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The Incidence of Dark Cutting Beef

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ABSTRACT

One aspect of beef quality which is of considerable interest to the beef processor is that of dark-cutting beef. The study of this subject has attracted many investigators during the past 25 years. There is one aspect of the problem, however, about which little is known, and that is the actual incidence of dark-cutting beef. Accordingly, over the past five years, we have checked for dark cutting in some 14,000 head of cattle. These samplings were done mainly at Canada Packers packinghouse in Toronto, but some were also checked in Edmonton.

The average incidence of dark cutting in steers was found to be approximately 8%. The incidence in heifers was of the same order of magnitude. However, the incidence in cows was considerably higher.

The seasonal and grade effects noted agreed well with those found by previous investigators.

INTRODUCTION

Good colour in meat, while it may not affect its nutritive value, is generally recognized and demanded by the consumer. The consumer associates dark-coloured beef with old animals or spoilage. With the continuing growth of the self-service meat counters, this problem is further aggravated. The economic significance of colour in beef is, therefore, obvious. It is for this reason that the study of dark-cutting beef has attracted the attention of many investigators.

Much has been written about the nature and cause of dark-cutting beef. However, the more recent work by Hedrick (1) has probably contributed the most towards a good understanding of this subject. Dark-cutting beef arises when glycogen supplies are abnormally low in the muscle tissue prior to slaughter. Since glycogen is converted into lactic acid after death, the consequent result is that the tissues are lower in acidity or higher in pH than normal meat. Since the permeability of the tissue to oxygen is reduced at higher pH's (5), and also due to the fact that oxygen utilization by the surviving enzyme systems is much greater at the higher pH (6), the muscle hemoglobin (myoglobin) remains in the reduced state (purplish colour), or is only partially oxygenated. The results is, of course, dark-cutting beef. On the other hand, normal beef, due to its higher acidity or lower pH, permits oxygenation of the myoglobin to produce the cherry red oxmyoglobin which we know as the appealing colour of fresh beef.

There is one aspect of the dark-cutting beef problem on which there is limited data available, and that is the actual incidence of dark cutting in beef animals. Most reporting to date on incidence has been spotty and of a somewhat contradictory nature.

The first sampling to determine the incidence of dark-cutting beef, was reported by a group of workers at the Ohio Agricultural Experiment Station (2). Over a one month period from mid-April to mid-May in 1939, they checked for dark cutting in some 6,000 cattle which were slaughtered at five major slaughtering establishments located at Columbus, Ohio. They found a variation in incidence of dark cutting that ran from 0.33 to 2.5% with an average of 1%. The incidence varied from plant to plant depending on the interpretation the plant placed on the words "dark cutting". In those plants that catered mainly to the hotel and restaurant trade, where colour is not of such great importance, the incidence was 0.33%. However, for plants selling mainly through retail outlets, the incidence was 2.6%.

The second report of incidence measurements was made by the National Livestock and Meat Board (3). They used 4-H Club cattle shown at expositions throughout 1939 to 1941. Among the over 1,700 cattle checked for dark cutting, they found some 4.7% dark cutters.

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Again in 1940 and 1942 similar data was collected by the National Livestock and Meat Board Committee on dark-cutting beef at representative packing plants. In one typical survey, the average number of dark cutters at six large packing plants during one year was 0.33% of the total kill within the top four grades.

Because of the contradictory nature of this data, we undertook in 1957 to determine the incidence of dark cutting in the cattle killed at our Toronto plant. The sampling was continued until the end of 1961. These measurements were supplemented by others at our Edmonton plant. The 14,000 cattle checked over this length of time has provided us with reliable average incidence figures.

Since Hedrick was able to produce dark cutters at will via the adrenalin-injection route, it is now generally accepted that the dark cutting is brought about by subjecting the animal to some form of stress prior to slaughter. Supposedly, change in season, would act as such a stress. Another objective of the study, therefore, was to extend the measurements over a sufficient number of seasons to determine whether changes of season, such as winter to spring and summer to fall, were factors in dark cutting.

EXPERIMENTAL

As already mentioned, one of the characteristics of dark-cutting beef is high pH. This fact has been used to advantage as a means of detecting dark cutters in these laboratories (4). The initial work in this field indicated that all carcasses with an ultimate rib-eye pH of 6.0 and above were dark cutters.

Equipped with this method of detecting dark cutters, the August, 1957, kill at the Toronto Plant of Canada Packers was sampled. Some 1,300 measurements were made, and the average incidence of high rib-eye pH (6.0 or above) was 12.2%.

The sample of carcasses was made up as follows:

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Steers - 57%	- (1,039 carcasses) showing an average incidence of 13.6%.
Heifers - 20%	- (359 carcasses) showing an average incidence of 11.7%.
Cows - 9%	- (158 carcasses) showing an average incidence of 9.5%.
Yearlings - 10%	- (175 carcasses) showing an average incidence of 8.6%.
Baby Beef - 4%	- (91 carcasses) showing an average incidence of 9.9%.

From November 11th, to December 10th, 1957, the pH's of the majority of the cattle killed at Toronto were measured. The results are contained in Table I.

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TABLE I

The Incidence of Cattle with Ultimate Rib-Eye pH's 6.0 and Above in the November-December, 1957 Kills

Week Ending	Nov. 15	Nov. 22	Nov. 29	Dec. 6	Dec. 13	Dec. 30
Steers						
Number	136	136	176	98	113	226
% with Ultimate Rib-Eye pH's 6.0 and above	11.8	16.2	3.5	3.1	0.9	0.9
Heifers						
Number	147	136	18		330	
% with Ultimate Rib-Eye pH's 6.0 and above	6.8	11.1	7.8		1.8	
Cows						
Number	849	571	795	788	670	753
% with Ultimate Rib-Eye pH's 6.0 and above	19.8	26.3	10.3	8.0	3.2	2.9

During this time some 6,589 cattle were tested. These cattle can be classified as follows:

	Steers	Heifers	Cows
Number	882	793	4,914
% with Ultimate Rib-Eye pH's 6.0 and above	5.8	5.7	11.2

The incidence for cows is significantly higher than for steers and heifers.

Although each sub-class (steers, heifers, and cows) shows a significant reduction of dark cutters during the above period, the rate of reduction has no simple relationship within or between sub-cleasses, although a linear trend can be fitted to the average of all sub-classes.

In addition to these measurements at Toronto, measurements were also made at our Edmonton plant during the period December 2nd, 1957 to February 20th, 1958. The results were as follows: 165

	Steers	Heifers	Cows
Total	500	108	320
% with Ultimate Rib-Eye pH's 6.0 and above	6.2	5.6	11.9

Again, the incidence for cows is significantly higher than for steers or heifers.

The weekly breakdown for all animals tested at Edmonton are as follows:

TABLE II

The Incidence of Cattle with Ultimate Rib-Eye pH's 6.0 and Above in the December, 1957, and January-February, 1958 Kills

Week Ending	% With Ultimate Rib-Eye pH's 6.0 and Above
December 6, 1957	6.9
" 12, 1957	14.5
" 19, 1957	6.9
" 23, 1957	5.9
January 17, 1958	11.8
" 24, 1958	10.3
" 29, 1958	6.7
February 6, 1958	3.5
" 14, 1958	9.0
" 20, 1958	7.0

Unlike the Toronto measurements, no simple relationship is evident from these figures.

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These preliminary measurements indicated a higher incidence of dark cutting than had previously been reported. In order to check whether, in fact, the incidence was actually higher than had previously been suspected, it was decided to start on a sampling program which would span a sufficient period of time to give us confidence in our results.

When planning an extensive program, however, it became obvious that the effort required to sample the total kill was too great. Accordingly, it was decided to restrict future testing to steers and the number to 10 cattle per day.

The following sampling procedure proved workable and therefore was adopted. Ten carcasses were chosen from the previous day's kill in the cooler approximately 24 hours after slaughter. These carcasses were selected in a random fashion with the exception of one restriction - only 1 carcass was selected from any one buying lot. In this way, we hoped to sample the greatest possible cross section of producers. The chilled carcasses were ribbed and judged by an experienced beef grader as to whether they were bright or dark cutting. pH measurements were not taken since it was felt that visual assessment by an experienced beef grader was adequate.

RESULTS

During the latter part of this study, some 6,472 carcasses were checked for dark cutting. Of these, some 511 or 7.8% were found to be dark cutting. The monthly findings are plotted in Figure I.

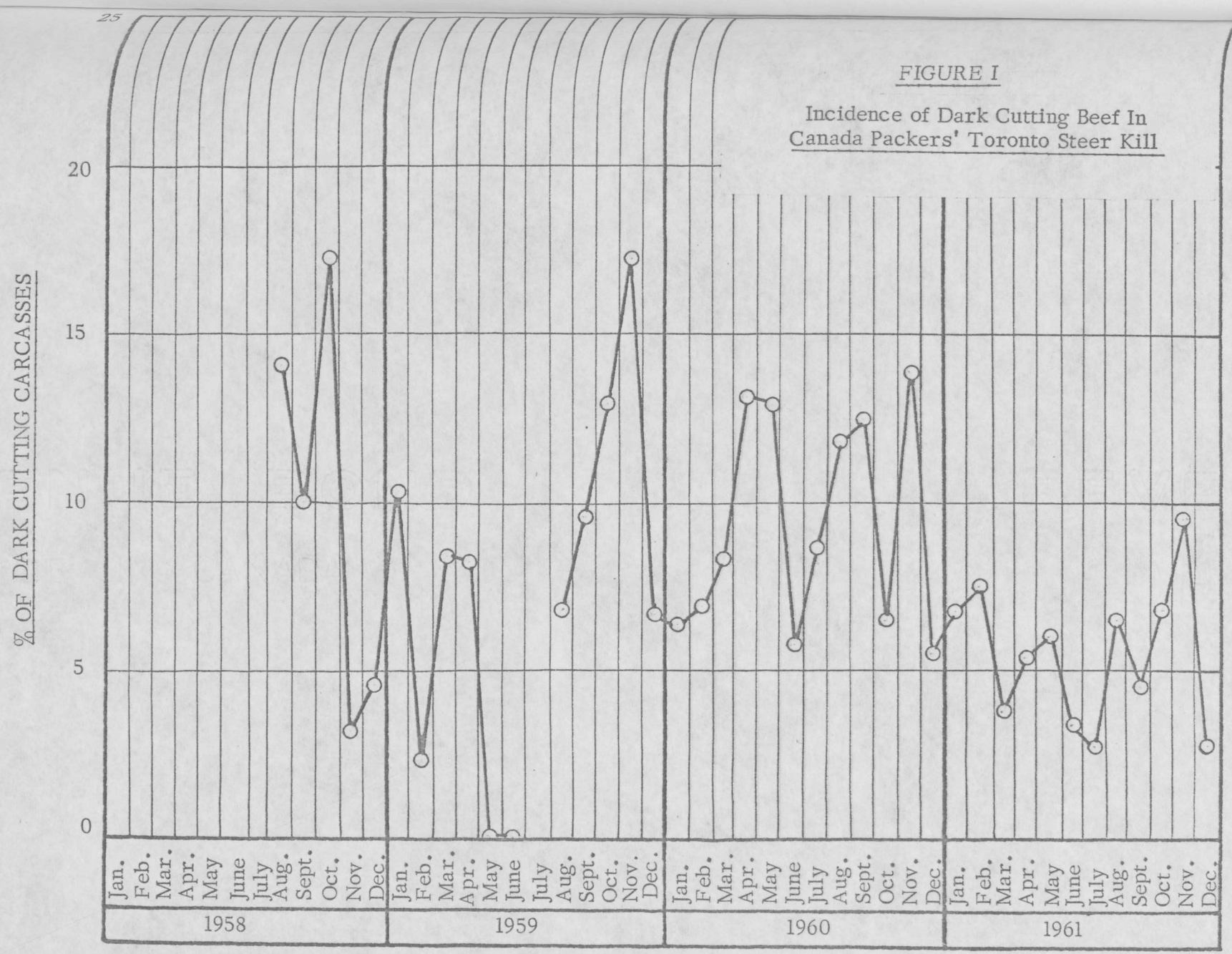
DISCUSSION

Taking into consideration only the last three years of this study, the distribution of dark cutters by years is as follows:

Year	No. of Steers	Dark Cutters	
		No.	%
1959	1,215	106	8.7
1960	2,351	219	9.3
1961	2,307	125	5.4

FIGURE I

Incidence of Dark Cutting Beef In
Canada Packers' Toronto Steer Kill



The drop from 1960 to 1961 is very significant; however, at the time of the preparation of this paper, we are at a loss to explain this finding.

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With the exception of only a few measurements, the quality of the steers measured was also recorded. In Table III, the measurements are tabulated by grade and also by the month of year.

The incidence figures by grades given in Table I are plotted in Figures II, III, IV and V.

The average % of dark cutters, given in Table III, was calculated to insure that the results were not distorted by the variation in sampling (differing ratio of Choice: Good: Commercial) from month to month. As can be seen, these variations caused little, if any, distortion.

It has been reported (3,5) that the incidence of dark-cutting beef appears to be seasonal. These investigators noted that the occurrence of dark beef is rare in the summer months but rises sharply in the fall following the first frost. Our results certainly substantiate this conclusion. The highest incidence recorded for each year of this study was in the fall (e.g. 17.2% in November, 1959; 13.8% in November, 1960 and 11.8% in November, 1961). Evidence for a spring peak is also fairly good (8.3% in March, 1959; 13.1% in April, 1960; and 5.9% in May, 1961) but it is less serene than the fall peak. This evidence of a relationship between the season and dark cutting lends further support to Hedrick's hypothesis of dark cutting.

Runnion (2) reported that he found dark cutting was more prevalent in the lower grades. Our findings also substantiate this (e.g., we found in average 12% dark cutting in commercial steers versus 3.5% in choice steers.).

FIGURE II
Incidence of Dark Cutting In
Choice Steers

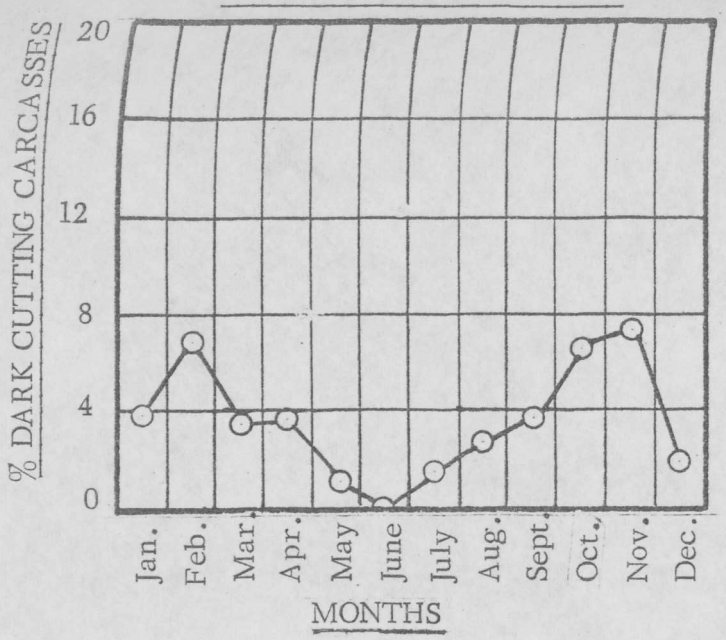

FIGURE III
Incidence of Dark Cutting In
Good Steers

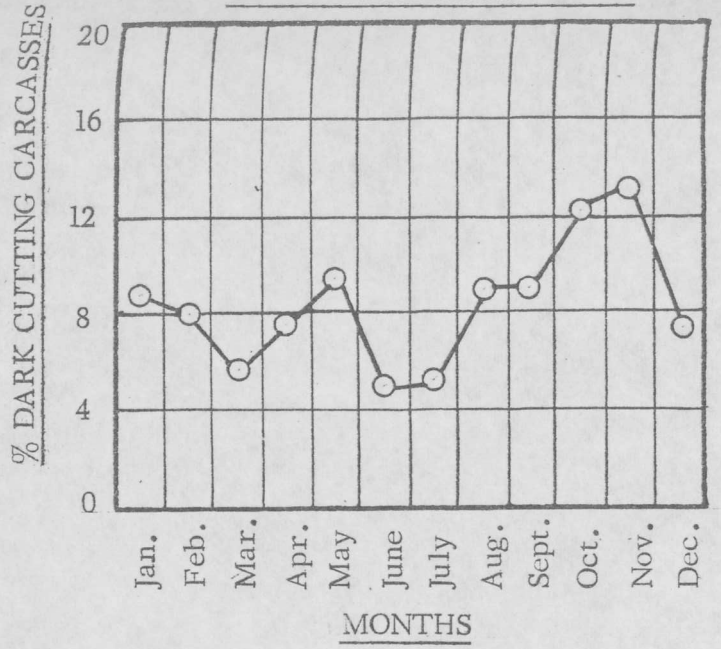

FIGURE IV
Incidence of Dark Cutting In
Commercial Steers

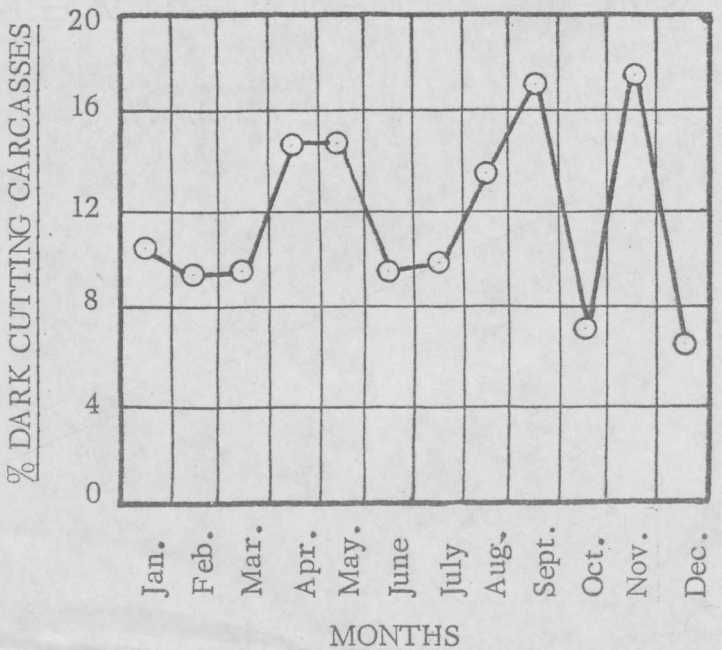

FIGURE V
% Average Incidence of Dark Cutting
In Steers

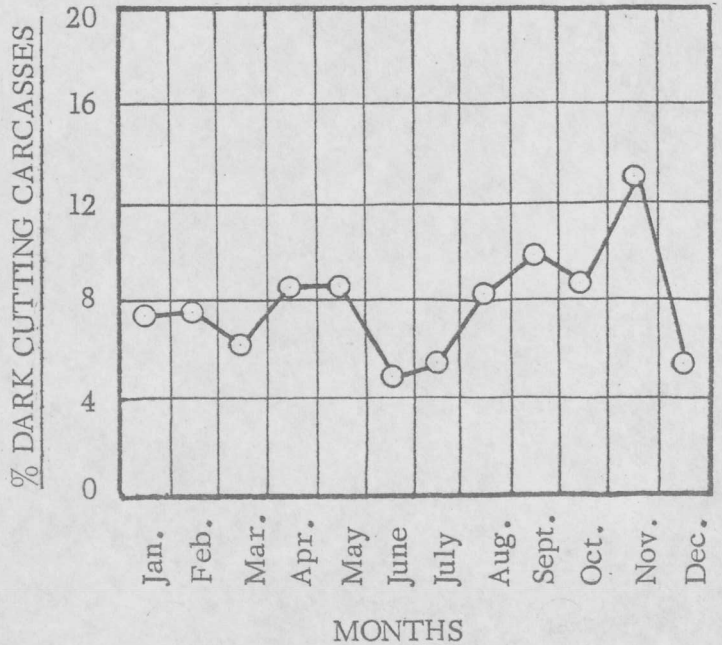

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TABLE III

DISTRIBUTION OF DARK CUTTERS IN STEERS ACCORDING TO MONTH AND GRADE
(1959-1961)

GRADE*	CHOICE			GOOD			COMMERCIAL			TOTAL			Average % Dark Cutters A+B+C/3
Month	No. of Steers	No. of Dark Cutters	% Dark Cutters (A)	No. of Steers	No. of Dark Cutters	% Dark Cutters (B)	No. of Steers	No. of Dark Cutters	% Dark Cutters (C)	No. of Steers	No. of Dark Cutters	% Dark Cutters	
Jan.	229	9	3.9	155	13	8.4	107	11	10.3	491	33	6.7	7.2
Feb.	134	9	6.7	139	11	7.9	119	11	9.3	392	31	7.9	7.4
Mar.	179	6	3.4	158	9	5.7	138	13	9.4	475	28	5.9	6.2
April	139	5	3.6	131	10	7.6	150	22	14.7	420	37	8.8	8.6
May	175	2	1.1	160	15	9.4	144	21	14.6	479	38	7.9	8.4
June	165	0	0	159	8	5.0	108	10	9.3	432	18	4.2	4.8
July	126	2	1.6	114	6	5.3	134	13	9.7	374	21	5.6	5.5
Aug.	196	5	2.6	167	15	9.0	185	25	13.5	548	45	8.2	8.3
Sept.	235	9	3.8	169	15	8.9	140	24	17.1	544	48	8.8	9.9
Oct.	184	12	6.5	166	20	12.1	144	10	6.9	494	42	8.5	8.5
Nov.	181	12	6.6	183	24	13.1	170	33	19.4	534	69	13.0	13.0
Dec.	216	4	1.9	200	15	7.5	159	10	6.3	575	29	5.1	5.2
TOTAL	2,159	75		1,901	161		1,698	203		5,758	439		
Avg.			3.5			8.5			12.0			7.6	7.8

* Canadian Government Grades for Beef Carcasses.

Actually, the magnitude of the difference in incidence between choice and good steers is surprising. Obviously, better finished cattle, in average, have higher tissue glycogen levels.

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SUMMARY

The best estimate of the average incidence of dark cutting in the steer kill at the Toronto plant of Canada Packers, during the four year period 1958 to 1961 inclusive, is 8%. The incidence was lowest (3.5%) in choice steers and highest (12%) in the poorer quality commercial steers. Measurements made over shorter periods of time indicate that the incidence in heifers is comparable to that in steers, while that in cows is significantly higher.

The incidence figures show a strong seasonal trend. The highest incidence each year was encountered in the fall. There is also evidence for a rise in the spring.

The incidence of dark cutting depends to a great extent on the quality of the animal. It is significantly less in choice than in commercial steers.

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Der Anfall an dunkel-schneidendem Rindfleisch

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Uebersicht:

Der Anfall an dunkel-schneidendem Rindfleisch spielt bei der Fleischverarbeitung eine wesentliche Rolle in Bezug auf die Qualitaetsbewertung. Zahlreiche Forscher haben sich waehrend der vergangenen 25 Jahre mit diesem Thema befasst. In einer Hinsicht ist jedoch sehr wenig in Erfahrung gebracht worden, und das betrifft den tatsaechlichen Anfall an dunkel-schneidendem Rindfleisch. Infolgedessen haben wir innerhalb der letzten fuenf Jahre 14 000 Rinder auf dunkel-schneidendes Fleisch hin untersucht. Die meisten Proben wurden im Schlachthaus von Canada Packers in Toronto entnommen, einige weitere in Edmonton.

Bei Ochsen betrug der durchschnittliche Anfall an dunkel-schneidendem Fleisch ungefaehr 9%. Bei Faersen wurde die gleiche Groessenordnung vorgefunden, waehrend der Anfall bei Kuehen betraechtlich hoeher lag.

In Bezug auf den Einfluss der Jahreszeit und der Handelsklasse, so stimmen die vorliegenden Ergebnisse gut mit denen anderer Forscher ueberein.

Zusammenfassung:

Nach der besten Schaetzung des durchschnittlichen Anfalls an dunkel-schneidendem Fleisch in Ochsen, die im Laufe der vier Jahre, 1958-1961, im Torontoer Schlachthaus von Canada Packers geschlachtet worden sind, belaeuft sich der Anteil auf 8%. Der Anteil war am niedrigsten (3.5%) bei erstklassigen Ochsen, und am hoechsten (12%) bei Ochsen niedrigerer Handelsklassen.

In kuerzeren Zeitabschnitten vorgenommene Messungen zeigten, dass der Anfall bei Faersen in der gleichen Groessenordnung wie bei Ochsen lag, waehrend er bei Kuehen wesentlich hoeher war.

Die Ergebnisse deuten auf wesentliche saisonbedingte Schwankungen hin. Der hoechste Anfall wurde in jedem Jahre im Herbst festgestellt. Auch im Fruehling haben wir Anzeichen fuer einen erhoehten Anfall vorgefunden.

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Der Anfall an dunkel-schneidendem Fleisch ist zu einem betraechtlichen Ausmass von der Qualitaet des Tieres abhaengig. Er ist bedeutend geringer bei erstklassigen Tieren als bei Ochsen niedrigerer Handelsklassen.

СЛУЧАИ ТЕМНОЙ ЗАКРАСКИ МУСКУЛОВ В МЯСЕ РОГАТОГО СКОТА

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РЕЗЮМЕ

Одним из важных моментов в мясном промысле есть случаи появления так называемых „темных мускулов", которые выступают, почти исключительно в мясе рогатого скота. Считается, что причиной этих темных мускулов, является недостаточное содержание гликогена в мускулах убойного животного в момент перед убоем.

Можно предположить, что превращение гликогена, первоначально в молочную кислоту и последовательно потом в конечные продукти углеводного обмена — CO_2 и H_2O, — равно как и биохимические процессы в гемоглобине мускулов, после убоя, играют большую роль в появлении темных мускулов в мясе.

За последних 25 лет этой проблемой интересовались многие ученые, но не нашли окончательной розвязки.

Целью наших исследований было понять причины и установить появления темных мускулов в свежем воловом мясе. Для этого мы производили опыты над 14,000 голов крупного рогатого скота в течении последних пяти лет, на мясных заводах CANADA PACKERS LIMITED, в Торонто и в Едмонтоне.

Результаты наблюдений и опытов показали, что появление темных мускулов в мясе взрослих волов и молодых бычков,

в 24 часа после убоя, доходит приблизительно до 8 %. Заметить надо, что количество темных мускулов у дойных коров доходит до 11 %.

Наши опыты потвердили также основательность прежних исследований, которые показали, что появление темных мускулов в мясе крупного рогатого скота связано также и с другими причинами, как например пора года в которой произведен убой и качество туши животного.