EFFECT OF FLUORESCENT LIGHT AND ULTRA VIOLET ENERGY ON THE RATE OF DISCOLOURATION OF FRESH PRE-PACKAGED BEEF.

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Introduction.

Disagreement in the literature on the effect of light, compared with darkness, on the colour of fresh meat was reviewed by Solberg (1968). Kraft and Ayres (1954), reported no significant difference between samples stored in the dark and those exposed to 50 to 150 foot-candles of fluorescent light at a temperature of 2.5 $\pm$ 1°C, whereas Marriot et al (1967) and Naumann (1968) reported no change in colour during 10 days storage in the dark at -1°C, but a significant change during exposure to 120 foot-candles of light at the same temperature.

There is also disagreement on the absolute effect of light on fresh meat colour. Ramsbottom et al (1951) found no loss of colour during 3 days storage at 60-200 foot-candles of fluorescent light. Kraft and Ayres (1954), found that meat discoloured on exposure to light and that the intensity of light was unimportant in influencing the course of discolouration. Marriot et al (1967) and Naumann (1968) reported rapid discolouration of meat stored under 120 foot-candles of light.

There is general agreement on the deletereous effect of ultraviolet light on fresh meat colour (Ramsbottom 1951, Kraft and Ayres 1954) although more quantitative information is required.

The present study was undertaken to resolve these questions, using a reflectance spectrophotometric technique to follow colour changes in samples of fresh beef.

Experimental.

Heifers, 0 or 2 teeth, were kept for at least a week after purchase and then slaughtered in the Meat Research Department abattoir under standard conditions. Carcases were chilled to a deep muscle temperature of 5°C in 48 hours. Hind-quarters were boned out and commercial primal cuts - fillet, short sirloin, sirloin, inside round (topside), outside round (silverside) and knuckle - were prepared from them.

The vacuum-packaged cuts were aged for two weeks at 0°C and then 6 muscles - M. longissimus dorsi, M. psoas major, M. gluteus medius, M. semitendinosus, M. semimembranosus, and M. vastus lateralis - from both sides were dissected out. Each muscle was dipped in boiling water and then cut into steaks, approximately 1.5 cm thick, using a sterile knife. Ten samples were selected at random from these steaks and placed in plastic containers, 4.5 cm x 3.5 cm x 1.5 cm.

Samples were held at 0°C for one hour and then overwrapped with PVC meat-grade film. After a further two hours at 0°C the reflectance spectrum of each piece of meat was recorded using a Unicam spectrophotometer fitted

with an SP 890 diffuse reflectance accessory. Colour measurement depends on finding the initial (K/S)572/(K/S)525 ratio for freshly bloomed meat containing 100% oxymyoglobin, and measuring the change in this ratio to follow the subsequent development of metmyoglobin. Accumulation of metmyoglobin at the surface of fresh meat is associated with a reduction in the initial value of (K/S)572/(K/S)525. The measurement is based on the method of Stewart et al (1965) and is described in detail elsewhere (Hood 1971).

Five samples from the left and five from the right muscle were allocated to each experimental treatment so that each muscle mean is based on ten replicate samples, and represents the combined muscles from left and right sides. Three animals were used in each experimental treatment.

In the first series of experiments the effect of fluorescent light on the discolouration of fresh beef was compared with darkness at two temperatures 0°C and 5°C. Samples were held in two refrigerators converted from deep-freeze chest-type cabinets. The top of one was replaced by a plate glass cover and the fluorescent light source was mounted above this, inside a reflector unit. Two fluorescent tubes (Philips TL 40W/33 White) were fitted into this unit at a distance of 14 in. above the surface of the meat. The intensity of light measured at the surface of the meat was 300 foot-candles.

This arrangement was designed to eliminate indirect effects of light as far as possible, particularly on temperature and humidity, which are difficult to control in an open display cabinet. Meat sample temperatures under light were controlled at 0 or 5 ± 0.5°C. Control samples were stored in the dark in a similar refrigerator cabinet at the same temperature. Discolouration measurements were performed, 48 hours and 96 hours after the initial measurement and discolouration is expressed as the change in (K/S)572/(K/S)525 after these time intervals.

A second series of tests at 0°C and 5°C was also carried out in which germicidal UV radiation was added to the fluorescent light illumination. Intensity of UV at the surface of the meat was less than 10 foot-candles and did not appreciably alter the light intensity used in the first series. The UV source was a 30W TUV lamp mounted inside the refrigerator compartment. This lamp radiates nearly all its energy at 2537A°.

Results and Discussion.

1. Darkness.

All samples of beef discolour gradually in the dark at 0°C and 5°C, (Tables 2 & 3) as a result of intrinsic biochemical factors present in the muscle. Bacterial effects in particular were reduced to a minimum in these experiments.

The rate of discolouration in the dark depends largely on the particular muscle involved (Table 1). This muscular effect on discolouration has been reported previously (Hood 1971). M. longissimus dorsi and M. semitendinosus are most stable, and M. psoas major and M. gluteus medius least stable in this respect.

TABLE 1.

D I S C O L O U R A T I O N

Change in (K/S)572/(K/S)525

		0°C	5°C	Significance Level
M. Psoas	48 Hours	0.13	0.23	0.01
	96 Hours	0.24	0.34	0.01
M.L. Dorsi.	48 Hours	0.01	0.00	N.S.
	96 Hours	0.02	0.03	N.S.
M. Gluteus.	48 Hours	0.04	0.07	0.05
	96 Hours	0.07	0.14	0.05
M. Semiten.	48 Hours	0.02	0.01	N.S.
	96 Hours	0.04	0.04	N.S.
M. Semimem.	48 Hours	0.03	0.02	N.S.
	96 Hours	0.05	0.05	N.S.
M. Vastus.	48 Hours	0.03	0.07	N.S.
	96 Hours	0.07	0.13	0.05

Effect of temperature on discolouration of beef muscles in the dark at two temperatures.

The poor stability of certain muscles even under ideal preparation and storage conditions is a major problem in a commercial central prepackaging operation.

By combining discolouration data on control samples in the dark from both series of light experiments, the effect of temperature on discolouration can be tested on a total of six animals at two temperatures. (Each experimental treatment contains three animals.) An analysis of variance of these data (representing six animals at two temperatures) shows that temperature has a significant effect on discolouration for meat held in the dark, in the case of the unstable muscles M. psoas major, M. gluteus medius and M. vastus lateralis. (Table 1)

A relatively small change in temperature from 0°C to 5°C has thus an appreciable effect on the rate of discolouration in susceptible muscles. The general instability of these muscles under the influence of any discolouration effect is again in evidence. McDougall (1972) has reported that the change in redness of meat which occurs between 24 hours and 48 hours at 5°C is equivalent to between 72 and 168 hours at 0°C.

2. Darkness v Fluorescent Light (300 foot-candles).

Muscle mean (K/S)572/(K/S)525 measurements for each treatment are given in Table 2 which also summarises the results of analyses of variance of discolouration data for each muscle after 48 hour and 96 hour time intervals, specifically with respect to the effect of light.

These analyses of variance (representing two temperatures and two light conditions with three animals in each treatment combination) show no significant difference in discolouration due to the effect of temperature. In three instances, after 48 hours in M. gluteus medius and after 48 and 96 hours in M. vastus lateralis) the difference in discolouration, due to presence or absence of light, is significant at the 0.05 level, but in most cases differences are not significant. The rate of discolouration is nevertheless consistently greater in light than in darkness for all six muscles. Differences are numerically small and at the same time the error due to between-animal variation is large; increasing the number of animals per treatment would increase the sensitivity of the test and possibly establish significance for differences shown by all muscles.

The effect of fluorescent light on discolouration of fresh beef is much less important than differences between muscles, e.g. between M. longissimus dorsi and M. psoas major. Light intensity of 300 foot-candles is in any case high, and storage is rarely as long as two days under normal display conditions. For these reasons, whether additional sampling proves that the differences are real or not, the effect of light on discolouration is of relatively little practical importance.

Marriot et al (1967) who found a rapid increase in colour deterioration under light, explained the acceleration in discolouration as the result of increased microbial growth. Meat samples in the present work were substantially free from bacteria initially and any possible microbial effect was thereby reduced to a minimum. Low bacterial contamination is an essential prerequisite of successful pre-packaging, particularly for a

TABLE 2.

		DARK (K/S)572/(K/S)525			LIGHT (K/S)572/(K/S)525			DISCOLOURATION 48 HOURS (A - B1)			DISCOLOURATION 96 HOURS (A - B2)		
		A Initial	B1 After 48 Hrs	B2 After 96 Hrs	A Initial	B1 After 48 Hrs	B2 After 96 Hrs	Dark	Light	Significance Level	Dark	Light	Significance Level
M. Psoas	0°C	1.32	1.20	1.11	1.34	1.18	1.07	0.12	0.16)	N.S.	0.21	0.27)	N.S.
	5°C	1.31	1.08	0.96	1.33	1.08	0.97	0.23	0.25)		0.35	0.36)	
M.L. Dorsi	0°C	1.37	1.37	1.35	1.36	1.34	1.34	0.00	0.02)	N.S.	0.02	0.02)	N.S.
	5°C	1.37	1.36	1.35	1.37	1.36	1.33	0.01	0.01)		0.02	0.04)	
M. Gluteus.	0°C	1.35	1.31	1.28	1.34	1.25	1.19	0.04	0.09)	N.S.	0.07	0.15)	0.05
	5°C	1.33	1.26	1.23	1.33	1.22	1.15	0.07	0.11)		0.10	0.18)	
M. Semiten.	0°C	1.38	1.37	1.37	1.38	1.35	1.34	0.01	0.03)	N.S.	0.01	0.04)	N.S.
	5°C	1.38	1.36	1.36	1.39	1.35	1.33	0.02	0.04)		0.02	0.06)	
M. Semimem.	0°C	1.37	1.35	1.33	1.37	1.30	1.38	0.02	0.07)	N.S.	0.04	0.09)	N.S.
	5°C	1.34	1.32	1.29	1.34	1.30	1.27	0.02	0.04)		0.05	0.07)	
M. Vastus.	0°C	1.37	1.35	1.31	1.38	1.31	1.28	0.02	0.07)	0.05	0.06	0.10)	0.05
	5°C	1.38	1.33	1.29	1.38	1.32	1.24	0.05	0.06)		0.09	0.14)	

Colour measurements on samples of beef showing the effect of darkness and light (300 ft-candles) on discolouration of 6 muscles at two temperatures.

TABLE 3.

		DARK			LIGHT			DISCOLOURATION					
		(K/S)572/(K/S)525			(K/S)572/(K/S)525			48 HOURS			96 HOURS		
		A	B1	B2	A	B1	B2	(A - B1)			(A - B2)		
		Initial	After 48 Hrs	After 96 Hrs	Initial	After 48 Hrs	After 96 Hrs	Dark	Light	Significance Level	Dark	Light	Significance Level
M. Psoas	0°C	1.37	1.22	1.12	1.37	0.95	0.85	0.15	0.42)	0.001	0.25	0.52)	0.001
	5°C	1.33	1.11	1.00	1.32	0.86	0.82	0.22	0.46)		0.33	0.50)	
M.L. Dorsi	0°C	1.40	1.38	1.37	1.40	1.11	1.04	0.02	0.29)	0.001	0.03	0.36)	0.001
	5°C	1.35	1.36	1.31	1.34	1.05	0.93	-0.01	0.29)		0.04	0.41)	
M. Gluteus.	0°C	1.36	1.32	1.29	1.36	1.00	0.89	0.04	0.36)	0.001	0.07	0.47)	0.001
	5°C	1.34	1.27	1.17	1.29	0.92	0.84	0.07	0.37)		0.17	0.45)	
M. Semiten.	0°C	1.41	1.38	1.35	1.42	1.07	0.97	0.03	0.35)	0.001	0.06	0.44)	0.001
	5°C	1.36	1.35	1.30	1.36	0.97	0.85	0.01	0.39)		0.05	0.45)	
M. Semimem.	0°C	1.38	1.33	1.32	1.37	1.05	0.93	0.05	0.32)	0.001	0.06	0.44)	0.001
	5°C	1.32	1.31	1.27	1.32	0.98	0.87	0.01	0.34)		0.05	0.45)	
M. Vastus.	0°C	1.39	1.35	1.31	1.42	1.07	0.96	0.04	0.35)	0.001	0.08	0.46)	0.001
	5°C	1.33	1.25	1.15	1.34	0.94	0.86	0.08	0.40)		0.18	0.48)	

Colour measurements on samples of beef showing the effect of darkness and light (300 ft-candles) + UV on discolouration of 6 muscles at two temperatures.

central pre-packaging operation. It is under these conditions, where extrinsic effects are minimised, that muscular differences assume their real significance.

3. Darkness v Fluorescent Light (300 foot candles) + UV.

The second series of analyses of variance of discolouration data for each muscle after 48 hour and 96 hour time intervals, (representing two temperatures and two light conditions with three animals in each treatment combination) again show no significant difference due to temperature, but highly significant differences due to the effect of light + UV. Muscle mean (K/S)572/(K/S)525 measurements are given in Table 3 which also summarises the results of the analyses of variance of discolouration data for each muscle after two time intervals, specifically with respect to the effect of light + UV.

Clearly germicidal UV has a marked accelerating effect on the rate of discolouration of all six muscles and beef turns brown very rapidly under this treatment. Stable muscles, M. longissimus dorsi and M. semitendinosus, which normally resist colour change under a variety of conditions, appear to be equally affected by germicidal UV compared with the unstable M. psoas major and M. gluteus medius.

Kraft and Ayres (1954) found the effect of UV light on cellophane wrapped beef to be dessicative. The present work, using meat-grade PVC film does not substantiate this view. Weight losses of beef samples under fluorescent light + UV, under fluorescent light and in darkness are summarised in Table 4. Samples in the dark lose less weight than in the corresponding light treatment, but samples under fluorescent light only, show greater weight losses than samples under fluorescent light + UV.

TABLE 4.

	Dark		Fluorescent light		Dark		Fluorescent light + UV	
	48 Hrs	96 Hrs	48 Hrs	96 Hrs	48 Hrs	96 Hrs	48 Hrs	96 Hrs
0 °C	2.15	3.56	2.89	4.68	1.15	2.11	2.00	3.20
5 °C	3.00	5.11	3.48	5.31	1.83	3.12	2.88	4.68

Percentage weight losses (treatment means) of beef samples.

TABLE 3

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