Results and Discussion

The results of this trial are shown in Table 2. The pigs receiving the ground or pelleted diets were fed an average of 96.3 and 90.8 days, respectively. The average daily gains and feed efficiencies of the pigs fed the pelleted diets were significantly superior to those of pigs fed the ground diets. Pigs fed pelleted diets also tended to have a lower average daily feed intake. No significant differences in performance were found due to the grain within the ground or pelleted diets. Treatments also had little apparent effect on probed backfat thickness.

Table 2. Effect of Pelleting on Performance of Growing-Finishing Swine.

	Ration Designation					
	Milo		Wheat		50% Milo-50% Wheat	
Item	Gr. 1	Pel. 2	Gr. 1	Pel. 2	Gr. 1	Pel. 2
Pens per treatment, no.	3	3	3	3	3	3
Pigs per pen, no.	18	18	18	18	18	18
Av. initial weight, lb.	53.5	52.3	53.1	52.8	52.0	53.7
Av. final weight, lb.	210.0	211.1	209.9	211.2	207.3	215.3
Av. daily gain, lb.*	1.64[1]	1.77[2]	1.61[1]	1.74[2]	1.67[1]	1.75[2]
Av. daily feed intake, lb.**	5.73[3]	5.60[2,3]	5.42[1,2]	5.29[1]	5.66[2,3]	5.34[1]
Feed per lb. of gain, lb.*	3.51[2]	3.17[1]	3.42[2]	3.07[1]	3.50[2]	3.12[1]
Av. adjusted backfat, in.	1.48	1.49	.148	1.49	1.50	1.51

* Any two means without a common superscript differ significantly ($P<.01$).
** Any two means without a common superscript differ significantly ($P<.05$).

Myodegeneration Syndrome In Swine

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Story In Brief

In recent years there has been noted an increased death rate of swine as a result of medical treatment, weighing, lot movement, exercise, and hauling. This increase in death rate has been attributed to a muscle abnormality known as Myodegeneration Syndrome. The purpose of this

research is to facilitate the separation of normal from Myodegeneration Syndrome susceptible animals by means of a rapid detection method utilizing measurements of serum Creatine Phosphokinase (CPK) level in the blood.

In the first study 40 Yorkshire pigs were used, twenty castrated males and 20 females. CPK determinations were made when the pigs were 3 months of age. The animals were then exercised on a treadmill and the CPK determination was repeated. After reaching 5 months of age, 6 pigs which had excessive elevations of CPK were slaughtered along with 6 animals which were considered to be normal. In order to determine the effectiveness of the method, detailed histological, gross, histochemical, chemical, and physical analyses were run on samples taken from the major loin muscle, the longissimus dorsi. Animals with the highest levels of CPK typically exhibited low initial pH in the range of 5.35 to 5.99 in the muscle tissue, very low scoring with regard to quality points such as color, marbling, and firmness, greater than normal fiber diameter, moisture, and shear values. Muscle temperature markedly increased reaching an average of 106.5°F. The lean cut yield was much higher in susceptible animals as compared to those animals classified as normal.

Introduction

Myodegeneration Syndrome has become a major problem in today's meat industry. The difficulty is to some degree the fault of the consumer who is pressuring the industry for not only more but a higher quality of meat both in the raw and cooked form. The food industry must realize that the shopper of today has become quite an educated buyer and it must strive to meet his demands. Realizing the scope of the problem, the swine producer has managed to provide animals with not only more but a higher quality meat through selective breeding, enriched feeds, or by a combination of the two. As a general rule, his efforts have succeeded, but exceptions may be drawn to any rule. Such is the case with Myodegenerations Syndrome.

It appears the meatier the animals, the more susceptible they are to the disease and the lower their quality. Animals which are Myodegeneration Syndrome susceptible are characterized by gasping, open mouth breathing, elevated body temperature, tensed back muscles, and show evidence of stiffness. Immediately after slaughter, the pigs exhibit severe rigor mortis and the muscles of the carcass are typically light in color, lacking firmness, and exude water. Such conditions in the live animal may ultimately result in death before slaughter or cause the carcass to be of such a poor quality as to be unacceptable to the consumer both in the raw and cooked form. If the pork industry expects to meet current de-

mand for high quality it becomes apparent that there is a great need for a method of rapid detection of animals which are susceptible to the Myodegeneration Syndrome.

Because the enzyme Creatine Phosphokinase (CPK) is found primarily in muscle tissue it was chosen as the best means of diagnosis. CPK was introduced as a diagnostic aid by Ebashi et al., and Dryfus et al., 1959 and 1960. Since the time of the introduction of CPK as a detection methods, it has received much attention in Europe, whereas few reports have been noted in the United States literature. Most work has been reported on muscular disorders in the human.

The enzyme Creatine Phosphokinase catalyzes the reversible reaction:

$$\text{Creatine} + \text{ATP} \xleftrightarrow[\text{Mg}++]{\text{CPK}} \text{ADP} + \text{Phosphocreatine}$$

Hence one can see that this reaction is a valuable source of energy, furnishingATP, particularly in muscle which has been forced to metabolize anerabically (absence of oxygen).

Several methods are available for the determination of serum CPK activity. The method used in this study is based on the technique of Tanzer and Gilvarg (1959). With this method, the primary reaction is coupled to two subsequent reactions:

$$\text{ATP} + \text{Creatine} \xleftrightarrow[\text{Mg}++]{\text{CPK}} \text{ADP} + \text{Creatine Phosphate}$$

$$\text{ADP} + \text{Phosphoenolpyrvate} \xleftrightarrow{\text{PK}} \text{Pyrvate} + \text{ATP}$$

$$\text{Pyrvate} + \text{DPNH} \xleftrightarrow{\text{LDH}} \text{Lactate} + \text{DPN}$$

Conversion of DPNH to DPN results in a decreased absorbance of the solution when measured at a wavelength of 340 mu. The amount of enzymatic activity is proportional to- the rate- of- oxidation- of- DPNH ——————→ DPN in the unknown measured against a blank. Under test conditions, one international unit of CPK activity will result in the oxidation of 1 micromole of DPNH/min/ml of the serum at pH 9 and 25°C. Normal ranges of CPK activity in other muscular disorders were found to be between 0 and 8 x 10^{-4} international units. Levels above 17 x 10^{-4} are considered to be abnormal (Hess et al., 1964). Studies by Vester et al., 1968 and Henson et al., 1966, showed that an elevation of CPK appears to exist for most diseases of skeletal muscle. Hopefully the use of CPK level of the blood will afford a rapid and accurate detection of diseased animals.

Procedure

In order to evaluate the efficiency of the blood CPK technique a detailed study of the muscle tissue was undertaken:

A. Evaluation of the carcass:
   1. Determinations of the amount of total muscling were made.

B. Evaluation of the Longissimus dorsi:
   1. The L. dorsi muscle was scored as to quality such as color, firmness, and marbling.
   2. Histological aspects were determined such as fiber diameter, degree rigor, sarcolemma thickness, nuclei number, length, and width, and the overall condition of the fibers.
   3. Histochemical examination utilizing NADH-TR (Nicotinamide Adenine Dinucleotide-Tetrazolium Reductase) in a technique described by Engel et al., 1965.
   4. Chemical determination of pH, moisture, and lipid.
   5. Physical evaluation utilizing shear force as a parameter for tenderness.

Results

In order to understand some of the causes of the Myodegeneration Syndrome it is essential that one have a working knowledge of muscle anatomy. Muscle is a highly complex tissue when viewed with the aid of the light microscope. It may be seen that the muscle is actually composed of bundles of fibers of varying degree of roundness. Within any given muscle there are essentially three basic types of fibers, red, white, and intermediate, which have their own physiological activities. The white fiber is described as being fast-contracting and metabolizes stored glycogen anaerobically yielding lactic acid as a waste product. Then there is the slow-contracting red fiber which metabolizes aerobically and possesses a Kreb's cycle and cytochrome system.

The last type of fiber is described as being intermediate in nature and is able to metabolize both anerobically and aerobically. Fibers posessing the Krebs and cytochrome system are able to synthesize 30 ATP molecules per glucose while those metabolizing via glycolysis yield only 2 ATPs per glucose molecule. Cooper et al., 1969, noted that the white fiber area expressed as a percent of total fiber area was 70-75 percent while the remaining 25-30 percent was composed of red and intermediate fibers in normal porcine muscle. It was also observed that one of the differences in normal and abnormal muscle was the distribution of certain fiber types. The fiber type affects post-mortem metabolism and this variable rate of post-mortem metabolism has important implications in the

ultimate usefulness of muscle as a food. In abnormal porcine muscle various scientists have noted that there is a much higher distribution of white and especially intermediate fibers.

It is also postulated that animals have the Myodegeneration Syndrome have lower capillary distributions and therefore lower myoglobin contents and that this effectively reduces the oxygen supply and storage in the muscle tissue. In an environment such as this muscles undergo a more rapid and severe oxygen debt. Due to the abnormal ratio to white and intermediate fibers, the muscle accumulate lactic acid in higher concentrations than normal, causing a rapid fall in pH during stress situations and post-mortem.

Rapid pH decline would be almost fatal to the delicate sarcoplasmic and myofibular proteins. The lack of oxygen also causes a "shut-down" of the cytochrome system so that the main source of energy to the muscle is lost. The muscles are forced to synthesize ATP, the energy source for contraction, via creatine phosphate. Once this reserve is drained no more ATP is available to facilitate relaxation, thus bringing about sudden rigor mortis noticed in several of the animals upon slaughter. In general this abnormal metabolism has a very detrimental effect on the muscle and hence meat quality.

As noted in Table 1, the level of CPK in the blood depended upon the individual animal and the degree of stress received prior to blood sample removal. As would be expected, the level of CPK increased following exercise, however some animals seem able to adapt readily to stress.

Table 2 shows the effect of Myodegeneration Syndrome on the carcass tissues. Animals with high lean cut yield were directly related to in-

Table 1. Creatine Phosphokinase Level of Porcine Blood Before and After Exercise.

Hog No.	Mild Exercise[1]		Severe Exercise[2]	
	CPK-1	CPK-2	CPK-3	CPK-4
11-3	230	550	53	—
14-8	45	73	32	79
15-4	48	65	9	51
15-6	71	240	72	76
15-7	130	270	33	102
16-7	112	345	730	520
17-1	112	93	74	1310
17-8	28	230	116	485
17-10	122	469	150	1075
18-9	60	49	88	95
20-8	71	62	24	40
20-10	50	35	10	38

[1] Mild exercise involved driving the pigs around the pen for 20 minutes.
[2] Severe exercise involved stress from exercise on the tread mill and ambient heat (80-85°F).

Table 2. The Effect of Myodegeneration Syndrome on the Porcine Carcass

Animal Number	Live Wt.	Chilled Side Wt.	Carcass Lean Cut Yield %	Live Lean Cut Yield %	Carcass Length (Inch)	Fat Thickness (Inch)	Muscle Temperature Deg. F.
11-3	Died	–	–	–	–	–	–
15-4	228	81.5	61.10	43.68	31.70	1.40	106.4
16-7	235	82.7	69.22	42.38	30.30	1.47	106.4
17-10	226	82.3	57.84	42.12	29.20	1.50	106.9
17-1	215	79.2	59.47	43.81	30.10	1.37	106.0
Normal							
14-8	222	79.6	56.91	40.81	31.00	1.27	–
15-6	232	81.7	53.98	38.02	30.70	1.43	–
15-7	226	78.2	55.80	38.67	31.00	1.57	105.5
17-8	242	84.0	56.55	39.26	30.80	1.60	106.0
18-9	220	75.5	55.1	37.82	31.60	1.47	105.0
20-8	231	78.7	56.42	38.44	31.30	1.40	104.0
20-10	222	78.9	57.54	40.90	31.00	1.23	–

creased levels of CPK and low quality pork. As may be noted, animals with the higher CPK value also possessed elevated temperatures.

Comprehension of the detrimental effect the disease has on muscle is enhanced by Table 3. Associated with the myodegeneration syndrome is a loss of meat quality. Various muscles of the carcass have a pale color, and lack firmness. Due to the anerobic type of metabolism, there is little fat synthesis, hence little intramuscular fat deposition in the form of marbling. The high ratios of white and intermediate fibers caused the tissue to be more acidic due to large amounts of lactic acid which accelerated the rate of pH decline. Most abnormal animals are characterized by a muscle pH of 5.5 or below, 30 minutes post-mortem. Those muscles that have greater amounts of red fibers have a pH of 6.0 or higher at, 60 minutes post-mortem.

A detailed analysis of the major loin muscle (longissimus dorsi) further substantiated practical measures for leanness. In general loin eye area and muscle weight were greater in these animals termed abnormal. Table 4. Fiber diameter was not found to be associated with meatiness, but may be associated with muscle degeneration. Degree of fiber rigor and animal stiffness may well be associated. It is interesting to note that the percent of fat as determined by ether extract was, on the average, lower in the abnormal animals.

Examination of cross-sections of the longissimus dorsi stained with NADH-TR yielded three very interesting facts. There is an extreme difference between the size of normal and abnormal muscle fibers. These animals which are Myodengeneration Syndrome susceptible posessed a higher amount of white and intermediate fibers. In normal muscles the red fibers were concentrated in the center of the fasciculus with the intermediate fibers surrounding them, the white fibers being on the exterior. In abnormal muscles there seemed to be a lack of organization of the fiber types as they were scattered throughout the fasciculus in a haphazard arrangement. Also there was noted in the high serum CPK pigs a "giant fiber" which has also recently been described by Cassens (et al., 1969). This fiber measured some 150 microns in diameter and was found to be in every one of the abnormal animals examined. Consequently, the histochemical analysis may prove to be a very useful parometer.

Summary

Preliminary investigations using 12 pigs showed that there may be a relationship between abnormally high serum CPK levels in the blood and susceptibility to the Myodengeneration Syndrome. The technique will be used to eliminate those animals which have already developed the disease and those which are susceptible to it.

Table 3. The Effect of Myodegeneration Syndrome on Porcine Meat Quality

Animal Number	Color Score	Firmness Score	Marbling Score	Shear Value lb.	Moisture Value %	Fat %	Initial pH	Final pH
11-3	–	–	–	–	76.31	0.20	–	–
15-4	pale (2)	soft (2)	scant (2)	17.5	74.77	0.13	5.99	5.20
16-7	ext pale (1)	very soft (1)	devoid (1)	16.4	74.39	0.19	5.35	5.21
16-7	pale (2)	soft (2)	scant (2)	23.4	75.69	0.26	5.50	5.38
17-1	sli pale (3)	sli firm (5)	scant (2)	21.4	75.68	0.62	6.60	5.64
Normal								
14-8	mod pink (4)	sli firm (5)	scant (2)	–	72.75	0.20	6.52	5.62
15-6	mod pink (4)	sli firm (5)	scant (2)	–	72.75	0.13	6.42	5.60
15-7	mod pink (4)	firm (6)	mod(5)	15.4	74.82	0.18	6.56	5.59
17-8	mod pink (4)	avg (4)	sli (3)	14.8	73.27	0.19	6.10	5.25
18-9	sli pink (3)	firm (6)	mod (4)	20.5	73.00	0.42	6.74	5.25
20-8	mod pink (4)	sli firm (5)	sli (3)	15.5	73.76	0.21	6.65	5.25
20-10	sli pink (3)	avg (4)	sli (3)	–	73.70	0.28	6.65	5.55

Table 4. The Effect of Myodegeneration Syndrome on the Porcine Longissimus Dorsi Muscle

Animal Number	LD Area (Sq. In.)	LD Weight lb.	Fiber Diameter μ	Degree Rigor %	Nuclei Length μ	Nuclei Width μ
11-3	–	–	–	–	9.57	4.96
15-4	5.50	5.20	79.80	1.69	11.69	4.35
16-7	6.15	5.20	58.80	1.36	13.32	2.95
17-10	5.51	4.80	68.70	3.84	12.12	3.26
17-1	6.45	5.40	88.20	3.62	15.88	2.87
Normal						
14-8	4.18	4.60	70.98	1.86	12.53	3.01
15-6	4.38	4.60	73.80	2.10	11.19	2.76
15-7	4.64	4.60	63.60	1.60	15.02	2.94
17-8	5.57	5.20	74.30	2.26	11.09	3.43
18-9	4.04	3.80	77.20	2.52	10.37	4.06
20-8	4.69	4.20	75.00	1.80	17.29	2.73
20-10	4.92	4.60	68.40	2.04	13.93	2.68

Muscle tissue from animals with the syndrome is very soft, high in moisture, and light in color. Animals possessing the syndrome are quite meaty but lack sufficient deposits of intramuscular fat. Abnormal muscle also exhibited very low pH at 1 hour post-mortem.

Although not enough data is yet available to substantiate many of these statements, one fact is obvious: Myodegeneration Syndrome has a very undesirable effect on the quality of pork and its eventual usefulness as a food.

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High Moisture Milo For Swine

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Story In Brief

Two trials were conducted to evaluate the relative merit of ground, reconstituted-rolled and dry rolled milo-soybean diets for growing-finishing swine.

In trial number 1, no significant differences in rate of gain or feed utilization were obtained among pigs fed the three milo treatments. However, pigs fed the ground milo diet tended to require less feed per pound of gain than pigs fed the reconstituted-rolled or dry rolled milo diets.

In trial two, pigs fed the reconstituted diet required significantly less feed per pound of gain and consumed significantly less feed per day than pigs fed the ground or dry rolled milo diets. No significant differences in average daily gain were noted among pigs fed the three diets, but pigs fed the ground milo diet tended to gain faster than pigs fed the reconstituted-rolled or dry rolled milo diets.

Introduction

Methods of processing are continuously being studied in an attempt to improve the feeding value of ceral grains and performance of swine. Recently, high moisture reconstitution has been compared with dry pro-