PACKAGING FRESH AND CURED MEAT

THE INHIBITORY EFFECT OF INTRAVENOUSLY ADMINISTERED SODIUM ASCORBATE ON THE DISCOLOURATION OF FRESH BEEF

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Discolouration of fresh beef, measured by the accumulation of metmyoglobin pigment, in four muscles from ten beef animals, intravenously injected pre-slaughter with sodium ascorbate, is compared with similar muscles from ten control animals at 0°C and at 5°C. The colour stability of meat from sodium ascorbate treated animals is significantly better than control, particularly M. psoas major and M. gluteus medius at the higher storage temperature.

EFFET INHIBITEUR DE L'ASCORBATE DE SODIUM ADMINISTRE PAR VOIE INTRAVEINEUSE SUR LA DECOLORATION DU BOEUF FRAIS

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La décoloration de la viande de boeuf fraîche, mesurée par l'accumulation de pigments de metmyoglobine, dans quatre muscles examinés sur dix animaux, ayant subi avant d'être abattus une injection intraveineuse de sodium ascorbique, est comparée à des muscles similaires examinés sur dix animaux de contrôle à des températures de 0°C et 5°C. La stabilité de couleur de la viande des animaux traités a l'ascorbate de sodium est nettement meilleure que le contrôle, en particulier M. psoas major et M. gluteus medius à la température de conservation la plus élevée.

DIE HEMMENDEN EFFEKTE DES INTRAVENÖS VERORDNETEN SODIUM ASCORBATE AN DER VERFÄRBUNG VON FRISCHEM RINDFLEISCH

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Verfärbung von frischem Rindfleisch, gemessen an der Anhäufung von metmyoglobin Pigment in vier Muskeln von 10 Rindern, intravenös eingespritzt vor der Schlachtung mit sodium ascorbate, ist verglichen mit ähnlichen Muskeln von 10 Kontrolltieren bei 0°C und 5°C. Die Farbstabilität von Fleisch bei Tieren, die mit sodium ascorbate behandelt wurden, ist wesentlich besser als Kontrolle, besonders M. psoas major und M. gluteus medius bei der höheren Lagerungs-temperatur.

ЗАДЕРЖИВАЮЩЕЕ ВЛИЯНИЕ ВНУТРИЖИЛЬНО ИНЪЕКТИРОВАННОГО АСКОРБАТА НАТРИЯ НА ОБЕСЦВЕЧИВАНИЕ МЯСА

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Обесцвечивание свежего говяжьего мяса, определенное аккумуляцией пигмента метмиоглобина, в четырьёх мышцах из десяти животных крупного рогатого скота, внутрижильно инъектированных аскорбатом натрия перед убоем, сравняется с подобными мышцами из десяти контрольных животных при 0°C и 5°C. Стабильность цвета животных, обработанных аскорбатом натрия, значительно превышает контроль, особенно в M. psoas major и M. gluteus medius при высших температурах хранения.

THE INHIBITORY EFFECT OF INTRAVENOUSLY ADMINISTERED SODIUM ASCORBATE ON THE DISCOLOURATION OF FRESH BEEF.

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1. Introduction

The discolouration of fresh beef in prepackaged consumer cuts has important commercial consequences, since it limits shelf life and prevents the centralization of beef cutting and packaging operations. Development of the brown discolouration in fresh meat is due to the accumulation of the oxidised myoglobin derivative, metmyoglobin. This pigment is formed a few mm below the surface of the meat at the interface of red oxymyoglobin at the surface and purple reduced myoglobin in the deeper tissues. Discolouration gradually increases as metmyoglobin diffuses outwards towards the surface.[1,2,3]

The rate of discolouration depends on bacteriological and biochemical considerations, the latter becoming increasingly significant as bacterial effects are reduced. Some muscles e.g. M. psoas major, M. gluteus medius are particularly susceptible to discolouration, whilst others e.g. M. longissimus dorsi, M. semitendinosis are considerably more stable in this respect under any given set of experimental conditions.[4]

Metmyoglobin formation occurs as a result of autoxidation and the loss of reductants from post rigor muscle.[4,5] Muscles which exhibit good colour stability generally have higher metmyoglobin reducing activity (MRA) than unstable muscles[4], although there is no clear correlation between colour stability and MRA for individual muscles.[6]

Ascorbic acid protects meat colour[7] and it has been claimed as a colour stabilizing agent in fresh ground meats.[8,9,10] In this case intimate contact between the meat pigment and the reducing agent is achieved but this is not so for whole slices of meat treated by spraying on to the surface, or by dipping the meat into a solution. Metmyoglobin forms initially below the surface of the meat where optimum oxygen tension conditions exist for oxidation to occur; the reducing agent must penetrate the meat at least to this depth. Nevertheless, preliminary tests, involving the spraying of 2.5% or 5% ascorbate solution on to the surface of prepackaged steaks, established that metmyoglobin formation is inhibited by this treatment, although the ability of the meat to 'bloom' (i.e. to form bright red oxymyoglobin) is also impaired by this treatment.

2. Experimental

2.1. Meat

5 to 10 min before slaughter, young heifers (0-2 teeth, approximate weight 7 cwt) were injected intravenously via the jugular vein with a single massive dose of ascorbate (500 ml of a 50% w/v solution of sodium ascorbate pH 7.2). No apparent physiological stress was caused by this treatment other than that normally associated with physical restraint of the animal and intravenous injection. Ten beef animals were treated in this way. They were then slaughtered under standard hygienic conditions in the Meat Research Department abattoir and the carcasses chilled for 48 h to a deep muscle temperature of 5°C. Ten control animals of the same sex and approximately the same age and weight were also slaughtered. Normally two animals, one control and one treated with ascorbate, were slaughtered at any one time. All animals were bought in a local market and were rested for at least a week before slaughter.

After chilling, hindquarters were broken into wholesale primal cuts. These were vacuum packaged in polythene/nylon laminate bags, evacuated and sealed on a Swissvac machine at a residual pressure $\leq$ 15 torr. These cuts were then stored at 0°C for 10 days in order to simulate good commercial practice, aimed at producing meat which has a bright red colour on exposure to oxygen and which is tender to eat.

After conditioning, four muscles M. psoas major, M. gluteus medius, M. semimembranosus and M. longissimus dorsi were carefully dissected out. A high level of bacteriological quality is an essential pre-requisite of extended storage-life of fresh beef. Whilst this may be achieved by good hygiene practice during every stage of slaughter and cutting, the preparation of small steaks required for spectrophotometric measurement presents an additional bacterial hazard. In order to ensure low bacterial counts on meat surfaces, the test muscles were therefore dipped in boiling water for 5 sec before cutting into small steaks, approximately 1.5 cm thick using a sterile knife. Eight samples were selected at random from among these steaks and placed on flat perspex trays, dimension 4.5 x 3.5 x 1.5 cm, the size being chosen to fit the sample holder of the SP 890 diffuse reflectance attachment of a Unicam SP 800 Spectrophotometer. After holding at 0°C for 1 h the samples were overwrapped with PVC meat-grade film held for a further 2 h at 0°C and the spectrum of each piece of meat was recorded on the spectrophotometer. These samples were then held in store.

2.2. Reflectance measurement

Light entering a partially opaque material is decreased by absorbance and scattering to which absorbance and scattering coefficients K & S may be assigned. Reflectivity (R_∞), which is defined as the reflectance of a sample layer sufficiently thick to prevent light being reflected from the background, is related to the absorption and scattering co-efficients by:

$$K/S = \frac{(1 - R_\infty)^2}{2 R_\infty} \quad (11)$$

This function may be used to relate percent reflectance to quantities of meat pigments and tables are available for converting percent reflectance to the K/S value.[12]

Analysis of reflectance spectra of meat is concerned with changes in percent reflectance at two specific wavelengths.[13] 525 nm is isobestic for all three myoglobin derivatives and the percentage reflectance at this wavelength indicates the total pigment content and overall colour intensity of the meat. 572 nm, on the other hand, is isobestic for oxymyoglobin and reduced myoglobin. A change in reflectance at this wavelength represents a change in the level of metmyoglobin relative to the two ferrous pigments. A method of pigment analysis by reflectance spectrophotometry, using ratios of K/S values at different wavelengths, was originally described by Stewart, Zipser and Watts.[13] A change in the ratios of K/S values at 572 nm and 525 nm is a measure of metmyoglobin accumulation, the limiting ratio for 0% metmyoglobin being determined after the meat is initially allowed to 'bloom' fully in air.[13] Tables are also available for converting absorbance readings obtained on the spectrophotometer, directly to K/S value ratios.[14]

2.3. Assay of ascorbic acid.

Ascorbic acid was determined by 2.6 dichlorophenolindophenol titration, after extraction of the meat tissue with 10% trichloracetic acid, centrifugation and filtration.

3. Results & Discussion

Intravenous injection of a massive dose of ascorbate (500 ml of a 50% w/v solution of sodium ascorbate) into beef animals, 5 to 10 min. before slaughter, distributed the antioxidant throughout the musculature. Meat from carcasses chilled for 48 h to a deep muscle temperature of 5°C, cut into primal joints and vacuum packaged, and then stored at 0°C for 10 days, contained residual levels of ascorbate of the order 100-200 mg/kg. No detectable level of ascorbate was found in meat from controls. Steaks sliced from primal cuts prepared in this way, packaged on polystyrene trays and overwrapped with PVC oxygen-permeable film, had a more stable colour than meat from control animals.

Table 1 shows the change in $(K/S)_{572}/(K/S)_{525}$ ratios for four beef muscles, (average of ten experimental animals) compared with similar muscles from controls (average of ten animals) after three different storage times, at two temperatures.

A change in $(K/S)_{572}/(K/S)_{525}$ of 0.15 - 0.17 is equivalent to a 20% pigment conversion to metmyoglobin, which is close to the limit of commercial acceptability. When meat at this level of discolouration is offered for sale in a supermarket with bright red meat as control the ratio of sales of discoloured beef to bright red beef is approximately 1 : 2[15]

At 5°C the accumulation of metmyoglobin pigment, and thus the rate of colour deterioration, was reduced in ascorbate treated meat compared with meat from control animals for three of the four muscles tested. At this temperature, and at the longer storage times, differences are statistically significant, especially in M psoas major and M gluteus medius, muscles which are consistently unstable with respect to colour. Assuming that a change of 0.16 units in $(K/S)_{572}/(K/S)_{525}$ defines the acceptable limit of fresh meat colour,[15] the shelf-life of control meat at 5°C was approximately 1 day for M psoas major and 4 days for M gluteus medius. The corresponding shelf-life for ascorbate treated meat at 5°C was at least 6 days for both muscles, indicating an extension of shelf-life of 5 and 2 days for M psoas major and M gluteus medius respectively. An increase in shelf-life of 1-2 days was also indicated for M semimembranosus at this temperature.

Under commercial retail display conditions meat from M longissimus dorsi has good colour stability and there is generally little discolouration problem with this particular muscle. This is borne out in the present series of experiments where the colour of M longissimus dorsi from both control and treated meat is still acceptable after six days storage, even at the higher temperature (Table 1). There is thus no beneficial effect due to the sodium ascorbate treatment for this muscle.

A guaranteed colour shelf-life of six days or more would contribute significantly towards making centralized prepackaging of meat a commercially viable proposition. However, with the exception of muscles with stable colour, such as M longissimus dorsi and M semitendinosus, meat discolours too quickly to make this practicable. Some muscles are so unstable with respect to colour that a shelf-life of one or at most two days is all that can be expected under commercial retail conditions. It is particularly significant that the advantage of the sodium ascorbate treatment is produced in muscles like M psoas major and M gluteus medius which normally cause most trouble in this respect.

Storage at 0°C produced a much smaller effect on metmyoglobin accumulation in both treatments. Colour stability was again improved by the use of ascorbate and this is important in practical terms in the case of M psoas major where an extension in shelf-life of at least 2 days was achieved over control meat.

Although low temperature storage of meat is desirable, 0°C is rarely achieved in practice and the advantage of using ascorbate should be viewed in relation to the higher temperatures which are more frequently encountered commercially, particularly in the retail store. These are likely to be 5°C or higher.[16,17] Under these conditions the protective action of intravenously administered ascorbate on fresh meat colour is a significant advantage.

MUSCLE	TEMPERATURE (0°C)	TREATMENT	STORAGE TIME (DAYS)								
			2			4			6		
			Mean	S.E. Diff between treatments	F.test signi-ficance	Mean	S.E. Diff between treatments	F.test signi-ficance	Mean	S.E. Diff between treatments	F.test signi-ficance
M. psoas major	0	Ascorbate	.06	.021	N.S.	.08	.028	*	.10	.034	**
		Control	.09			.16			.23		
	5	Ascorbate	.09	.034	**	.10	.039	***	.14	.058	***
		Control	.23			.33			.40		
M. gluteus medius	0	Ascorbate	.04	.013	N.S.	.03	.010	N.S.	.04	.015	*
		Control	.03			.05			.07		
	5	Ascorbate	.05	.014	*	.05	.020	***	.09	.038	***
		Control	.08			.16			.28		
M. semimembranosus	0	Ascorbate	.03	.011	N.S.	.02	.010	N.S.	.02	.011	N.S.
		Control	.01			.02			.03		
	5	Ascorbate	.04	.009	N.S.	.04	.013	*	.08	.040	*
		Control	.04			.07			.17		
M. longissimus dorsi	0	Ascorbate	.03	.009	N.S.	.02	.011	N.S.	.03	.012	N.S.
		Control	.01			.02			.03		
	5	Ascorbate	.05	.012	N.S.	.04	.013	N.S.	.12	.035	N.S.
		Control	.04			.05			.11		

TABLE 1. The effect of ascorbate treatment on metmyoglobin accumulation ($\Delta (K/S)_{572}(K/S)_{525}$) in four beef muscles at two temperatures. Ten animals in each treatment.

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