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SOME PHYSICAL, ORGANOLEPTIC AND BIOCHEMICAL EFFECTS OF CONDITIONING BEEF QUARTERS

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INTRODUCTION

Systematic studies on chemical and palatability changes affected by holding beef above the freezing point are not new. In 1874 Bouley described experiments in which increases in tenderness (but off odour development) occurred in beef stored for two months under light refrigeration; and the investigations on this topic of Richardson and Scherubel (1909) and of Hoagland, McBryde and Powick (1917) may be regarded as classical. An interesting development in this field arose from the work of Moran and Smith (1929) and of Steiner (1939), who found sufficient tentative evidence that improvement in tenderness was proportionately greater in beef of poor quality than in that of good quality to merit further study.

The present paper describes experiments to determine the effects, on both palatability and drip (after subsequent freezing and thawing), of holding both good and poor quality beef quarters above the freezing point.

MATERIALS AND METHODS

The experiments were carried out in the C.S.I.R.O. Meat Research Laboratory, Brisbane, Queensland, using the facilities of an adjacent abattoir.

Twelve beef cattle carcasses from each of the Australian grades, first quality export (Grade 1) and Canner, constituted the experimental material. The carcasses in Grade 1 were from steers $3\frac{1}{2}$-4 years old; those in Canner grade were from cows from 8-9 years old. Within each grade, dressed carcasses of similar weight and conformation were purchased on the slaughter floor from abattoir operators over a six weeks' period.

Of each four carcasses, two were allocated at random for examination (after holding treatment) as fresh sides; the other two were allocated for examination after freezing, storage and thawing (applied subsequent to the holding treatments). Four holding treatments were applied according to a balanced incomplete block design (Table 1). All sides were held for 24 hours in the commercial chiller (-0.5 to +1.5°C air temperature). Thereafter the four treatments were as follows:-

I. Examined or transferred to freezer direct from chiller.

II. Held for 3 days at 0°C.

III. Held for 1 day at 0°C and for 2 days at 20°C.

IV. Held for 14 days at 0°C.

All quarters were weighed as received from the chiller and again

at completion of the holding treatment. The material to be frozen was then placed for 3-5 days in the commercial freezer at -12°C to -18°C, weighed, covered with stockinette and hessian wraps and stored at -10°C. At sites to be subsequently used for cooking tests (sirloin, topside and rump), temperatures were measured throughout the holding and freezing periods by thermocouples connected to recording instruments.

At the completion of the holding treatments sides for examination as fresh beef were cut into butchers' joints. From each side a rolled roast from the sirloin and from the topside, and a grill from the rump were prepared and cooked. Shrink on cooking was measured and eating quality was assessed by a trained taste panel. The scheme of cutting into joints and the methods of cooking have already been described (Howard, 1956a,b).

A sample was taken from each joint before cooking. Alkali-insoluble protein (Husaini, Deatherage, Kunkle and Draudt, 1950), soluble nitrogen (Anon., 1945) and pH were determined in each sample and, from each, an extract was prepared for chromatographic indentification of amino acid constituents. The concentrations of the latter were calculated, from spot area and intensity, in arbitary units.

The sides for examination after frozen storage were removed from store after 18 weeks at -10°C. After weighing, sections were removed for determination of drip from standardized pieces of psoas and longissimus dorsi muscles (Laboratory Drip). The rest of the quarters was allowed to thaw. The percentage loss of weight of the quarters after 48 hours at +10°C was taken as a measure of Quarter Drip. The additional percentage loss in weight after cutting into butchers' joints and thawing for a further 24 hours at +10°C gave a measure of Butchers' Drip; whereas the percentage loss in weight of 6" cubes cut from the leg at the same time as the joints measured Cube Drip.

The shrinkage, and eating quality, of roasts from the sirloin and topside, and of a grill from the rump, were determined for each side, as with the unfrozen material.

The pH of a sample from each joint before cooking was measured and the hydroxyproline concentration estimated. (Wierbicki and Deatherage, 1954).

RESULTS[1]

(a) Weight Losses

During the period of holding, evaporative losses increased in the following order:- I. no holding; II. held 3 days at 0°C; III. held 1 day at 0°C and 2 days at 20°C, and IV. held 14 days at 0°C. Such losses (mean of Grades 1 and Canner) were in treatments II, III and IV respectively 0.8%, 2.2% and 3.0% of the initial carcase weight, more than those in I. There was considerable darkening on exposed muscle surfaces of sides which had been held for 2 days at 20°C.

The losses during and after thawing (recorded as the various forms of drip) show significant effects of the holding treatment in the case of Quarter Drip(**) and Laboratory Drip (combined results for psoas and longissimus dorsi muscles*).

As seen from Fig. 2, drip decreases in the following order of

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1 Note. Throughout this paper the symbols *, ** and *** refer to statistical significance at the 5%, 1% and 0.1% levels of probability, respectively.

treatments: I. (no holding); II. (held 3 days at 0°C; III. (held 1 day at 0°C and 2 days at 20°C) and IV. (held 14 days at 0°C). Although the effect of treatment on Cube Drip just failed to be significant (at the 5% level of probability), the data for this and Butchers' Drip, nevertheless, show a similar pattern to those for the other two measures of drip. It will also be noted (Fig. 2) that, with Quarter Drip, the changes due to the holding treatments are more marked with the Canner beef. The treatment x grade interaction is significant).

Considering the general pattern of weight losses, there is a marked change from treatment I to II and then a rather smaller change from II to III and IV.

(b) Eating Quality

Data on the meat odour and flavour, tenderness, juiciness, colour and overall acceptability of fresh beef, and corresponding data for beef after freezing and storing at -10°C for 18 weeks, are summarized in Fig. 2. There is a statistically significant effect of treatment with tenderness(xxx), juiciness (in the frozen material)(xx), colour(xx) and acceptability(xxx). The juiciness scores for fresh material show a similar pattern to those for the frozen but, owing to the high variability, the effect does not reach significance.

In fresh beef from both grades, tenderness and overall acceptability increases, and juiciness decreases, in the following order of treatments: 1.(no holding); II. (held 3 days at 0°C); III. (held 1 day at 0°C and 2 days at 20°C) and IV. (held 14 days at 0°C). As with the weight losses, the maximum difference occurs between treatments I and II and there is little difference between treatments III and IV. Colour decrease in Canners and increase in flavour in both grades follows the same pattern (although the latter is not statistically significant). Meat odour is not significantly altered by the nature of the holding treatments. It will also be noted from Fig. 2 that, especially with colour and overall acceptability of the fresh material, the degree of response to holding treatment is greater for Canners than for Grade 1 beef. This is shown by significant interactions involving grade (for colour T x G = xxx and for acceptability TG = xxx).

Figure 2 indicates in addition that freezing either considerably modifies or even eliminates these trends and this is confirmed by the presence of significant interactions involving freezing (e.g. holding treatment x freezing = xx for tenderness). The process of freezing - in the case of flavour, tenderness and general acceptability - tends to raise all scores to about the same level. The latter approximates to that attained by treatments III and IV in the fresh material.

(c) Cooking Losses

Total loss of weight during the cooking of sirloin and topside roasts, and rump grills, are recorded in Table 2. Each entry in the table represents in general the mean data from six sides. There is no consistent effect of treatment on cooking losses from topside or rump grill but the loss of water and the total loss from the sirloin roast decrease as the period of holding increases. This is in agreement with the finding of Moran and Smith (1929) in relation to holding at 5°C.

(d) Objective Biochemical Measurements

Data on the effects of the various prefreezing holding treatments on soluble nitrogen, carnosine and anserine (in extracts),

hydroxyproline, alkali-insoluble protein and ultimate pH are summarised in Table 3.

Although there appear to be no progressive changes in soluble nitrogen due to the series of treatments, indicating no appreciable increase in the degree of proteolysis with increased time and temperature of holding, nevertheless peptides are broken down, since the quantity of carnosine/anserine in extracts diminishes in proceeding from treatments I to IV. The effect is statistically significant, (IV < I,** II* and III*).

As might have been anticipated, the holding conditions do not affect hydroxyproline concentrations.

Since alkali-insoluble protein is reported to measure collagen and elastin (Lowry, Gilligan and Katersky, 1941), the finding that the mean content was less in Grade 1 than Canners (1.71% and 1.91% respectively) was not unexpected. It will be noted from Table 3, however, that, with Grade 1 beef, alkali-insoluble protein increases in proceeding along the series of holding treatments from I to IV. Hypoxanthine - the end product of nucleotide breakdown - also increases with increased time and temperature of holding.

Although differences in ultimate pH, due to the holding treatments, are not statistically different, values increase with increased time and temperature of holding in the same sequence as with other features mentioned above.

(e) Time-temperature Relationships

Carcasses of Grade 1 beef cool more slowly than those of Canner quality and the mean temperature of a carcase at any given time remains appreciably higher in the Grade 1 than in the Canner for a time of the order of 2 days from slaughter (i.e. 1 day's chill and 1 day's holding at 0°C). On the other hand, if the carcases are transferred from 0°C to 20°C at the end of two days the response by the Canner carcases is much more rapid than by the Grade 1 so that the mean temperature over the period 48 to 96 hours (i.e. in the period between treatments I and IV) is greater for the Canner than the Grade 1 carcases. These findings would be predicted by virtue of the greater difficulty of heat exchange in the Grade 1 due to size and fat coverage.

DISCUSSION

An interesting feature of the results is the progressive nature of the changes in eating quality, in the tendency to drip and in certain biochemical criteria with a progressive temperature-time sequence - namely, no holding, holding for 3 days at 0°C, holding for 1 day at 0°C and 2 days at 20°C and holding for 14 days at 0°C; (the last two conditions being not greatly different). Such findings indicate that the organoleptic and water retention changes may have a common biochemical origin.

From this point of view, the proportionately greater increase of tenderness (and of overall acceptability)(Fig.2), and the proportionately greater decrease in Quarter Drip (Fig.1) in Canner sides than in those of Grade 1, when both were exposed to identical holding conditions, requires comment. During the first 24 hours after slaughter (when all sides, irrespective of subsequent holding treatment, were placed in a commercial chiller at 0°C) the greater ease of heat exchange made possible by the small bulk and limited fat insulation of Canners caused the mean temperature in the latter to be considerably lower than that of Grade 1 sides (as mentioned above). Thus, it is to be expected that at the end of 24 hours'

chilling post mortem biochemical and biophysical changes will have proceeded further with Grade 1 sides than with Canners; so that the basal condition (Treatment I), on which other treatments are superimposed, will show a greater departure from the in vivo state with the Grade 1 than with the Canner carcases. Inspection of the data suggests that tenderness (and acceptability) tends to increase (and Quarter Drip to decrease) asymptotically, presumably indicating that the changes are limited by the attainment of a definite equilibrium value not greatly dependent on grade. (Hoagland and co-workers (1917) found tenderness reached a maximum after 2-4 weeks' ageing and Harrison (1948) that aroma and flavour scores reached maxima after 10 days at 1-2°C. Consequently it may be assumed that the extent of changes subsequent to treatment I. will depend on how far they have already proceeded in the basal condition for the two grades. Applied treatments might thus be expected to have a greater effect with Canner than with Grade 1 carcases, and it is unnecessary to postulate that there is any fundamental difference between the grades in their post mortem biochemical behaviour.

Presumably
The changes brought about by holding treatment in eating quality and water holding capacity arise from alterations in the protein molecules. On the other hand, it is obvious that no intensive breakdown into smaller units takes place since no significant increase in soluble nitrogen occurs and ~~at least, in the case of holding treatments,~~ amino acid changes are limited to a breakdown of carnosine/anserine. This supports earlier contentions that proteolysis plays little part in post mortem conditioning (Hoagland, McBryde and Powick, 1917; Wierbicki, Kunkle, Cahill and Deatherage, 1956).

An unexpected practical aspect of the present work has been the increase in tenderness, meat flavour and overall acceptability (especially of Canner beef) effected by the process of commercial freezing. As a result, the palatability of unaged beef (or of that aged for only three days at 0°C), as measured by these three attributes, has been increased close to the level of material conditioned for two days at 20°C or for 14 days at 0°C. Even so, however, there is still evidence that conditioning effects are additional to those effected by freezing and the overall acceptability of the conditioned fresh beef is superior to that of the conditioned or non-conditioned frozen beef. Moreover, the process of freezing is associated with a definite loss of meat odour. In earlier work (Howard and Lawrie, 1956: Bouton, Howard and Lawrie, 1957), freezing and frozen storage have been shown to reduce juiciness of unconditioned carcases, and in the present work the effect, though not statistically significant, is in the same direction. Therefore, while ordinary commercial freezing would appear to be almost as effective as 14 days' holding at 0°C in increasing tenderness, the loss of other attributes of eating quality and, of course, the occurrence of drip on thawing, would offset this advantage. On the other hand, if beef has to be frozen, the diminution in drip on thawing, and in cooking losses, might commend a period of conditioning, despite the greater evaporative losses which would be entailed and the space involved.

Respecting the efficacy of a short period of holding at relatively high temperature in comparison with a rather longer period just above the freezing point, the value of storage space saved by the former would have to be considered in relation to high evaporative losses, especially from Canner sides. A temperature of 20°C over two days is also associated with considerable darkening of exposed meat surfaces.

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Table 1. Allocation to various holding treatments of sides subsequently examined fresh or after frozen storage

FRESH					
GRADE 1			CANNER		
Carcase No.	Treatment L	R	Carcase No.	Treatment L	R
1	III	II	5	I	II
3	I	IV	7	III	IV
9	IV	III	13	I	III
11	II	I	15	IV	II
17	III	I	21	III	II
19	IV	II	23	I	IV

FROZEN					
GRADE 1			CANNER		
Carcase No.	Treatment L	R	Carcase No.	Treatment L	R
2	II	IV	6	I	III
4	III	I	8	IV	II
10	II	III	14	III	IV
12	I	IV	16	I	II
18	II	I	22	I	IV
20	III	IV	24	III	II

Key - Treatments of sides (after 24 hours in chill at 0°C).

I. Examined or transferred direct to freezer from chiller.

II. 3 days at 0°C.

III. 1 day at 0°C + 2 days at 20°C.

IV. 14 days at 0°C.

Table 2. Effect of prefreezing holding conditions on cooking losses
(Losses given as % weight before cooking)

TREATMENT	JOINT		
	Sirloin (Roast)	Topside (Roast)	Rump (Grill)
No holding	34.9	40.2	40.3
Held 3 days at 0°C	34.5	41.9	40.2
Held 1 day at 0°C and 2 days at 20°C	33.3	43.4	39.1
Held 14 days at 0°C	28.2	40.7	39.8

Table 3. Effect of prefreezing holding conditions on various object measurements

	TREATMENT			
	I. No Holding	II. Held 3 days at 0°C	III. Held 1 day at 0°C and 2 days at 20°C	IV. Held 14 days at 0°C
Soluble Nitrogen[1] (as % total N)	7.19	8.17	7.36	7.17
Carnosine/Anserine[2] (arbitary units)	52.0	41.2	33.0	39.5
Hydroxyproline[1] (mg/100 gm)	99	112	107	99
Alkali-insoluble[1] Protein (as % wet wt.)	1.17	1.40	1.90	2.39
Ultimate pH[1]	5.46	5.53	5.55	5.56

1. Mean data from muscles of sirloin, topside and rump from 3 Grade 1 sides.

2. Mean data from TCA extracts of sirloin, topside and rump from 3 Grade 1 sides.

Fig. 1.

The effect of prefreezing holding conditions on weight losses from two grades of beef during thawing (● = Grade 1, O = Canner). Each point on the graph represents the mean of data from three sides. Methods used for determining Quarter, Butchers', Cube and Laboratory Drip have been published. (Howard, 1956a: Howard & Lawrie, 1957).

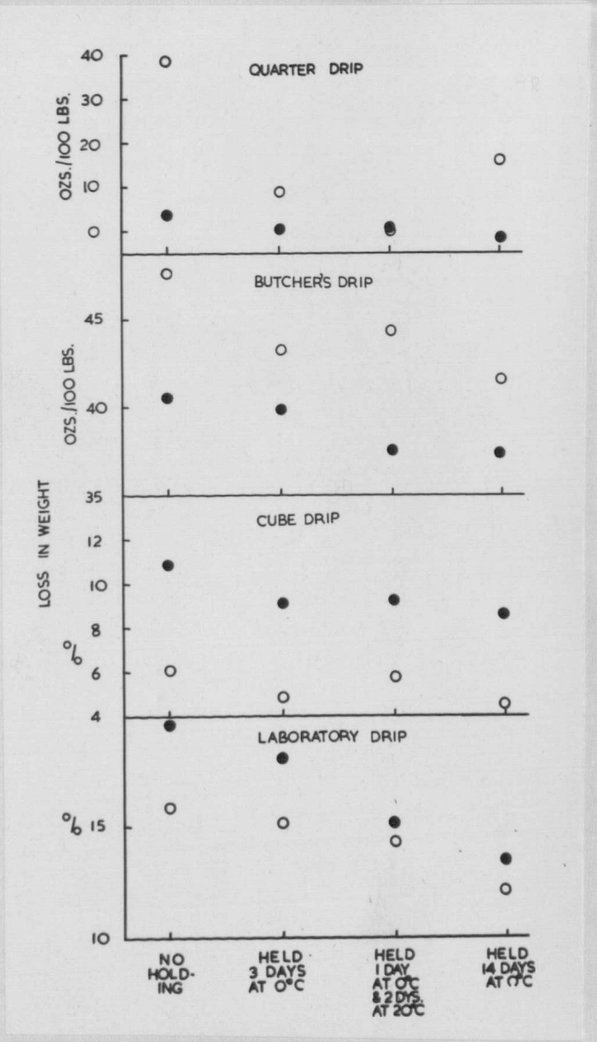
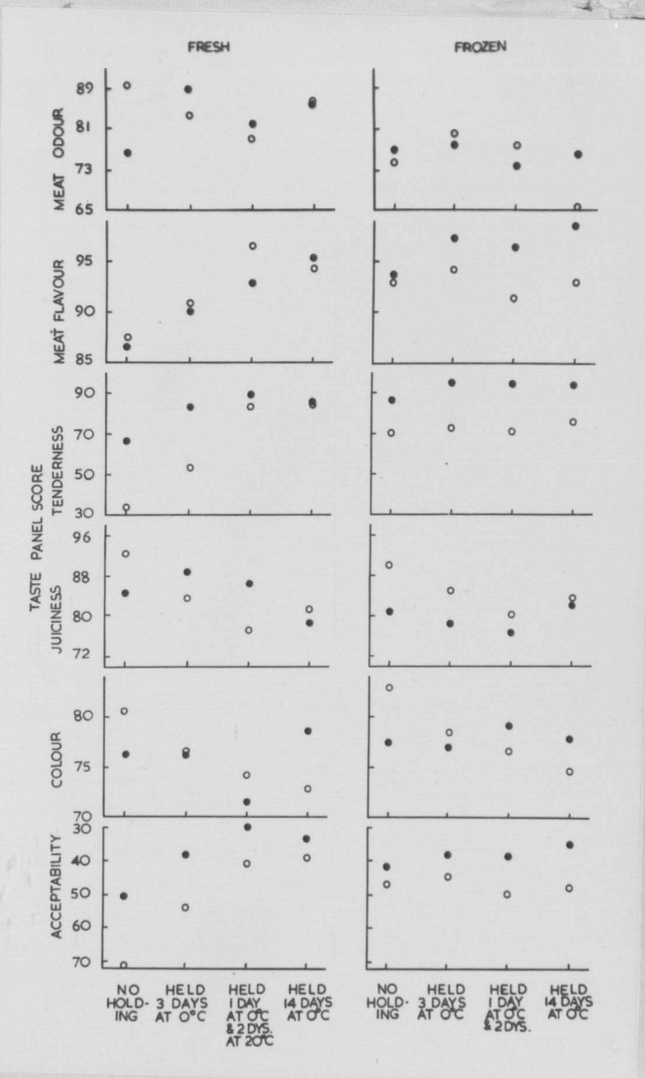


Fig. 2.

The effect of prefreezing holding conditions on the eating quality of two grades of beef, tasted fresh and after storage at -10°C for 18 weeks. Each point represents the mean (three sides) total score given by a taste panel of six members to a roast from sirloin and topside and a grill from the rump. The method of tasting has been published. (Howard, 1956b) (● = Grade 1, O = Canner.)



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