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Meat Industry Research Institute of New Zealand

By N. H. Law
Meat Industry Research Institute of New Zealand Inc., P.O. Box 617, Hamilton, N.Z.

The Meat Industry Research Institute of New Zealand Inc., which is one of several research associations connected with the New Zealand Department of Scientific and Industrial Research, has now been in existence for over eight years. In this article the Director, Mr. N. H. Law, describes the facilities available and outlines past and current research activities of the Institute.

THE need for a meat research institute in New Zealand had been recognized for many years, but it was not until 1946 that preliminary discussions aimed at establishing one were held. At that time, when the end of the Bulk Purchase Contract with Great Britain was in sight, it was recognized that the question of maintaining or even improving upon the high standard of quality of New Zealand meat was urgent, in view of the fierce competition expected in the export market following the restoration of normal meat marketing procedures.

The Institute was formally incorporated in 1955, under the Incorporated Societies Act 1908, and began operations on a moderate scale in 1957, occupying temporary accommodation in the Dominion Laboratory of the Department of Scientific and Industrial Research at Lower Hutt, near Wellington. The opening of its new, modern laboratories in Hamilton was an important milestone, and these new laboratories are a fitting tribute to an industry that is constantly striving to maintain its high reputation in the meat markets of the world.

MANAGEMENT

The activities of the Meat Research Institute are broadly controlled by a management committee, referred to as the Executive. This comprises three representatives of the North Island Freezing Companies' Association, three representatives of the South Island Freezing Companies' Association, three representatives of the New Zealand Meat Producers' Board, and two representatives each from the Department of Agriculture and the Department of Scientific and Industrial Research. The New Zealand Association of Bacon Curers became an affiliated member of the Institute in 1960.

The Institute carries out research of a more general or fundamental nature than can be undertaken by scientific staffs of individual freezing works. It does not, therefore, duplicate a service already in existence, but provides an organization through which the industry may reap the full benefits of scientific knowledge and collaborative research. Its income is derived from contributions and levies from the industry and a subsidy from the Government. As with all such research associations in New Zealand, the Government subsidy matches the total income derived from industry on a pound-for-pound basis, up to a limit fixed by Cabinet on the recommendation of the National Research Advisory Council. During the eight years or so of its existence, the Institute's annual income has risen from £NZ50,000 to £NZ87,000.

THE LABORATORIES

The new laboratories of the Meat Industry Research Institute are located close to the Ruakura Agricultural Centre, Hamilton, and were officially opened by His Excellency the Governor-General, Viscount Cobham, on March 4, 1961. They are situated on a 10½-acre site, chosen because of the local interest in animal production. This site is leased in perpetuity to the Institute by the Department of Agriculture.

The broad and comprehensive research interests envisaged for the Institute had a direct bearing on the planning of its new laboratories but further extensions were very soon required. The original concept involved five departments—Biochemistry, Home Economics (Quality Evaluation), Microbiology, Product Development, and Engineering. After completion of the laboratory, and following upon a review in 1963 of the programme of research, extensions were recommended to provide facilities for refrigeration research and for electron microscopy, instrumentation, and biophysics. These extensions were officially approved, and the new sections will be in operation by 1966 or 1967.

The main building is approximately 16,000 sq ft in area, and houses the original biochemical, microbiological, and engineering laboratories, together with offices, stores, and a library. A functional electron microscope suite of some 1050 sq ft, in which will be installed an E.M.200 electron microscope, is being erected near the main building; and a refrigeration research unit of some 2000 sq ft for low-temperature studies is being constructed adjacent to a local meat export works. One wing of the main building is being extended to accommodate an enlarged home economics unit. The area vacated will be converted into a biophysics laboratory.

In the design of this building, emphasis was given to an adequate fusing of functional and aesthetic requirements, and this constituted a challenge of some magnitude to the architect. The manner in which the problem was solved ranks the laboratory high among similar edifices whose specialized function has dictated a particular constructional form. The exterior form of the buildings directly reveals some of these functional requirements: laboratory widths dictated column spacings; stud heights dictated the location of slab levels; the number of laboratories conditioned the length of the buildings; and light requirements determined window areas. To satisfy these functional demands while retaining a pleasing appearance for the building, means were chosen to contribute texture and contrast to the exterior, which as a consequence is enlivened by the play of shadow across the facade.

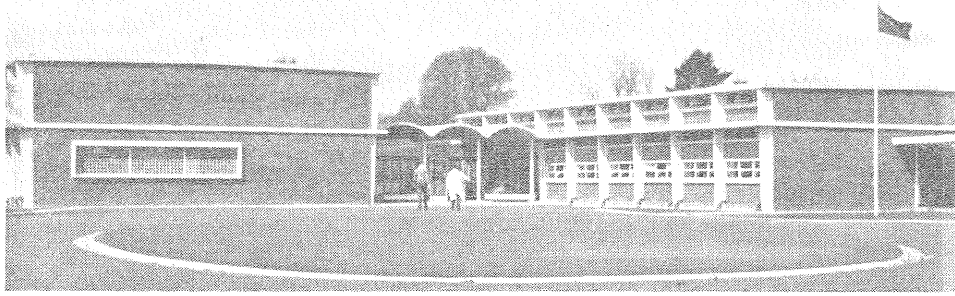
Each laboratory incorporates features that represent the most modern thinking in laboratory design, including floor heating, facilities for unit refrigerated storage, auxiliary rooms conditioned at high and low temperatures, and individual control of mechanical services. In addition, there is a well-equipped workshop, along with all the other engineering facilities required, and there are two refrigerated cold stores capable of operating over the temperature range $-40°F$ to $+40°F$.

POLICY AND OBJECTIVES

The aims of the Meat Industry Research Institute are to foster, promote, and undertake research on all matters appertaining to meat and the meat industry, whether in New Zealand or overseas. The word "Industry" was deliberately included in the Institute's title in order to stress the extent and scope of its research interests. It is the central research organization of the entire New Zealand meat industry—an industry that collectively, even by world standards, is very big indeed. In 1960, when the Institute moved to Hamilton from Wellington, the establishment consisted solely of five research officers covering biochemistry, microbiology, and engineering, and there were three technicians. At that time the research programme undertaken was necessarily restricted in scope owing to the staff's limited knowledge of the industry and to the difficulty the industry itself had in defining its own problems. From experience gained over the years, and through the guidance and assistance given by the Technical Consultative Subcommittee in formulating annual research programmes, it became increasingly evident that the 1960 concept of the function and future of the Institute required modification. The demands of industry on the Institute had increased at such a pace that there was a definite need in 1963 not only for a review of the research programme, but also for extending and broadening the scope of the research to be undertaken by the Institute. This necessitated an increase in personnel, which now stands at 24.

In a recent publication on research management in the United Kingdom,* definitions were given for pure and objective basic research and applied research. Pure basic research was defined as work carried out to

* Report of the Committee on the Management and Control of Research and Development. (H.M.S.O., 1961.)



The Meat Industry Research Institute of New Zealand Inc.

increase scientific knowledge. Objective basic research was defined as basic research relevant to a definite technological objective. Applied research was defined as work with a definite practical goal. By these definitions the work that the Meat Industry Research Institute listed as basic research in the 1963–68 research programme was, in the main, objective basic and applied research. The term basic research is applied to all of it, not to indicate the lack of immediate objectives, but to emphasize the approach of the Institute towards its work. The proportion of pure basic research in the programme relative to objective basic and applied research is low indeed, but its mere presence indicates the desirability of opening up new fields of activity when the opportunity presents itself.

From its inception, the Institute has eschewed empirical research in favour of an approach as fundamental as the facilities and abilities of the staff allow. The success of the Institute and the future technological status of the industry will depend in no small measure on the continued observance of this policy.

RESEARCH ACTIVITIES

The formal research programme of the Institute has been prosecuted with enthusiasm right from the beginning. There is an increasing awareness that unless a meat research worker can show that his results are fully consistent with and understood in terms of present knowledge of muscle physiology and biochemistry, there is little prospect of his being able to project and expand his findings and thus help to make meat research a clearly defined and productive science. An enlightened blending of fundamental and applied studies is called for, together with a constant reassessment of the Institute's relationship with the New Zealand meat industry so as to maintain and cement a mutual harmony of interest; also, interest in animal production research at sister research organizations should be expanded. The Institute has endeavoured to meet these requirements by initiating collaborative studies with the Ruakura Agricultural Research Centre and with the Massey University of Manawatu.

In New Zealand the meat industry is passing through an intensely interesting phase of experimentation and reorganization aimed at improving the quality of its products for export. The concept of the importance of quality rather than quantity is gaining ground, and is not confined to the meat industry. There is an increasing awareness amongst those responsible for animal production that the quality of our meat exports is dependent initially on the production of good-quality livestock—the quality requirements being determined by consumer demand. The recognition by both producer and processor of the need for a common policy in meeting current overseas requirements is an interesting development in New Zealand, and offers exciting prospects of dealing confidently with our competitors abroad.

Collaborative Projects on Meat Production

The trend towards collaboration of producers with processors is already having interesting repercussions on the work being undertaken by the Institute. Owing to its very close association with the industry, the Institute can be expected to reflect such trends in its work more than other research organizations with similar interests but less favourably placed. Nevertheless, the increasing collaboration between the scientists of the Ruakura Agricultural Research Centre and the staff of the Institute amply illustrates the developing mutual interdependence of the agriculturist and the meat scientist. This is a heartening development, and is basically sound.

At present the following projects, of importance to producers and processors alike, are subjects of joint collaborative effort: the control and elimination of salmonellas (Nottingham and Urselmann 1961); the production of lighter and leaner lambs for the export trade; the effect of the sire on the palatability of meat of its progeny; and the evaluation of the relative palatability of bull and steer meat.

Research associated specifically with meat tenderness has been undertaken by the biochemistry and home economics sections of the Institute over the last two to three years, and is another instance of the contribution the Institute is making towards an industry sensitive to the need for marketing a quality product. This project required much detailed background research into the many aspects of meat structure.

Technological Research

It is often difficult to determine where research ends and development begins, but industrial research covers a very wide range of activities, and if the closely related developmental function is added the scope is even greater. The Institute's research programme has never remained static but continues to enlarge, and this surely indicates that research is making a significant contribution to the technical progress of the New Zealand meat industry.

In support of this contention some of the studies that have been undertaken and completed by the Institute may be mentioned. These include the identification of the cause of bone taint in beef and its control (Nottingham 1960); physical aspects of freezing and packaging of boneless meats (Earle 1959); studies on boiler performance and recommendations on the storage of heat as an economic measure (Earle 1960*b*); development of a continuous spray washer for conveyor belts, so as economically to improve hygiene in the handling of cut meats (Macfarlane and Nottingham 1963); an evaluation of the effectiveness of solid carbon dioxide for cooling railway wagons (Earle 1963); thermal conductance of some packaging materials in relation to the design of light-weight cartons (Macfarlane 1963); and a heat-conservation survey, the first part of a broader study aimed at reducing increased costs consequent upon the greater quantities of hot water utilized in conforming with the new Meat Inspection Regulations (Fleming 1964).

This year the Institute proposes to establish an instrumentation section and a refrigeration research unit. The instrumentation section will be responsible for introducing physical controls on established processes, so as to improve the uniformity and reproducibility of products. The refrigeration research unit will aid in studying the physical aspects of freezing meat as well as providing data helpful to plant design and operation. Its establishment is timely, considering that the economic welfare of New Zealand is dependent on the efficiency of the chilling, freezing, and refrigerated storage of its primary products.

Engineering research has always been and always will be of considerable interest to the meat industry, for it usually has short-term objectives and can be exceedingly profitable. In recent years the engineering group has directed its attention to investigating the physical aspects of freezing meat in cartons, the calorimetric properties of carcass meats, automatic weighing (Earle 1960*a*), steam surveys, cooling-floor studies, the transportation of frozen meat in railway wagons, and heat economy and conservation. Work being done on the measurement of rates of heat transfer to objects cooling in an air stream is of particular importance (Earle 1962), since when sufficient data have been acquired accurate prediction of surface heat transfer rates to carcasses should be possible. The new refrigeration research facility will prove of immense value in developing this work.

Meat Quality

A current interest of the biochemistry section is a study of changes in meat tenderness induced by variations in treatment *post mortem*. It has been reported that the tenderness of meat may be determined largely by the extent of *rigor mortis* at the time of "cold-shock" application. This effect has been investigated further (Locker 1959, 1960*a*; Locker and Hagyard 1963; Marsh 1964; Marsh and Thompson 1958), and it is now apparent that the zone of toughness development is associated more directly with intermediate shortening values than with a particular phase of *rigor* onset. This phenomenon is of particular interest, since the elucidation of its mechanism would clarify considerably our knowledge of meat tenderness.

Associated with these investigations on meat tenderness are chemical, physical, and histological studies of meat (Davey 1960, 1962; Locker 1960; Marsh 1959, 1960). From evidence obtained so far, it is tempting to suggest that variations in tenderness in meat can be explained in large part by the extent of bonding between actin and myosin. This possibility offers a promising avenue of investigation of meat texture at the sub-microscopic level.

From electron-microscopic studies, a hypothesis of how muscle shortens during activity has been propounded. Myosin extracted from batches of iodoacetamide-treated myofibrils of differing degrees of contraction has been examined viscometrically for its actomyosin-forming ability. Results so far show that myosin extracted from contracted myofibrils retains its ability to form actomyosin, but myosin extracted from treated myofibrils isolated from stretched muscles has little ability to form actomyosin. This observation is in accordance with the sliding filament theory of muscular contraction. A study of the subunits produced by carboxymethylation and acetylation on myosin has been greatly assisted by the use of the ultracentrifuge, and has contributed valuable information towards elucidating the structure of this protein, one of the principal proteins of muscle.

Regardless of its nutritional excellence, meat will be consumed in adequate and increasing quantities only if it appeals to the palate of the consumer. The evaluation of the eating quality of cooked meat, mainly by taste panel techniques, is an essential part of the work of the home economics unit. A quick and objective method of measuring tenderness, a most desirable quality, has been developed. It is used extensively in all these studies but, despite excellent correlation between panel and tenderometer performance, the panel is always accepted as the final arbiter. A further interest of the home economics unit is the science of cooking, and studies have been made on the effects of thawing periods and cooking temperatures on cooking times, cooking losses, and palatability of meat cuts (Woodhams and Mathews 1965; Woodhams and Ridall 1963). Information from these studies is likely to be immensely important to overseas promotional agencies responsible for establishing new markets for New Zealand meat.

The importance of microbiological quality in respect of meat is due to two main factors. Meat is an ideal substrate for the growth of many types of microorganisms, whether they be aerobes, anaerobes, saprophytes, or pathogens. During slaughter and dressing there is ample opportunity for meat to be exposed to the risk of contamination with some of the vast number of organisms associated with the skin and intestines of the animal; contamination from other sources, human and environmental, must also be expected. Microbial contamination of meat can result in spoilage, food poisoning, or the transmission of disease.

In addition to undertaking qualitative studies of microbial flora on various types of meat and conducting *Salmonella* surveys and investigations, the microbiology department is becoming increasingly involved in the fundamentals of sanitation and disinfection to help industry meet the stringent requirements of overseas markets (Nottingham 1963, 1964).

BY-PRODUCTS

In recent years the Institute has become increasingly aware of the potential value of meat trimmings and by-products, which hitherto were sent to the digesters for tallow recovery and for the production of stockfoods and manure. The high protein and low fat content of some of these materials has justified investigations leading towards the recovery of edible protein (Stafford and Cameron 1965). These investigations have included a quantitative study of the viscera during growth of sheep and cattle, in association with the Ruakura Agricultural Research Centre. Romney, Southdown, and Romney/Southdown crossbred sheep have been studied

The home economics section is equipped with cooking and other facilities for the quality evaluation of meat.

from 11 weeks of age to maturity; Aberdeen Angus steers at 18 months and 2 years. The recovery of tripe from lambs and its conversion into a high-protein dried powder for incorporating into low-protein diets have also been studied.

This year the Institute accepted one further responsibility by establishing a meat trade wastes research group. The treatment and disposal of trade effluent is proving an increasing and costly burden on the meat industry. The complexity and challenging nature of this problem will call for maximum ingenuity and skill from a team now being formed, comprising a microbiologist, a chemist, and a chemical engineer.

INFORMATION SERVICE

In addition to the principal activities of the Institute, comprising basic and applied investigations, a broad and comprehensive programme of industry education is also carried out. A Meat Industry Research Conference is held annually, and scientific information is disseminated through the medium of the bi-monthly *Technical Digest* and technical reports. Considerable importance is attached to maintaining good public relations with the industry. To this end, research projects are placed in individual works whenever practicable, and the staff are also encouraged to visit members for consultations.

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Weight Losses of Cattle prior to Slaughter

By W. R. Shorthose
Division of Food Preservation, CSIRO, Ryde, N.S.W.

The extent of the economic loss due to weight losses during transport of cattle from a property to the meatworks and throughout any holding period has been the subject of much debate, and various methods of selling slaughter animals have been advocated. One reason for this is a lack of appreciation of the source and relative economic importance of weight losses observed in live cattle. Another is the limited factual information available and the wide diversity apparent in the weight losses cited in the few published reports on this subject. Little work has as yet been carried out on this topic in Australia, but in this article Dr. Shorthose reviews data obtained in Australian and overseas investigations.

SOURCES OF LIVE-WEIGHT LOSS

The live weight of an animal is the sum of the weight of body tissues and the weight of gut and bladder contents. Loss of weight of the animal in transit from the growing area to the meatworks is made up of:

- Faecal, urinary, and moisture losses, which affect the monetary value of the animal only in special circumstances.
- Changes in weight of the viscera, which also affect the value of the animal only slightly.
- Loss in carcass weight, which is the major source of economic loss caused by live-weight losses.

Faecal, Urinary, and Moisture Losses

Though animals in transit are deprived of feed and water for varying periods, they continue to defecate and urinate, often more frequently than normal, and these uncompensated losses result in a loss in live weight. Defecation and urination usually occur at a maximal rate in the early stages of transport and become slower as the amount of ingesta and water remaining declines, and as remaining water is conserved by the animal.

Losses in live weight due to loss of water also occur during sweating and respiration. No estimate of moisture loss due to this cause has been made—it could be a large proportion of the total losses in live weight, but is likely to vary markedly according to the prevailing ambient temperature and relative humidity.

Loss of Carcass Weight and Change in Weight of Viscera

An animal in transit will begin to lose weight from body tissue when the quantity of nutrients absorbed from its gut falls below the level necessary to support its physiological activities. In ruminants such as cattle and sheep considerable amounts of ingesta may be stored in the rumen, and in these animals the physical condition referred to will be attained later in time than in single-stomached animals, such as pigs. Loss of weight due to depletion of body tissues would be expected to increase with the period of food deprivation. This has been shown to be true for lambs: loss of carcass weight was found to be a nearly linear function of fasting time, and for up to 4 days of fasting occurred at a rate equivalent to approximately 1·5% of initial carcass weight per day (Starke 1948).

The extent of loss of body tissue would depend on the lapse of time since the last feed prior to transport, on the quantity and type of feed consumed at that time, and on the metabolic rate and activity of the animal. During transit, most animals would have a higher metabolic rate than normal, and excitable animals a considerably higher rate.

Little information is available on changes in the weight of viscera during transport, but a general loss might be expected. It is known, however, that in certain circumstances an animal's reaction to transportation may cause an increase in its liver weight.

INVESTIGATIONS INTO LIVE-WEIGHT LOSSES OF CATTLE

Investigations on losses in live weight of cattle are particularly important when the animals are sold on a live-weight basis, though loss in carcass weight cannot be calculated from observed changes in live weight. In the U.S.A., cattle are often sold on live weight, and weight losses during transit are allowed for by deducting from the original live weight a standard percentage ('pencil shrink'), appropriate to the class of cattle being sold. Comparisons of actual loss of live weight with the 'pencil shrink' allowance are informative, since they have financial import when this system is in use.

Factors that exert an influence on the amount of live weight lost by an animal do so for the most part by affecting the loss in weight ascribable to excretory products. These factors may be grouped according to whether they exert their effects before removal of the cattle from the property, during their transport from the property, or while they are being held at the meatworks prior to slaughter. Losses during these three phases must clearly be interrelated, but no comprehensive study on this aspect has been published.

Losses prior to Removal from Property

Clearly, any factor that influences the weight of gut content, or 'fill', when the initial weights of the animals are recorded prior to transport is likely to influence the extent of subsequent live-weight loss. Since live-weight losses are usually expressed as a percentage of initial weight, all such data are affected by initial variations in the weight of the gut content, and comparisons of data from different studies could be seriously vitiated by these initial variations.

The *potential* fill of any group of animals is related to their live weight, sex, and previous nutritional history. Pasture-fattened cattle can have a greater fill than lot-fattened cattle of equal initial live weight, and could consequently lose more weight in transit (Ward 1913; Anon. 1964). The *actual* fill, however, will be affected most by the lapse of time since the last feed or drink. In experiments on weight losses of lot-fed cattle, it is relatively easy to determine and standardize the interval between the time of the last feed and the time of weighing prior to transport, and this permits the effect of other factors on weight loss to be assessed with greater accuracy. In groups of pasture-fattened cattle, however, weighing of the animals a fixed time after removal from pasture will not ensure a uniform fill, owing to variation in the grazing pattern of the animals; wide variations in grazing times occur on account of seasonal and other environmental factors. The accuracy with which the effects of further treatment may be assessed is consequently reduced. Reported seasonal variations in loss of weight in transit may thus only reflect variations in the grazing behaviour of the particular cattle studied.

Transport Factors

There is little information on the live-weight loss of cattle walked to slaughter, although some estimates are given by Allen, van Holst Pellekaan, and Bodle (1959). Available evidence on live-weight losses of cattle transported by road or rail indicates that time in transit has a greater effect on live-weight loss than distance travelled. This

Table I

Effect of Distance and Time in Transit on Percentage Loss of Live Weight of Yard-fattened Cattle transported by Road to 'First Market'*

Distance (miles)	Av. Loss (% of initial live wt.)	Range of Percentage Loss†
0–14	1·41	0·75–2·97
15–24	1·49	0·48–3·90
25–34	2·14	1·18–3·36
35–200	2·24	1·52–4·10
Time (min)		
0–34	1·36	0·75–2·45
35–69	1·16	0·64–2·17
70–104	1·51	0·48–3·36
105–144	2·18	0·74–3·90
145+	2·30	0·79–4·10

* Henning and Thomas (1962).

† Percentage loss in live weight is the loss in weight expressed as a percentage of initial live weight. The range of percentage loss represents the percentage loss of the groups of cattle with the lowest and highest loss respectively.

Table 2
Effect of Prior Feeding and Watering on Live-weight Loss in Transport*

Distance (miles)	Av. Loss in Live Wt. (% initial wt.)		Difference (% wt. loss of fed cattle)
	No Feed†	Feed‡	
0–24	1·23	1·85	33·5
25+	2·12	2·40	11·7
Time (min)			
0–34	—	1·36	—
35–70	0·97	1·43	32·2
71–104	1·28	2·07	38·2
105–144	1·76	2·47	28·7
145+	2·17	2·83	23·3

* Henning and Thomas (1962).

† No feed or water available for approx. 16 hr before weighing.

‡ Feed and water available up to time of weighing.

is to be expected, as animals would defecate and urinate more in the longer time.

A comprehensive study of factors affecting live-weight losses in yard-fattened cattle conveyed up to 200 miles by road transport was carried out in the United States of America by Henning and Thomas (1962), and some of their observations are reproduced in Tables 1 and 2. Over the range of distances and transit times indicated, the lowest average loss in live weight recorded among the groups was 0·48%, and the highest 4·10%, calculated from initial live weight (Table 1). Table 2 shows the results obtained when cattle were rested overnight with or without food and water prior to trucking. It may be seen from the last column in Table 2 that about a third of the variation in live-weight loss is accounted for by differences in fill. This fraction would be expected to be higher still in pasture-fed cattle.

The results of a limited study on live-weight losses of pasture-fed cattle transported somewhat longer distances by road (Luther, Embry, and Whetzal 1961) are given in Table 3. These animals were allowed access to hay and water overnight, and were weighed 30 min before trucking.

Henning and Thomas (1962) have also given weight loss data on pasture-fed cattle. Twenty-two lots of such cattle were transported by rail over seven different routes, each of approximately 1400 miles and occupying a period of 5 days, with rest spells of at least 5 hr every 36 hr. The average live-weight loss in 12 lots of animals (617 steers) was 8·73%, with a range from 4·6% to 11·3%, and in another 10 lots (473 heifers) the average loss was 9·16% (range 6·5–15·9%).

The most comprehensive investigation into live-weight and carcass weight losses during rail transport was carried out on 5746 'young' cattle, 3089 bullocks, and 8448 cows in Italy (Salerno 1949). The animals were weighed at rail loading yards before transport, and again on arrival at the slaughterhouse after rail journeys of 1, 2, 3, or 4 days. No indication was given regarding the treatment of the animals prior to railing. The results of this study are summarized in Tables 4 and 5. Percentage loss of live weight was greatest in cows and equal in 'young' cattle and steers.

Ward (1913) gave figures for the loss of live weight in range cattle and in lot-fed cattle, which indicated that range cattle lost more weight than lot-fed cattle and that cows lost more weight than steers. When cows and steers were transported together, weight losses were higher for both sexes.

Treatment at Meatworks prior to Slaughter

The changes in the live weight of animals between arrival at the meatworks and slaughter will depend on treatment prior to arrival, the length of time the animals are rested, and whether they are fed or watered. In an early study, Ward (1913) found that the intake of feed and water by cattle arriving at a sale yard after transport was influenced by many factors, and a later report from

Table 3
Loss of Live Weight of Pasture-fed Cattle Transported by Road*

No. of animals	20	39	20	20
Miles trucked	240	300	240	140
Approx. transit time (hr)	6·5	8·2	6·5	3·7
Av. initial live wt. (lb)	588	557	637	579
Av. live-weight loss (% initial live weight)	6·27	6·67	5·08	2·11

* Luther, Embry, and Whetzal (1961).

Table 4
Loss of Live Weight of Young Cattle, Bullocks, and Cows during Rail Transport for 1,2, 3, and 4 Days*

	1 Day			2 Days			3 Days			4 Days		
	Av. Initial Wt. (lb)	Av. Final Wt. (lb)	Av. Loss of Live Wt. (%)	Av. Initial Wt. (lb)	Av. Final Wt. (lb)	Av. Loss of Live Wt. (%)	Av. Initial Wt. (lb)	Av. Final Wt. (lb)	Av. Loss of Live Wt. (%)	Av. Initial Wt. (lb)	Av. Final Wt. (lb)	Av. Loss of Live Wt. (%)
Young cattle	871	791	9·21	874	783	10·56	867	754	13·16	—	—	—
Bullocks	1583	1442	8·84	1577	1407	10·76	1592	1396	12·32	1633	1409	13·64
Cows	1129	1014	10·14	1150	1009	12·34	1139	971	14·81	—	—	—

* Salerno (1949).

South Africa indicated the extent of live-weight changes that can occur in this period in particular circumstances (Bisschop and Hirzel, unpublished data, cited by Starke 1948). These two investigations further illustrate the influence of fill on live-weight changes, and the care that must be taken in drawing conclusions from live-weight data.

Some of the results of Bisschop and Hirzel are given in Table 6. In this investigation, 24 cattle, previously railed for 48 hr, were divided into three groups that were successively killed 18, 66, and 114 hr after the animals arrived at the meatworks; during these intervals they were allowed access to water but not to feed. Because of their water intake, animals in the first two groups actually gained weight during the pre-slaughter intervals, but those in the third group did not lose weight; the weight of the gut contents was similar at slaughter in the three groups.

LOSS OF CARCASS WEIGHT

Transport Factors

Studies have been made, though not without difficulty, of the loss of carcass weight during transport from property to slaughter. Investigations of this kind would be much simplified if a mob of cattle could be divided on the hoof into groups of animals with equal carcass weights, these groups then being transported for different periods and their carcass weights determined after slaughter. However, the errors in any system

Table 5
Percentage Loss of Live Weight and Extent of Increase of Loss in Animals railed for 1, 2, 3, and 4 Days*

	1 Day % Loss	2 Days % Loss	Difference 1–2 Days	3 Days % Loss	Difference 2–3 Days	4 Days % Loss	Difference 3–4 Days
Young cattle	9·21	10·56	1·35	13·16	2·60	—	—
Bullocks	8·81	10·76	1·95	12·32	1·56	13·64	1·32
Cows	10·14	12·34	2·20	14·81	2·47	—	—

* Salerno (1949).

Table 6

Change in Live Weight of Cattle Rested with Water but no Feed at Meatworks after a 48-hr Journey*

Time between Arrival and Slaughter (hr)	Farm Live Wt. (lb)	Live Wt. on Arrival at Meatworks (lb)	Live Wt. just before Slaughter (lb)
18	1192	1020	1061
66	1219	1034	1053
114	1203	1018	1018

* Bisschop and Hirzel (unpublished data, 1948).

of prediction of carcass weight of a live animal are large in comparison with the losses in carcass weight that probably occur in transit.

One effective approach to the problem was that of Salerno (1949), who recorded the initial individual live weights of large numbers of animals and determined the carcass weights at slaughter of groups that had undergone various periods of rail transport. Since the total number of animals used and the number in each group were both large, the average initial carcass weight for the whole mob would have been close to the average initial carcass weight for each group. Comparisons among the average ratios of observed carcass weights to initial live weight for each group thus provided a valid indication of the differences in average loss in carcass weight from property to slaughter among these groups.

In Salerno's experiment 'young' cattle, steers, and cows were killed after 1, 2, 3, or 4 days of rail travel (the author gives no indication as to whether the animals were rested or fed and watered prior to slaughter). The 'killing-out' percentages (carcass weight at slaughter divided by initial live weight prior to railing) are given in Table 7. Salerno does not state whether the carcass weight used was the 'hot' weight or the 'cold' weight (i.e. obtained as soon as possible after slaughter, or after the carcass had cooled).

Table 7 shows that the reduction of 'killing-out' percentage was, under the conditions of the experiment, greatest in young cattle, less in steers, and least in cows. It can also be shown that the proportion of live-weight loss to carcass weight loss is greatest in young cattle and is least, by a significant percentage, in cows.

The only other information at hand on the subject of carcass loss due to live-weight loss in transit is an unpublished report by Mulhearn,* who compared the carcass yield of cattle killed in Gladstone and in Brisbane. In this work, 123 cattle (43 cows and heifers, and 80 young bullocks) were walked 50 miles

* Mulhearn, C. R.—Weight loss in cattle in rail transit. Unpublished report, Dep. Agric. Stock, Qd., 1956.

Table 7

Effect of Transport on Killing-out Percentage*

	Av. Killing-out after 1 Day (%)	Av. Killing-out after 2 Days (%)	Difference 1–2 Days (%)	Av. Killing-out after 3 Days (%)	Difference 1–3 Days (%)	Av. Killing-out after 4 Days (%)	Difference 1–4 Days (%)
Young cattle	48·51 (422)	47·49 (413)	1·02 (8·9)	46·92 (408)	1·69 (13·8)	—	—
Steers	48·47 (727)	47·85 (718)	0·62 (9·3)	47·14 (707)	1·33 (20·0)	46·64 (700)	1·83 (27·5)
Cows	44·75 (501)	44·12 (494)	0·63 (7·1)	43·69 (489)	1·06 (11·9)	—	—

* Salerno (1949). Figures in parenthesis indicate carcass weights and weight losses with initial live weights of 870 lb for young cattle, 1500 lb for steers, and 1120 lb for cows.

Table 8
Comparison of Carcass Yield of Cattle killed in Brisbane and Gladstone*

	Av. Initial Live Wt. (lb)	Av. Hot Carcass Wt. (lb)	Av. Killing-out (%)
Bullocks			
Gladstone	952	553	58·0
Brisbane	980	556	56·7
Cows and heifers			
Gladstone	812	430	53·0
Brisbane	879	451	51·3

* Mulhearn (unpublished data, 1956).

into Gladstone, the cows and heifers drafted at random into two mixed groups of 21 and 22 and the bullocks into four groups of 20. Two groups of bullocks and one group of heifers and cows were taken to a Gladstone meatworks and slaughtered; the other groups were railed to Brisbane, fed and watered, and rested for approximately 48 hr before killing. Hot carcass weights were recorded. The results are shown in Table 8. Transport to Brisbane reduced killing-out percentages by 1·3% for bullocks and 1·7% for cows and heifers; the carcass weight losses, expressed as percentages of carcass weights at Gladstone, were 2·26 and 3·49% respectively.

Pre-slaughter Holding

Information on carcass weight losses ascribable to the duration of the holding period prior to slaughter is available from the study by Bisschop and Hirzel already cited in relation to live-weight losses. The average carcass weight losses, expressed as percentages of the average 18-hr carcass weights, were 0·32% (18–66 hr) and 2·91% (18–144 hr).

DISCUSSION

The results of most of the experiments on live-weight losses reviewed in the preceding pages are illustrated in Figure 1. Since the evidence shows that time in transit affects live-weight loss more than distance travelled, losses are least in the most rapid form of transport. The influence of staging periods on weight losses during transport is not known, but it would appear probable that staging may increase live-weight losses, and carcass losses too. The sex of the animal is another factor: percentage live-weight loss is greater in cows than in steers or in bulls.

Studies of live-weight losses can provide only limited information on the economic loss from property to slaughter and, though more difficult to estimate, reduction in carcass weight is a more valuable indicator of financial loss. Carcass weight loss would be expected to be less, on a percentage basis, in heavier animals than in lighter animals.

Some idea of the extent and pattern of loss of carcass weight from property to slaughter may be obtained from Figure 2. The dashed portion of the lower curve indicates the approximate loss in carcass weight of steers transported by rail for 1 day, calculated from the data of Salerno (1949). The solid portion of the same curve corresponds to the total carcass weight loss that might be expected if the same cattle were held at the meatworks for 2 days, with feed and water, after a rail journey of 1 day (after Mulhearn).

The upper curve (Fig. 2) again uses data by Salerno (1949) to show carcass weight losses of steers in transit by rail for 2 days (dashed portion). The remainder of this curve is based on data of Bisschop and Hirzel and shows the expected total carcass weight loss if the cattle were then held for up to 114 hr, without feed but with water, after a rail journey of 2 days.

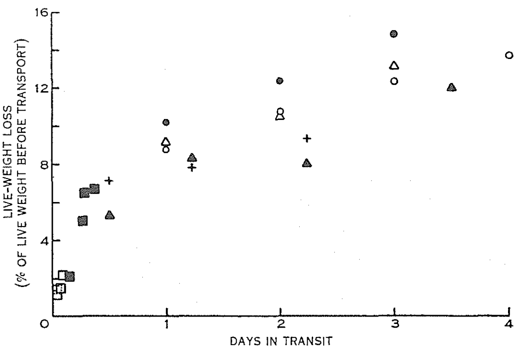

Fig. 1.—Reported live-weight losses, as a function of transit time, of various classes of cattle transported by road and rail. ■, *Henning and Thomas (1962);* □, *Luther, Embry, and Whetzal (1961);* △, *Salerno (1949)—young cattle;* ○, *Salerno (1949)—bullocks;* ●, *Salerno (1949)—cows;* +, *Ward (1913)—range cows;* ▲, *Ward (1913)—range cattle: cows and steers railed together.*

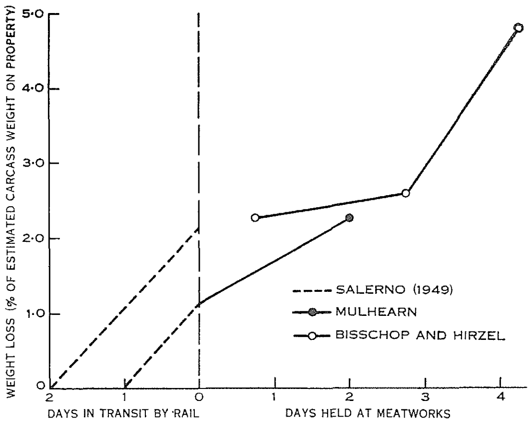

Fig. 2.—Estimated cumulative losses occurring in steers during rail transport and while awaiting slaughter.

The carcass weight losses in Figure 2 are expressed as a percentage of the calculated carcass weight of animals on the property. On this basis, an over-all average rate of carcass weight loss of approximately 0·75% per day is indicated for journeys of 1–2 days when followed by holding periods of 2–6 days. It should be emphasized, however, that this figure is very approximate, because the pattern and rate of loss differed considerably in the reports from which the data were drawn.

From data available at the moment it is clearly not possible to predict carcass weight loss accurately, and more information is needed on the extent of the losses in carcass weight that occur during transport and holding, and on factors that influence these losses. Without such information it is not feasible to devise a system of handling and transport that would ensure the minimum of carcass weight loss and the maximum return of high-quality meat.

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Bitterness in Cucurbits

By B. V. Chandler

Division of Food Preservation, CSIRO, Ryde, N.S.W.

In this short article Dr. Chandler discusses a problem that has at times caused concern to pickle manufacturers. The extreme bitterness sometimes encountered in cucurbits such as cucumbers and gherkins is not eliminated simply by processing them into pickled products. Fortunately, after such products have been stored for a few weeks, bitterness is imperceptible, even if initially it was very marked.

IN 1963 and 1964, several local processors reported that their pickled cucumbers and gherkins had a disagreeable bitterness that rendered them unmarketable. At the same time there were complaints of intense bitterness in other cucurbits, such as melons grown for eating fresh or intended for jam manufacture. The problem of bitterness in gherkins has occasionally reached serious proportions in Europe and America (Enslin 1954), while in South Africa the level of bitter principles in certain 'edible' cucurbits has been reported to be so high that serious illness, or even death, can result from their consumption by man or animal (Enslin, Joubert, and Rehm 1954).

The bitter principles in cucurbits have been identified as complex triterpenoid derivatives. These are present in the fruit either in the free state or in combination with sugars (see de Kock *et al.* 1963 for a recent discussion of the extensive chemical literature). Although much work has been done on the genetics of their occurrence and distribution (see Rehm 1960 for a full review of this subject), little advance has been made in eliminating these bitter principles from cultivated cucurbits, or in assuring an immediately acceptable processed product such, for example, as sweet or brined pickles. Because of the extensive literature on this general subject, this article will deal only with those aspects that concern the most commonly processed cucurbit, namely *Cucumis sativus.* However, much of the information is also relevant to the same problem in other cucurbits.

Up to 1957 it was generally accepted (cf. Barham 1953) that bitterness in cultivated cucumbers, as in other cucurbits, was derived from parent wild species through a single dominant gene. This gene was regarded as independent of other genes, since bitter fruit cannot be distinguished morphologically from non-bitter fruit. But the report of Rehm and Wessels (1957) that even non-bitter forms of cucurbits produce bitter seedlings indicated that bitterness is controlled not by a bitterness-producing gene but by another genetic mechanism, which is concerned with the elimination of the bitter principle. Prior to this observation it seemed likely that, by application of plant genetics, selection of non-bitter fruit for breeding purposes might provide a solution to the problem. Now it appears that the mechanism resulting in bitterness in fruits is so labile that fruit taste alone cannot be used as an efficient criterion for breeding purposes, and that absence of bitterness in the seedlings is the only reliable guide for selection of suitable strains.

Some idea of the difficulty inherent in this latter approach can be obtained by comparing an early statement by Enslin, Joubert, and Rehm (1954) with a later observation made by the same group. In the earlier report it was stated that most newly developed cucumber varieties never showed any degree of bitterness, even when cultivated under adverse conditions; whereas later (Rehm and Wessels 1957) it was concluded that all cultivated cucumber varieties studied had bitter seedlings and hence were unsuitable for breeding purposes. It may be noted that strains producing non-bitter seedlings have been identified in other cucurbit species not used widely as food crops.

Horticultural studies also lead to no completely satisfactory solution of the problem of bitterness in cucumbers. Bitterness is found in both field and glasshouse crops (Truscott and Gullett 1958), although it is most prevalent in hothouse fruit (Enslin, Joubert, and Rehm 1954). It is difficult to distinguish bitter from non-bitter fruit visually, although spiny fruits are more liable to bitterness than smooth-skinned fruits. The bitterness is concentrated near the stem end, but can extend through the length of the fruit in or under the skin. In terms either of area affected or of intensity it does tend to decline with maturity, but bitterness can persist in some fruits well beyond usable maturity, and accelerated ripening at 100°F is without effect (Truscott and Gullett 1958). Conditions of abnormally slow growth are associated with bitterness, which reaches its highest incidence in old plants (Vogel 1934). Vogel also reports that bitterness is increased by strong illumination, dry air, a sudden rise in day temperature, a low night temperature, and a high level of nutrition. It is difficult to see an application of these observations that would effect an immediate solution to the problem.

Though genetic and horticultural studies provide little hope for the control of bitterness, it is fortunate for the processors of cucumbers that bitterness in processed cucurbits does not present them with a serious permanent problem. The reason for this lies in the comparative instability of the bitter principles, which readily break down to non-bitter fragments under mild conditions, e.g. one minute in boiling water (Truscott and Gullett 1958). This degradation is far more deep-seated than the simple hydrolysis of the sugar group, for when such hydrolysis is brought about by the naturally occurring enzymes there is no effect on the bitterness.

As a result of this general instability of the bitter principle, bitterness in pickled cucurbits presents only a short-term problem: bitterness becomes imperceptible on continued storage, no matter how unpalatable the original processed product was. On the other hand, no method has yet been published for the preparation of an immediately acceptable product from bitter cucumbers. The most recent studies on this problem were by Olthof (1959), who attempted to remove bitterness through altering the pickling procedure by varying time, temperature, acid and salt concentrations, and type of acid used. In no instance was the bitterness decreased by the treatments, but both treated and untreated gherkins had lost their bitterness after storage for 4 months at 10°C.

It is clear, therefore, that while no recommendations can yet be made to ensure the cultivation of non-bitter cucumbers, bitterness that may be quite objectionable in the freshly processed product is unlikely to persist in either sweet or brined pickles. Nevertheless, the onus is placed on processors to ensure that their product is held in store long enough for bitterness to be eliminated.

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NEWS FROM THE DIVISION OF FOOD PRESERVATION

MEAT RESEARCH LABORATORY

Construction of new buildings for the CSIRO Meat Research Laboratories at Cannon Hill, Qld., which are attached to this Division, commenced in December 1965. The laboratories were planned to have initially a floor area of about 23,000 sq ft, at a cost of £290,000, to be utilized principally for research on beef. However, plans have since been made to extend the area to approximately twice this size, in order to provide for research on sheep meats as well. When these plans are put into effect the total cost will be roughly doubled also.

UNIVERSITY POSTS

Two members of the Division's Plant Physiology Unit have accepted posts at the University of Adelaide at Bedford Park, S.A. Dr. A. B. Hope accedes to the Chair of Biophysics in the School of Biological Sciences, and Dr. G. P. Findlay has been appointed Lecturer in the same school. Dr. Hope is a graduate of the University of Tasmania, and joined the Plant Physiology Unit in 1953. He has specialized in biophysical investigations on the movements of ions in plant cells and across cell membranes. Dr. Findlay also graduated from the University of Tasmania; he joined the Plant Physiology Unit as a collaborator of Dr. Hope in 1961.

Dr. F. V. Mercer, Professor of Cell Physiology in the University of Sydney and joint leader of the Plant Physiology Unit, has been appointed Chairman of the School of Biology at Macquarie University, Sydney's third university, which will open in 1967. Professor Mercer will, in the meantime, retain an active interest in the Plant Physiology Unit at the University of Sydney.

VISITORS FROM ASIA

During 1965, the Division of Food Preservation has provided laboratory accommodation and training for a number of Asian scholars.

Mr. Ihsan-Ul-Haque Chaudhary, from the West Regional Laboratories of the Pakistan Council for Scientific and Industrial Research at Lahore, joined the Division in May 1964, and returned to Pakistan in September 1965. Mr. Chaudhary, who came to Australia under the Colombo Plan for the purpose of obtaining training in food technology, participated in research projects and visited food research laboratories and food processing plants.

Dr. N. A. Khan, Head of the Food and Fruit Research Division, Eastern Regional Laboratory, Pakistan Council of Scientific and Industrial Research, Dacca, East Pakistan, came to Australia to attend the UNESCO seminar on 'Science and Research Organization' in Sydney in August 1965. At the conclusion of the seminar he remained in Australia for nearly four months as a Colombo Plan Special Visitor. Dr. Khan made a close study of the research in progress in the Division of Food Preservation, and visited many food processing plants in Sydney and other Australian capitals. He also travelled widely in all the Australian States, except Western Australia, to study food production.

Mrs. Sriwai Singhagajen, a research worker from the Ministry of Agriculture, Bangkok, Thailand, came to Australia as a Colombo Plan Fellow in September 1965, planning to spend six months in the Division. She has made a special study of dried foods, especially bananas and coconuts, and has toured New South Wales, Victoria, South Australia, and Queensland to study the production and processing of fruits and vegetables.

RECENT PUBLICATIONS OF THE DIVISION

Copies of these papers are available from the Librarian, Division of Food Preservation, Box 43, P.O., Ryde, N.S.W. (Telephone 88 0233.)

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* Division of Physics, CSIRO.

† Australian Atomic Energy Commission, Lucas Heights, N.S.W.

‡ N.S.W. Department of Agriculture.

§ Division of Mathematical Statistics, CSIRO.