Tropfsaft im vakuumverpackten Fleisch

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Wenn ein erschlaffter Muskel, z.B. infolge der Kälte - oder Rigorkontraktion, verkürzt wird, nimmt das Übereinandergreifen von Aktin und Myosin zu. Diese Verkürzung der Muskelfasern kann von großen Veränderungen in der Geometrie des innermuskulären Bindegewebes begleitet werden, die zu einer Zunahme des hydrostatischen Druckes innerhalb des Muskels führen. Der Druck kann seinen Einfluß nur ausüben, wenn der Gehalt an immobilisierten oder in Kapillaren kondensierten Wassers im Muskel befähigt wird, aus der Zellwand und dem extrazellulären Raum herauszudringen und zum Äußeren zu gelangen, wo er als Tropfsaft wahrnehmbar ist. Wenn der Tierkörper im Gefrierraum den Rigor Zustand erlangt, nachdem er entweder elektrisch stimuliertist oder am Hüftbein aufgehängt wurde, ist die Muskelverkürzung vermindert.

Die Arbeit diskutiert Untersuchungen bezüglich der Einflüsse der Abkühlungs- und Verarbeitungsbedingungen auf die Menge des von abgekühlten vakuumverpackten Hauptteilstücken hergestellten Tropfsafts.

Weep in vacuum packaged meat

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When a relaxed muscle is shortened, e.g. by cold or rigor-shortening, the overlap of actin and myosin increases. Accompanying this muscle fibre shortening there can be large changes in the geometry of the intra-muscular connective tissue resulting in an increase in the hydrostatic pressure within the muscle. The pressure is only capable of exerting its effect when the immobolised or capillary-condensed water content of the muscle becomes amenable to translocation across the cell membrane and down the extracellular space to the exterior where it is visible as weep or drip.

If the carcass goes into rigor in the chiller after being electrically stimulated or restrained by aitch bone hanging then the response to the stimuli promoting muscle shortening will be reduced.

The paper will discuss the investigations on the effects of chilling and processing conditions on the amount of weep (drip) produced from chilled vacuum-packed primals.

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Le Suintement dans la Viande Embalée Sous Vide

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Quand un muscle relaxé est raccouri, par exemple dû à la contraction par le froid ou par la rigidité, le chevauchement de l'actine et de la myosine s'augmente. Cette centraction de la fibre musculaire peut être accompagnée des grands changements de la géometrie du tissu conjonctif intramusculaire aboutissant á l'accroissement de la pression hydrostatique dans le muscle. La pression est capable d'exercer son influence si seulement le centenu en l'eau immobilisee ou condensée dans les vaisseaux capillaires devient susceptible d'être transportée à travers la membrane cellulaire et vers le bas par l'espace extracellalaire à l'extérieur ou il est visible comme le suintement ou la stillation.

Si la carcasse subit la vigidité dans le réfrigérateur après avoir été stimulée electriquement ou restreinte dû à la suspension par l'os coxal, la réponse aux stimulants favorisant la contraction du muscle sera réduite.

Ce travail discutera les recherches, effectuées par le Laboratoire de Recherches en Viande de l'Organisation de Researches Scientifiques et Industrielles du Commonwealth d'Australie sur les effets des conditions de refrigeration et de traitement sur la quantité de suintement (stillation) produite à partir des tranches principalés frigorifiées et emballées sons vide.

Просачивание в вакуум-упакованном мясе.

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Когда релаксированная мышца укорачивается, например из-за холода или трупного окоченения, тогда перекрытие актина и миозина увеличивается. Это сокращение мышечных волокон может сопровождатся большими изменениями геометрии внутримышечной соединительной ткани ведущими к увеличению гидростатического давления в мышце. Давление способно осуществить свое действие только если содержание неподвижной воды или воды конденсированной в капилярах мышцы может поддаться перемещению сквозь клеточную оболочку, вниз по внеклеточному пространству и выйти наружу где оно видно как просачивание или капание.
Если туша становится жёсткой в морозилке после предвратительного электрораздражения или сдерживания подвешиванием за тазобедерную кость, тогда реакция к стимулам способствующим сокращению мышцы понизится.
Настоящая работа обсуждает исследования касающиеся влияния условий охлаждения и переработки на количество просачивания /капания/ выделенное охлажденными основными кусками мяса упакованными в вакууме.

Weep in Vacuum Packaged Meat

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Introduction

Of the total volume of water in living muscle, 85-95% is held within the fibres in dynamic equilibrium with the remaining water in the plasma outside the fibre walls. Within the fibres the water occupies the intrafibrillar space between actin and myosin filaments, and the sarcoplasmic space between myofibrils. The water equilibrium allows the exchange of metabolites into and out of the fibre without any alteration to the overall amount of water held by the muscle (Penny, 1974).

When a muscle goes into rigor a number of important changes take place which affect the water equilibrium. The actin and the myosin filaments become bonded together, and tend to squeeze the water out of the filament lattice into the sarcoplasmic space, and possibly also into the space between the fibres (Penny, 1975). Thus water previously immobilised by association with protein is released for redistribution within the fibres, and also into the spaces outside the fibres, and makes up most of the fluid which we call "drip" or "weep."

Confirmation of this water transfer in post mortem muscle has come from Pearson *et al* (1974), who found that the changes observed in NMR signals from a muscle going through rigor could best be explained by the transfer of about 17% of the water from one region of the muscle fibre to another, the most likely regions being from inside the fibre to the outside (fig.1).

Further losses of water from the fibre and closer packing of the fibrillar protein also result from protein denaturation (i.e. irreversible alteration to the structure and properties of protein). Protein denaturation in muscle is a function of the post mortem rate of cooling and the rate of pH fall. It increases dramatically if cooling is slow, and pH fall is concurrently rapid.

Penny (1977) stated that there are other factors not yet accounted for which also contribute to changes in extracellular space and the amount of drip.

For most carcasses, pH fall is slow and therefore the rate of cooling is the most important consideration if weep losses are to be reduced. Taylor (1972) showed that rapid chilling reduced weep and suggested that even quicker cooling than he was able to achieve during post slaughter chilling would reduce weep losses even further. However, a rate of chilling which is too high can lead to conditions where toughness due to muscle "cold shortening" becomes a problem.

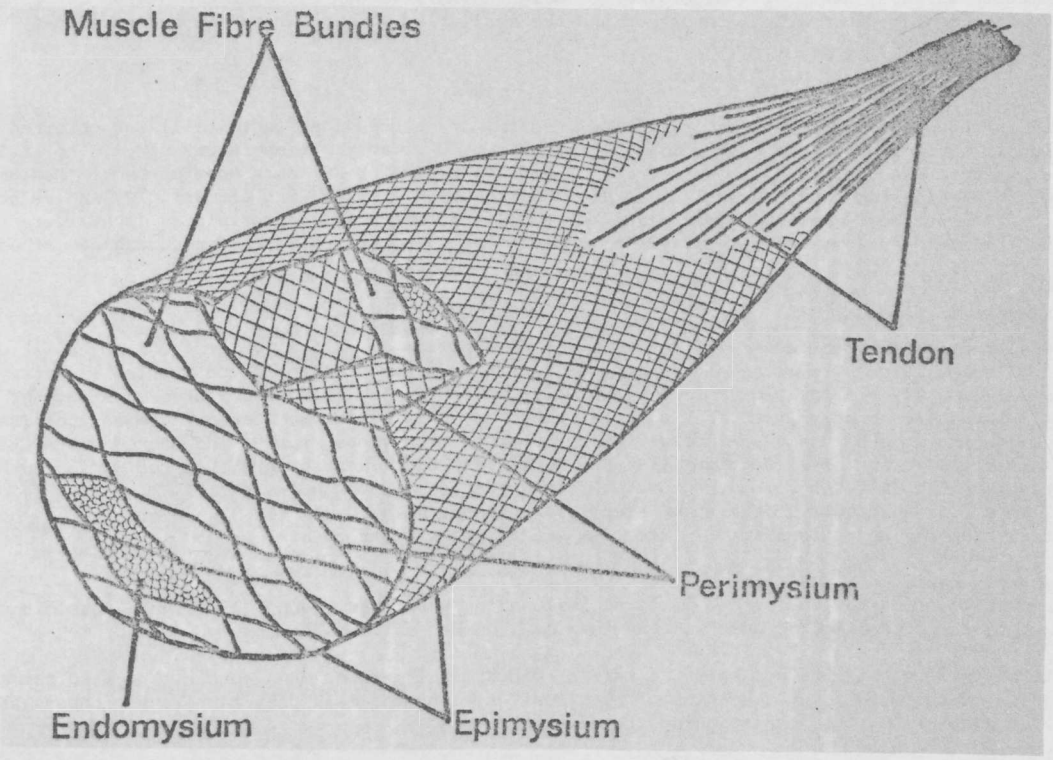

fig.1 Diagram of a muscle cut transversely to show the subdivision of the muscle into fibre bundles by the perimysium, and surrounding each fibre is the endomysium. The sheets of connective tissue making up the epimysium and the perimysium are represented as having a criss-cross lattice of collagen fibres. In the diagram the lattice has been drawn very open, whereas *in vivo* the sheets of collagen are almost solid.

D 1:4

In a series of papers, Rowe (1974, 1977a, 1977b) clearly demonstrated that toughness/tenderness variability of meat resulting from differences in contraction state is a reflection of changes in geometry of both of the two major fibrous components of meat, i.e. (i) the muscle fibres, and (ii) the collagen fibres of the connective tissue (fig.1), and not just changes in the contribution made by the muscle fibres. Before the work of Rowe, and following the work of Locker (1960), the role of connective tissue toughness was thought of as one providing "background toughness" which may or may not be dominant, depending on the quantity and age of the collagen. Relationships between weep and factors affecting muscle contraction have not been fully explored.

The present study was undertaken to measure the interaction between rapid chilling and weep, and the influence that aitch bone hanging and electrical stimulation has on this interaction.

Experimental

All animals, except those in sub-section ii), involved in the weep experiments were yearling steers (one or two tooth), yielding carcasses of dressed weight from 175-222 kg, and having a fat cover from 1-5 mm at the 12-13th rib.

i) *Hot Boned Muscles*

M. Biceps femoris (B.F.) muscles which were obtained hot boned from a local abattoir, were trimmed of all surface fat and connective tissue to leave a smooth muscle surface. Each muscle was sliced into four pieces (10 x 10 x 2.5 cm) plus at least four off cuts, which were kept for temperature and pH measurements. Each slice was dried with paper towels, weighed (W_1) and suspended in stockingette within a polythene bag which was sealed and placed in a chiller or incubator at either 0°C, 5°C, 15°C or 25°C within two hours post slaughter. At 24 hours post slaughter each slice was removed from its bag, dried with paper towels, weighed (W_2), rewrapped in the same stockingette and placed back in its respective chiller or incubator. This procedure was repeated at 48 hours and 72 hours. After the last weighing the slices of muscle were discarded. Temperature and pH were monitored hourly for 10 hours post slaughter on the off cut pieces of the B.F., which were stored adjacent to the weighed slices. The mean of three temperature and pH measurements for each treatment was then calculated. The amount of weep was calculated as follows:

$$\text{WEEP} = \frac{W_1 - W_2}{W_1} \times 100\%$$

ii) *Hanging Procedures*

After carcasses randomly selected from the slaughter floor were dressed and split, sides were assigned at random to be hung either by the Achilles tendon or by the aitch bone (pelvic region). The sides (12) were loaded into a commercial chiller (at 6°C). On completion of loading the chiller (2½ hours post mortem), the air temperature was reduced to 0-1°C for 10 hours and then raised to 3°C for the remainder of the 20 hour chill. The topsides (*M. semimembranosus* [S.M.] plus adductor A), and striploins (*M. longissimus dorsi* [L.D.]) were removed from the sides 24 hours post mortem, trimmed of all surface fat and connective tissue to leave a smooth muscle surface, dried with paper towels, weighed (W_1), vacuum packaged and stored for six weeks at 0-1°C. After storage the packs were opened and the meat dried with paper towels and reweighed (W_2). Weep was calculated as above.

iii) *Chilling Procedures*

Two chilling procedures, defined as 'fast' and 'medium,' were used. A 'fast' chill was obtained by placing randomly six sides in an empty commercial chiller precooled to an air temperature of -1°C to -2.5°C. Air at this temperature was circulated at a velocity of 0.5-1.5 m/sec for 20 hours post mortem. 'Medium' was obtained by placing the contralateral sides (6) into an empty chiller with air at 10°C, and velocity 0.5-1.5 m/sec for 20 hours post mortem. The topsides (S.M. plus adductor A) and striploins (L.D.) were removed 24 hours post mortem and weep was determined for these commercial cuts using the procedure described in Section ii.

iv) *Electrical Stimulation*

A stepwise progression from 20 to 110 volts D.C. over a period of either 1.5 or 4.0 minutes was used for electrical stimulation of carcass sides, a pulse generator being used to induce a pulse frequency of 40 Hz (Shaw & Walker, 1977). *Deep pectoral* (D.P.) muscles which were obtained one hour post slaughter (hot-boned) from stimulated and nonstimulated contralateral sides had all the surface fat and connective tissue carefully removed, leaving smooth muscle surfaces. The hot muscles were vacuum packed and stored at 0-1°C for six weeks; weep was calculated as above (Section ii). The sides with D.P. removed were then cooled for 20 hours in a chiller with air at 1°C and velocity 0.5-1.5 m/sec. The *M. semitendinosis* (S.T.), *M. rectus femoris* (R.F.), B.F., S.M. & L.D. muscles from the stimulated (4) and nonstimulated (4) sides were obtained 24 hours post slaughter, prepared and stored at 0-1°C for six weeks, and weep then determined.

Results & Discussion

In an attempt to consider the 'other factors' influencing weep loss (Penny, 1977), the possible contribution of the state of contraction of meat was examined by a number of means.

The rate of chilling affects not only the rate of biochemical changes in a muscle, but also the state of contraction of the muscle. Contraction of muscle after slaughter is highly temperature dependent, and is minimal at about 15°C (the 'conditioning' temperature) (fig.2).

When hot-boned beef muscle was subjected to temperatures which would have induced quite different final contraction states, minimum weep loss was apparent at around 15°C (the 'conditioning' temperature) (fig.3). At temperatures above 20°C, the rapid increase in weep with time is probably due to autolytic degradation of the cellular structure.

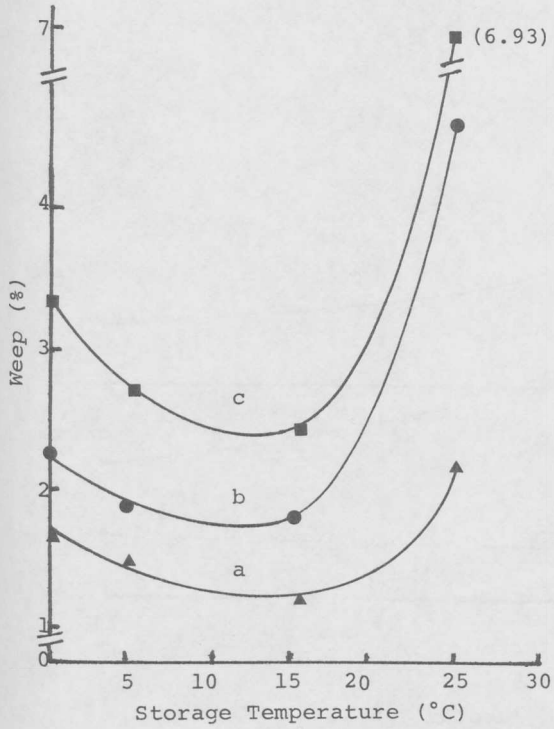

fig.3 Approximate relationship between percentage weep and storage temperature pre-*rigor*.

a) 24 hours
b) 48 hours
c) 72 hours

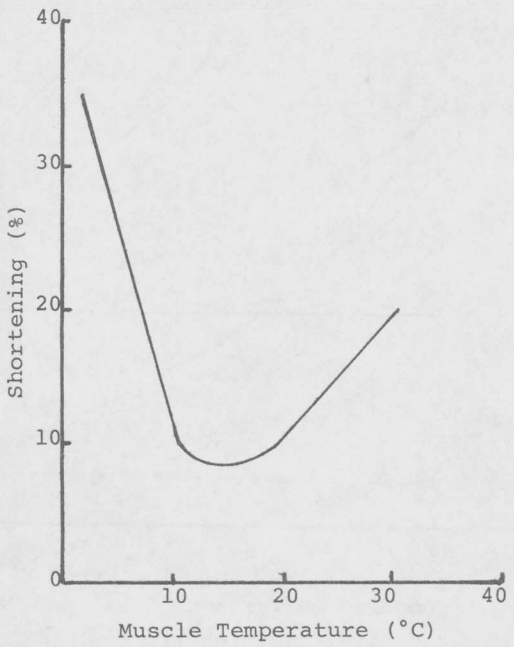

fig.2 Approximate relationship between percentage shortening and muscle temperature pre-*rigor*.

The architecture of connective tissue in muscle is such that there is minimal tensioning of the collagen fibre network when the muscle is at rest length (Rowe 1974 & personal communication). When the muscle contracts the network is progressively tensioned by the increasing diameters of the contracting muscle fibres. When a muscle enters rigor in a contracted state, then the tension in the collagen network is locked into the muscle.

It is the opinion of Rowe (personal communication) that this tension results in an increase in hydrostatic pressure within the muscle, and that it makes a significant contribution to the exudation of weep.

On the basis of the observations with hot-boned meat, it was predicted that if beef muscle is prevented from contracting during the rigor process as with the aitch bone (pelvic) hanging method (Hostetler *et al*, 1970, Bouton *et al*, 1972) which restrains a number of the important muscles of the back and hind leg from shortening, significant reductions in weep would be observed.

In practice, weep from striploins and topsides was reduced to less than half in cuts taken from sides hung by the aitch bone when compared to the same cuts from the contralateral sides of the same animals hung by the Achilles tendon during chilling (table 1). This is slightly at variance with Joseph (1977), who reported a significant decrease in weep with the S.M., but not for the L.D. However, 'cold toughening' was observed with the L.D. during his 'fast' chilling procedure.

TABLE I

Weep resulting from different suspension methods - vacuum packed cuts held at 0-1°C for six weeks

commercial primals	% weep aitch bone	% weep Achilles tendon
Striploin (L.D.)	2.3	5.0
Topside (S.M. + adductor A)	2.1	5.0

From the observations reported above, it was predicted that if beef sides with light-medium fat cover hung from the Achilles tendon could be cooled extremely rapidly ('fast'), than larger quantities of weep would be produced than from those sides cooled at a slower ('medium') rate. This proved to be so (table II). Fig.4 indicates cooling curves for the beef sides studied.

The foregoing results suggest that, for minimizing weep, the carcass should be cooled rapidly to about 15°C where least muscle shortening occurs, followed by much slower cooling over the remainder of the chilling cycle. Coincidentally, such a procedure has also been recommended for minimizing evaporative moisture loss during chilling (Herbert *et al*, 1978); therefore a dual advantage may be gained.

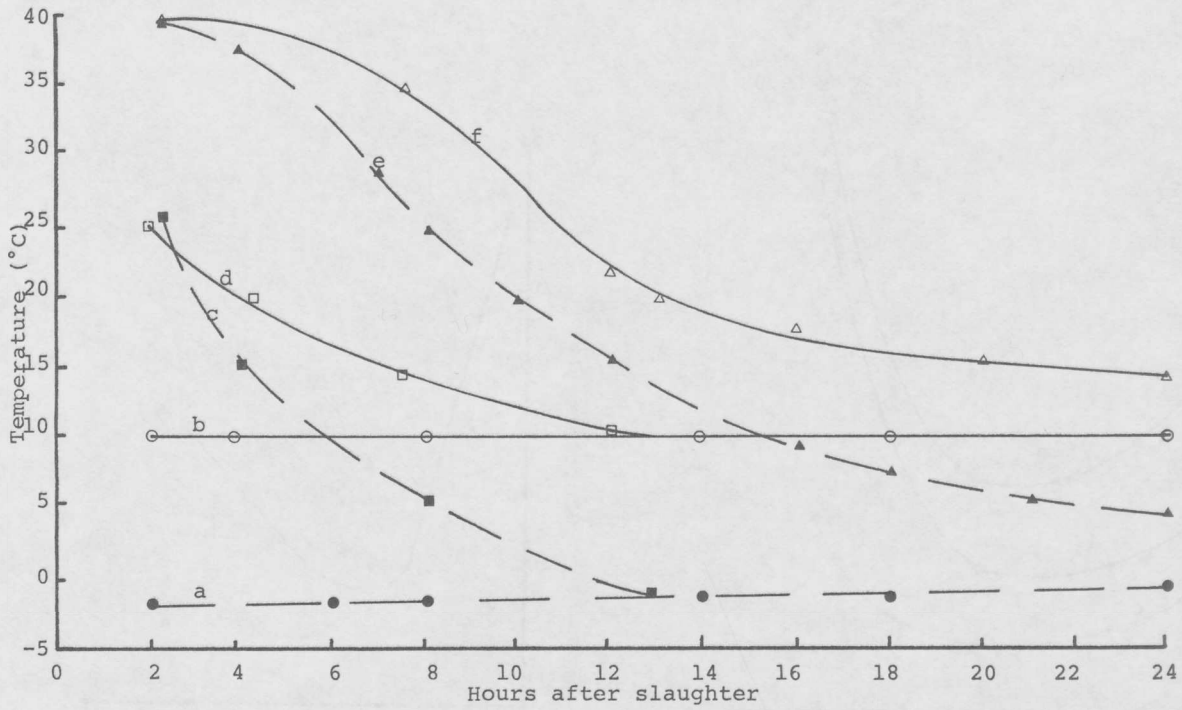

fig.4 Cooling curves for 'fast' and 'medium' chill.

a) Air 'fast' chill
b) Air 'medium' chill
c) L.D. 'fast' chill
d) L.D. 'medium' chill
e) Deep butt 'fast' chill
f) Deep butt 'medium' chill

TABLE II

Weep resulting from different chilling procedures - vacuum packed cuts held at 0-1°C for six weeks

commercial primals	% weep	
	fast chill	medium chill
Striploin (L.D.)	4.3	3.6
Topside (S.M. + adductor A)	5.0	4.0

Another process which minimizes post slaughter contraction of muscle is electrical stimulation of the carcass (Chrystall & Hagyard [1976], Bendall [1976], Davey *et al* [1976]). Accordingly, weep from hot-boned muscles from stimulated carcasses could be independent of chilling rates and should not be more than that of muscles from nonstimulated control sides, also hot-boned.

Although only the D.P. muscles were available for this study (Table III), weep lost by the muscles hot-boned from stimulated sides, while not completely independent of the chilling environment, was less than that hot-boned from the nonstimulated controls.

TABLE III

Weep from hot-boned *deep pectoral* muscle (mean of five observations)

Treatment	Storage Temperature for initial 24 hours	% weep after six weeks' storage @ 0°C
Control	15°C	3.4
	0°C	7.1
Stimulated	15°C	3.4
	0°C	6.0

Preliminary results on weep from muscles, S.T., B.F., S.M., L.D. & R.F., removed from sides 24 hours post slaughter indicate no significant difference between stimulated and nonstimulated carcasses.

Electrical stimulation of beef, however, also leads to a rapid fall in pH while the carcass temperature is still high. This should, perhaps, lead to a massive loss of drip due to protein denaturation. Our results suggest that this does not occur.