The Effects of Pre-slaughter Injection of Magnesium Sulphate on Glycolysis & Meat Quality in the Steer

David Lister* & P.W. Ratcliff+

INTRODUCTION

The muscle-relaxing properties of magnesium are well known, and have been used experimentally to improve certain aspects of meat quality. In steers, the anaesthetic dose of $MgSO_4$ has been injected intravenously before slaughter (Howard & Lawrie[1,2,3]) in an attempt to reduce the exudation of drip from the frozen quarters of beef, when these are thawed. This work provided evidence that magnesium retarded ATP breakdown and delayed the rate and extent of pH fall in the muscles after death, but drip (except from the blast-frozen quarters) was not affected. The results reported with regard to organoleptic quality of the meat were inconclusive. Similar techniques have been used with pigs[4], thereby obtaining a sufficient degree of control over pH fall and loss of CP and ATP in the muscle to prevent the development of the P.S.E. condition.

The present work with steers was undertaken to ascertain the effects of magnesium injection on the quality and water-holding capacity of the meat. The associated biochemical parameters were investigated, and observations on colour and organoleptic quality were recorded.

* A.R.C. Meat Research Institute, Langford, Bristol.
+ J. Sainsbury Ltd., Research Laboratory, London.

EXPERIMENTAL

Animals

Four steers of the North Devon breed (1½-2 years old) were injected intravenously with aqueous $MgSO_4$ (50%), immediately prior to slaughter. The volume of solution used (150 - 350ml) was injected into the jugular vein over a period varying between 2 and 15 minutes. An additional two steers served as controls; these received no injection.

The six animals (all supplied from the same source) were stunned by captive bolt and then pithed and bled according to normal practive at the abattoir. The carcasses, after dehiding and evisceration, were split and cooled in air at 0 ± 1°C. After 8 days conditioning in cold store (0° ± 1°C) the carcasses were butchered and examined for meat quality.

Sampling & Preparation of Muscle Tissue.

The M.semimembranosus of the right side of each steer was sampled at intervals from ¼ to 24 hours post-mortem. Each sample (~ 20g) was excised to a depth of 2.5cm, and frozen immediately in liquid nitrogen. The samples were held below - 30°C until required for use.

1g of the frozen sample was placed, together with liquid nitrogen, in a mortar and crushed to powder. A weighed portion of the powder was macerated in 5% perchloric acid. After standing for 30 minutes the macerate was filtered, neutralised with 5M K_2CO_3, and stored at 4°C.

pH

The pH of the muscle tissue was determined, using a macerate of 1g of frozen sample in 8ml. of 0.005M iodoacetate (pH

exudation from the cut surfaces was observed and measured.

Colour of the meat, and organoleptic quality of the cooked samples, were assessed by a trained panel.

RESULTS

Beef Semimembranosus.

The two groups, of test and control carcasses, showed no significant difference initially (at 15 minutes post-mortem) either in pH or in levels of ATP. An initial pH of 6.81 ± .05 was recorded in all the steers (Fig.1a) corresponding to a lactate concentration of 12 ± 7 umols/g. muscle (Fig.1a). Lactate increased steadily, and at closely similar rates during the next 24 hours, reaching 70 ± 10 umols/g in both the test and control steers. Both groups reached an ultimate pH of 5.5 ± 0.15.

ATP in both groups amounted initially to 6.4 ± 0.8 umols/g then falling to 1.1 ± 0.6 umols/g at 24 hours. (Fig.1b).

The initial levels of glycogen, glucose and the various products of glycogenolysis, also the subsequent pattern of change in all of these parameters, were broadly similar in the test and control groups. Glycogen, averaging 70 umols/g initially, declined to an ultimate value (at 24 hours) of 20 umols/g (Fig.1c). Glucose also fell from an initial average level of 14 umols/g to an ultimate value of 6 umols/g, at 24 hours (Fig.1c). On the other hand, G-6-P and F-6-P accumulated in the muscle during the same period, the initial levels of G-6-P (1.5 umols/g) and F-6-P (0.5 umols/g) rising to 10 and 2 umols/g respectively at 24 hours (Fig.1d). Glycerol-1-P, initially present at a concentration of 0.5 umols/g, showed a fourfold increase within a period of 8 - 10 hours, and then

showed a slight decline; G-1-P rose steadily from an initial level of 0.2 umols/g to an ultimate level (at 24 hours) of 0.6 umols/g.

The concentrations of all the other glycolytic intermediates investigated, - Pyruvic acid, DHAP, Gly-3-P, 2-PGA, 3-PGA, F1-6DP and PEP, - were small (0.1 - 0.5 umols/g) and showed little tendency to change. ADP and AMP were also maintained at low levels, - 1.5 and 0.5 umols/g. The initial concentration of NAD ranged between 0.4 and 0.6 umols/g and then showed a slight tendency to fall.

Magnesium content of the meat was in the range 232 - 255ppm in the test carcasses, 235 - 236 in the controls.

Water holding capacity of the meat, in terms of the exudation recorded for the segmented semimembranosus muscles, appeared to be unaffected by the magnesium treatment. No significant differences were observed between the test and control groups in colour of the meat or in tenderness and flavour of the cooked samples.

DISCUSSION

In the steers, injection of magnesium produced no significant effects upon post-mortem glycolysis in the Semimembranosus. The initial values recorded for Lactate, pH and ATP in both the injected animals and the controls, were similar to those previously reported for normal carcasses of both beef and lamb.[7] Subsequent rates of change in all of the biochemical parameters investigated, with the single exception of ATP, were unaffected by magnesium treatment, and conformed with the patterns normally found in beef.[7]

ATP was maintained at the initial high level (6.5 $\pm$ 0.7

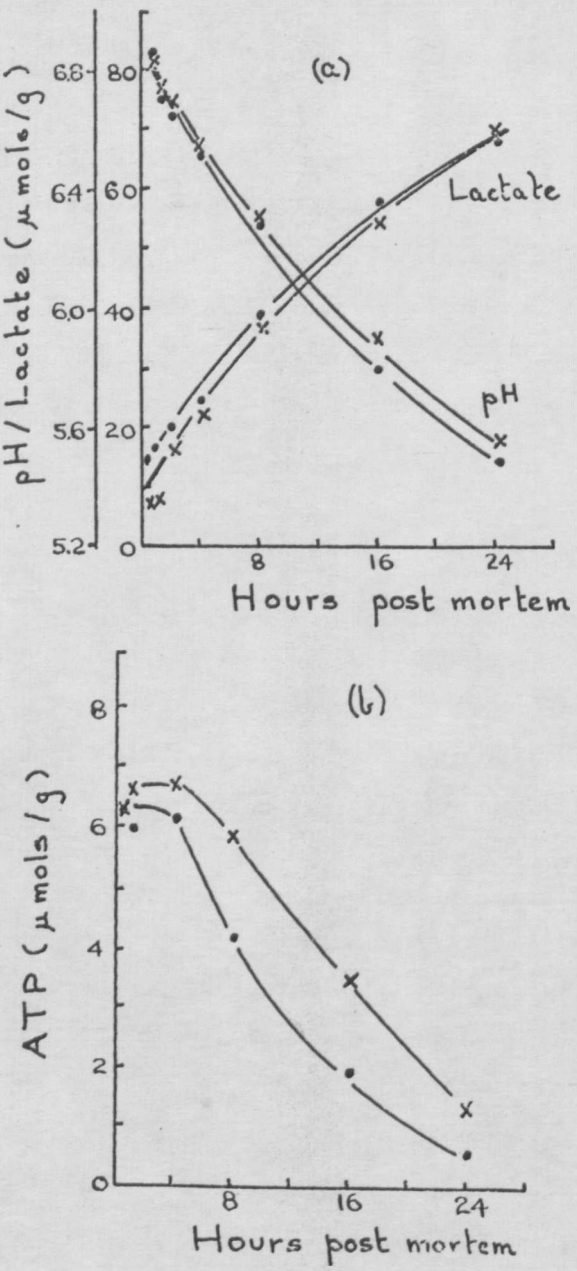


Fig. 1 a, b. Beef Semimembranosus Muscle
-x- Magnesium injected Steers
-•- Control Steers

umols/g) for as much as 4 hours post-mortem, and then declined sharply: the rate of decline being slightly slower in the muscles of the treated animals. The delayed fall in ATP was however of dubious significance. Comparison of the curves depicting changes in ATP concentration (Fig.1b) with those for Lactate or pH (Fig.1a).show clearly that lactate accumulated at a rate which was unaffected by the changing levels of ATP in the muscle. Presumably however, the rate of post-mortem glycolysis is determined by factors which affect the rate of utilisation of ATP, such as those associated with stress suffered by the animal at slaughter. Since glycolysis was unaffected by the magnesium treatment given to the steers, it is concluded that stress factors were not inhibited or reduced by the administration of magnesium to these animals. This lack of effectiveness of magnesium may be due to the difficulty that was experienced in injecting the necessarily large volumes of solution (constituting a lethal dose) by the intravenous route.

It was observed that the amounts of (a) lactate, together with G-6-P, G-1-P, and F-6-P, accumulating in the muscle during 24 hours post-mortem, and (b) glycogen degraded in the same period, were not stoichimetrically equivalent. Similar observations have been reported for Lamb semimembranosus muscle[7].

REFERENCES

1. Howard, A., & Lawrie, R.A, C.S.I.R.O., Div. Food. Pres. Tech. Paper, No.2, Part II, 1956.

2. Howard, A., & Lawrie, R.A., C.S.I.R.O., Div. Food Pres. Tech. Paper, No.3, 1957.

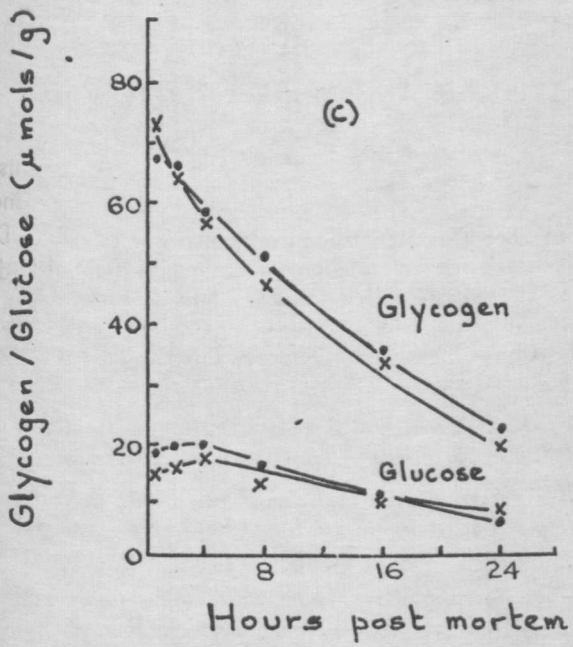
3. Howard, A., & Lawrie, R.A., D.S.I.R. (Fd. Invest.) Spec. Report No.65, 1957.

4. Sair, R.A., Lister, D., Moody, W.G., Cassens, R.G., Hoekstra, W.G., & Briskey, E.J., Am. J. Physiol., 1970, 218, No.1.,

5. Bergmeyer, H.V., (ed), "Methods of Enzymatic Analysis," 1965.

6. Mokrasch, L.C., J. Biol. Chem., 1954, 208, 55.

7. Follett, M.J., & Ratcliff, P.W., 1969, XVth Eur. Meeting of Meat Res. Workers, Helsinki, Paper No.C4.



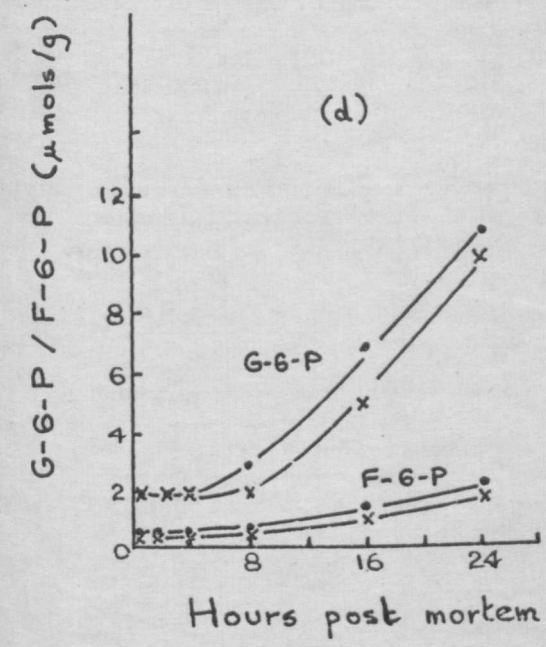


Fig. 1 c, d. Beef Semimembranosus Muscle
-x- Magnesium injected Steers
-.- Control Steers