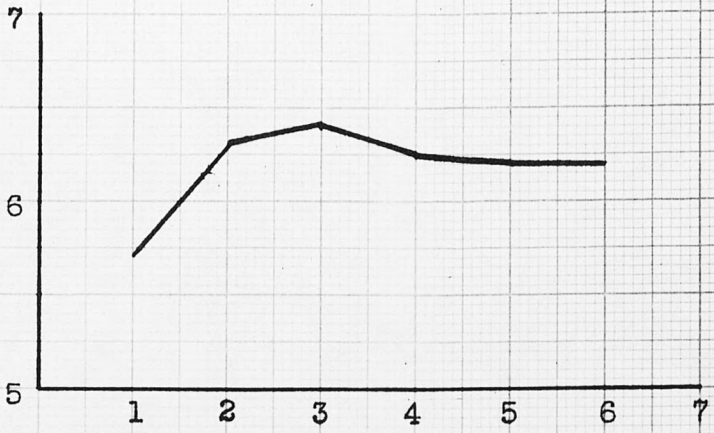

Fig.17. Number of times frozen and thawed

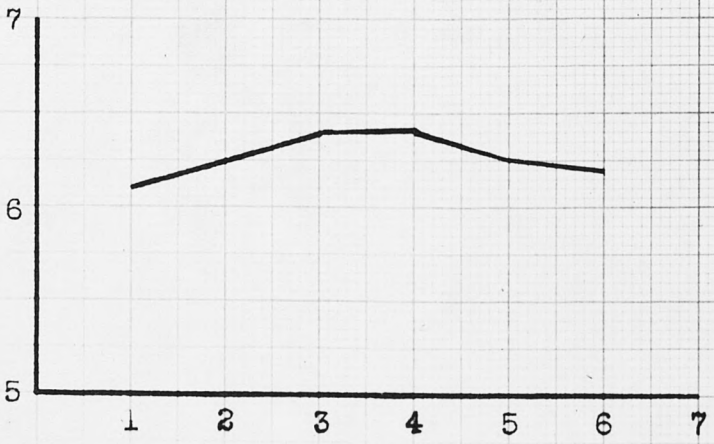

Fig. 18. Number of times frozen and thawed

SUMMARY

1. Determination of pH by inserting a glass electrode in conjunction with a calomel reference electrode gave an accurate pH of the tissue.

2. There appears to be a rise in the pH of fresh pork following slaughter and terminating at approximately six hours after slaughter. There also appears to be a rise in pH at approximately forty-eight hours after slaughter.

3. The pH of hams determined by inserting the electrodes directly into the ham, and the pH of a portion of the hams removed from the carcass gave approximately the same value.

4. Hogs rested two hours and given only water appear to have very little change in the pH from the sixth hour to the forty-eighth hour after slaughter.

5. Hogs rested two hours and given feed and water appear to have a greater variation in pH from the sixth to the forty-eighth hour following slaughter than the hogs given rest for two hours and only water.

6. Hogs given sixteen hours rest with only water had a smaller rise in pH soon after slaughter than the hogs given feed and water.

7. The ultimate pH of the Psoas major appeared to have a higher pH value than the ham.

8. The repeated freezing and thawing of fresh pork appeared to have little, if any effect on the pH value.

9. The blade end of the pork loin appeared to have a higher pH value than either the center or loin end.

10. The loin end of the pork loin appeared to have a lower value than either the center or blade end.

11. The pH value appeared to decrease from the blade end to the loin end.

It was intended in this study to obtain information on the pH of fresh pork, and the study was undertaken to gain data on a subject which has received little attention. The information obtained here, along with the past data, might enable future developments concerning the handling of fresh pork and the treatment of animals before slaughter to be made.

ACKNOWLEDGMENT

The author wishes to express his sincere thanks and indebtedness to Mr. D. L. Mackintosh, Professor of Animal Husbandry, for his valuable supervision and assistance in planning this study, and for his suggestions and helpful criticisms on this manuscript.

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SOME OBSERVATIONS ON THE pH OF PORK UNDER VARIOUS CONDITIONS

by

JOHN FRANCIS MC CARTHY

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SOME OBSERVATIONS ON THE pH OF PORK UNDER VARIOUS CONDITIONS

This study was undertaken to secure additional information on the pH of fresh pork under various conditions.

The role which the pH (the negative common logarithm of the hydrogen ion activity) of meat plays affords a useful plane to which the complicated events which take place in the carcass can be related, and upon which they can be oriented.

In planning this study it was decided to make pH readings on all animals slaughtered in the Meats Laboratory at Kansas State College during the school year 1950-1951.

The experimental part of this study was divided into five major parts. First, the determinations of the pH of hams by inserting the electrodes directly into the hams while on the carcass. The next part was determining this pH value of a portion of the ham removed from the carcass. This second part was performed to establish the accuracy of pH reading made by inserting the electrodes directly into the carcass. Third, the Psoas major was removed from the carcass immediately following slaughter and pH determinations were made for forty-eight hours. Eight of these sets of readings were from hogs which were shipped thirty-six miles and four of these hogs were given two hours rest and four hogs were given sixteen hours rest. These two groups were divided into two lots, two hogs were given feed and water and two were given water only. The effect of rest on the pH of the Psoas major was studied after slaughter.

The last two parts deal with the effect of repeated freezing and thawing on the pH of the Longissimus dorsi and on pork sausage. Boned pork loins were divided into three roasts of approximately equal length. They were packaged according to approved methods and frozen in a plate freezer at -10° F., and then were thawed twenty-four hours in a 34° to 36° F. cooler after which the pH was determined. This process was repeated until the complete loin was used.

The equipment consisted essentially of a Beckman Model H-2 glass electrode pH meter with a saturated potassium chloride calomel reference electrode. Both electrodes were specially constructed for pH determinations on material of a semi-solid nature.

The data obtained indicates that accurate pH values can be determined by inserting the electrodes directly into the tissue. The pH value of the Psoas major appears to have a higher pH value than the hams. In the hogs rested sixteen hours before slaughter, there was a larger variation in the pH than in the hogs rested two hours and the hogs given feed appeared to have a larger variation in pH than those given water only.

In this study the repeated freezing and thawing on the loins appeared to have little, if any, effect on the pH. However, there appeared to be a difference in the pH value from different locations on the loin.