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Contents

Foreword

This issue of the Food Research Quarterly is a tribute to the distinguished career in CSIRO of Dr J.H.B. Christian and will give the reader some idea of his central role in the Division both as a Chief and as a food microbiologist of international repute.

Dr Christian's career in CSIRO spanned 40 years from 1951 - 1990 and the papers in this issue are by colleagues who have known him for much of that time. He was a member of the editorial committee of the Quarterly from 1957 to 1977 and has strongly supported the journal both as Chief and as an individual contributor.

It is with pleasure we enter the 50th year of publication of the Food Research Quarterly with this special issue.

K.C. Richardson
Chairman, Editorial Committee

John Christian, Chief of Division, 1979 - 1986

D.J. Walker

Chief, CSIRO Division of Food Processing, North Ryde, NSW 2113

In 1976 the Federal Government initiated a major review of the objectives, structure and programs of CSIRO. The Birch Report, named after the inquiry chairman, Professor Arthur Birch, was tabled in October 1977 and contained 122 recommendations. Among the more significant of these was that which urged the grouping of CSIRO's Division into Institutes, each led by a Director. The adoption of this recommendation by Government had two immediate consequences for the Division of Food Research as it was then named.

Firstly, the Division was included in an Institute of Animal and Food Science. Secondly, the Executive of CSIRO appointed our Chief, Mr Michael Tracey, Director of the Institute of Biological Resources from December 1978. John Christian was appointed Acting Chief of the Division and, some eight months later, was confirmed in this position for a period of seven years.

As Chief, John was confronted with the beginnings of what has turned into a decade and a half of ongoing reductions of appropriation support for CSIRO. The cuts in funding continued for the entire duration of his term as Chief and made it nearly impossible for him to replace staff as they retired or resigned. As a consequence, many skills were lost to the Division and to the Australian food industry. Further, very few newly-trained staff were appointed, especially to the research ranks, as more and more positions were sacrificed to cope with the declining budget. This was particularly distressing to John Christian.

For the most part, there was little that the Division could do to replace appropriation funding with monies derived from industry. The food processing industry had no general R&D levy and then, as now, showed little interest in funding collaborative or contract research - even though it wanted the CSIRO Division to be always there when needed for free assistance.

The Australian Meat Research Committee had, in 1966, placed an upper limit of $405,000 per annum for the funding of the Division's Meat Research Laboratory (MRL). This limit was maintained until 1981/82 and imposed an additional difficulty on John as Chief and his Assistant Chief at MRL.

Whilst things were qualitatively different at the Dairy Research Laboratory (DRL), John had to cope with unsatisfactory funding there, too.

The Dairy Research Committee had a comparatively small R&D budget and DRL was receiving rapidly declining support from that source. Considerable sums were derived from industry on new technologies, especially 'Cheesebase' and Sirocurd'.

It required a person with special capabilities to manage the Division successfully under such trying circumstances. In John Christian we had one.

It was perhaps John's unfailing good humour and courtesy which most helped the staff of the Division to cope with the gloomy funding scene. Those characteristics, plus a determination to achieve the best possible outcome from any opportunity, helped his Assistant Chiefs in the ongoing struggle to maintain high morale in their respective Laboratories.

Not widely known within the Division was John's strong championing of appropriate rewards for staff who performed well. He was reported to have fought fiercely for salary justice when he was convinced that a colleague had amply demonstrated the meritorious performance required.

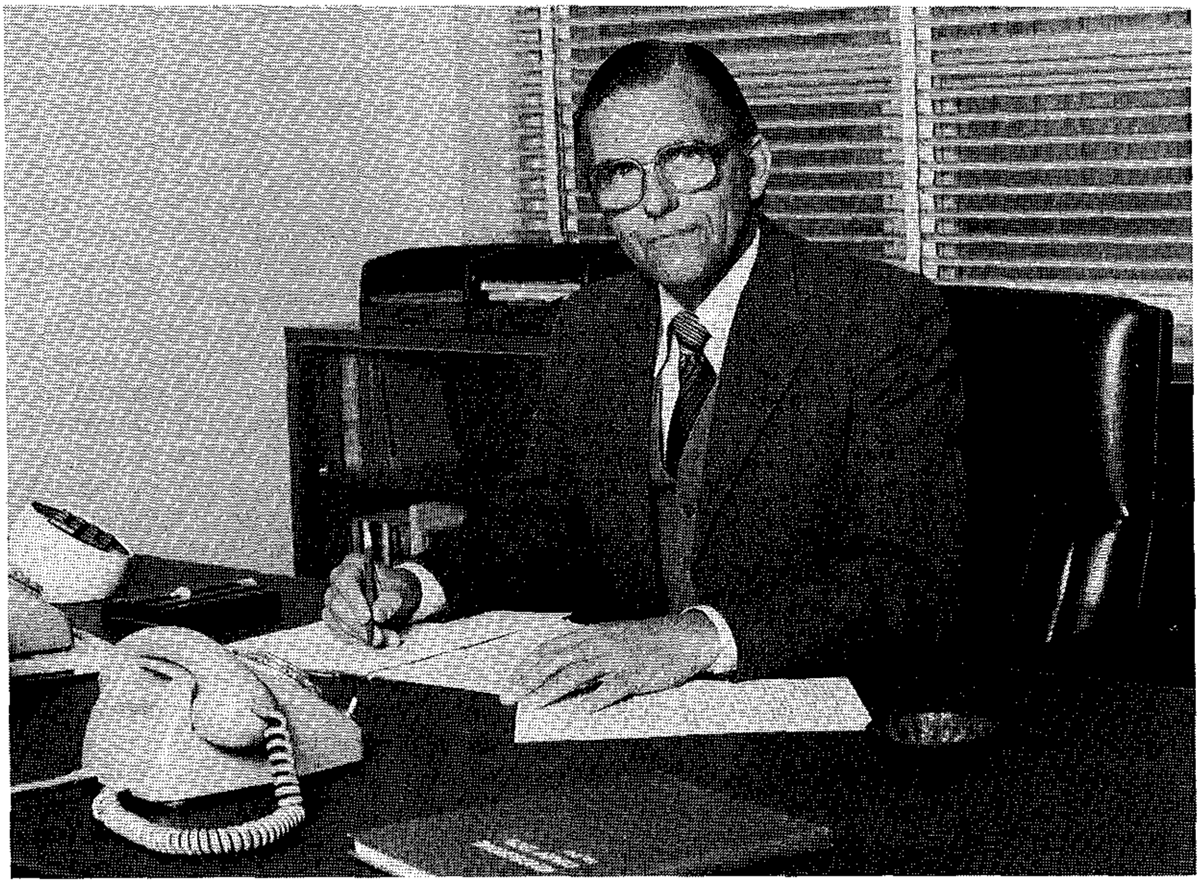
Finally, as Chief, John used line management principles long before they became fashionable in CSIRO. Having settled with his Assistant Chiefs on an agreed general program for each of the three Laboratories, he gave great freedom and responsibility to Laboratory Heads.

This generated excellent job satisfaction in difficult times and helped create an excellent corporate spirit within the Division.

Ever energetic, John has retired only in the sense that he is no longer a full-time member of staff at CSIRO. He continues his heavy involvement in food microbiology, regulatory matters and the further development of global concepts of microbial specifications for foods.

It is of considerable satisfaction to the Division that John has accepted the position of Honorary Fellow and will continue to share with us his immense knowledge and valued friendship.

Dr John Christian, Chief of the Division, 1976-1986, who retired from the CSIRO in 1990.



Dr J.H.B. Christian & His Role in the Understanding of Microbial Water Relations

J. I. Pitt

CSIRO Division of Food Processing, North Ryde, N.S.W. 2113

John Christian has had a long and distinguished career as a research scientist and scientific administrator at CSIRO Division of Food Processing. This paper sets out some of his scientific accomplishments.

John Hinton Bassett Christian was born in the central New South Wales coastal town of Gosford. After schooling at Knox Grammar School, Wahroonga, he served in the Royal Australian Air Force, in England. After the War, he obtained a B.Sc. Agr. with First Class Honours in Microbiology under Mr (now Emeritus Professor) J.M. Vincent at the University of Sydney, and in 1951 joined CSIRO Division of Food Processing - then known as the Division of Food Preservation and Transport - as a Research Scientist.

When he joined CSIRO, John came under the influence of W.J. Scott, whose research interests lay in developing an understanding of the effect of dried, concentrated or salty environments on microorganisms. John took little time becoming involved in this infant area. Scott's first pioneering paper on the influence of water and solutes on a bacterium was on the important food poisoning species *Staphylococcus aureus* (Scott, 1953). Immediately following it, in the same journal, came John Christian's first paper (Christian and Scott, 1953) on the influence of water and solutes on the growth of salmonellae.

These papers were the first two in which the concept of water activity (a_w) was used to describe the influence of reduced water availability on microbial growth, and they remain classics in the field, both because of the extraordinarily valuable new concepts set forth, and because of the care and attention to detail in their experimental design and execution.

John Christian then pursued the water relations of one *Salmonella* species in more detail. In the first of three papers on *S. oranienburg* (Christian, 1955a), he explored the influence of nutrition on growth. He showed that the minimum a_w for growth was much lower (0.95 v. 0.97) when this species was grown on complex rather than minimal media. He further showed that the amino acids proline and methionine accounted for much of this difference, and vitamins most of the rest.

Christian (1955b) continued this work, looking at the influence of other solutes, including glycerol, on growth of *S. oranienburg*. The influence of a_w on respiration was also examined for the first time. Pioneering experiments on solute accumulation inside cells were also conducted. He reported that *S. oranienburg* accumulated potassium ions, and opened up a new field of work, which was soon to lead into studies towards his Ph.D.

One more paper in that sequence ensued: Christian

(1958) looked at the influence of washing in water and a range of solutes on the retention of absorbed Na^+ and K^+ in cells of *S. oranienburg*. Based on this study, he concluded '...the sodium content of cells is probably a function of the sodium content of the growth medium while the potassium content of cells is largely independent of the external potassium concentration. In the light of earlier experiments (Christian 1955) it is likely that the content of cellular potassium is a function of the a_w of the growth medium'. With the benefit of 35 years of hindsight, this is a remarkable statement, underlying much of what is currently known about bacterial water relations.

DOCTORATE AT CAMBRIDGE

John Christian had been at CSIRO Division of Food Preservation and Transport for only three years before he took up a studentship leading to a Ph.D. He went to Cambridge, where he worked at the Low Temperature Research Station under the awesome Dr Maurice Ingram. Under Ingram's tutelage, John developed the study of water relations into a life-long interest in the interaction of water, foods and microorganisms.

During his Ph.D. years, John Christian explored the unknown territory of microbial water relations. Outwardly simple questions were posed: Does a microbial cell have to maintain turgor in concentrated solutions? If so, and it seemed on theoretical grounds to be essential, how does the cell cope with this? He demonstrated, by careful freezing point measurements, that the internal a_w of cells from a range of halophilic bacteria closely matched those of the growth medium. The cell freezing point was always a little bit lower, indicating a positive turgor pressure. From extensive experiments on the moderate halophile *Vibrio costicolus*, John showed that, on dilution of media containing NaCl, lysis (i.e. bursting of cell walls from reduced osmotic pressure in the diluted medium) always occurred at a constant fraction, about 30%, of the NaCl concentration in the growth medium. This suggested that the internal osmotic pressure of the cells, under these experimental conditions, bears a constant relationship to the osmotic pressure of the growth medium. The first question posed above was answered. The second was to occupy several more years' work, and remained for others to answer fully. Much of the thesis work was published by Christian and Ingram (1959a,b).

RETURN TO CSIRO

On his return to CSIRO in 1957, John set out to study this second question, with particular reference to halophiles and food poisoning bacteria. During the ensuing ten years, he produced several papers in this area, either as sole author, or in collaboration with his young associate, Judy Waltho. Christian and Waltho (1961) studied the relationship between tolerance of low a_w and internal potassium and sodium concentrations. In keeping with the thoroughness of his previous work, 32 isolates belonging to 22 or more species were studied. Findings were based on a large number of runs, many analyses of K^+ and N^+, and experimental determination of interstitial spaces between cells, a tedious and exacting operation. The major conclusion from this work was that the ability of a non-halophilic bacterium to grow at reduced a_w was correlated with internal K^+ content, and unrelated to internal sodium. Clearly, bacterial cells concentrate potassium ions, and presumably a charge balancing anion, to provide an internal solute concentration sufficient to balance the external environment. Postulates by Christian (1955) were shown to be correct by Christian and Waltho (1961). It is characteristic of the care and attention to detail in John Christian's work that, thirty years on, the experimental methodology and conclusions remain unchallenged.

Continuing a line of work earlier explored with *S. oranienburg*, John next examined the effect of different washing solutions on the contents of cells of *Staph. aureus*: a simple experiment, with very complex conclusions (Christian, 1962). Sodium was readily washed out, and undoubtedly replaced by other cations, indicating it was not bound inside the cell. Potassium, on the other hand, could not be removed from *Staph. aureus* cells by any washing process which did not damage cell integrity. Understanding of cell membrane structure and function was limited at that time, but experiments with butanol: water solutions indicated that 'a butanol-labile barrier' existed in the cells, and that this barrier 'differ[ed] greatly in its permeability properties towards sodium and potassium'. It appeared that sodium ions readily penetrated the cell membrane, and were readily replaced, while potassium was strongly retained in the cells, by an unknown mechanism. Some organic molecules, as measured by UV absorption, behaved as potassium did.

A logical continuation of these studies led Christian and Waltho (1962) to examine the concentrations of solutes, both cations and anions, within a range of bacterial genera and species. The importance of potassium as an internal solute was shown to be widespread, as both halophilic and nonhalophilic bacteria were found to concentrate K^+; in the case of the halophilic bacterium, *Halobacterium halobium*, the level of potassium could approach saturation. Clearly, halophilic bacteria possessed very concentrated internal environments. Christian and Waltho (1962) noted a recent discovery that enzymes from *H. salinarium* were nearly all more active in KCL than NaCl solutions, and pointed out the importance of this for effective cell metabolism in bacteria where potassium levels were high.

Sodium levels were higher in the medium than within the cells, for both halophiles and nonhalophiles. Anions, essential to balance the high concentration of K^+, appeared to be mostly Cl^- in obligate halophiles, and organic acids in other groups of bacteria.

Christian and Waltho (1964) turned their attention to *Staph. aureus*. The paper summary reports that cells of *Staph. aureus* 'grown in basal medium of ...a_w 0.993 and in basal medium adjusted to several different a_w values by addition of NaCl, were analysed for the following components: sodium, potassium, calcium, magnesium, total amino acids, inorganic phosphate, chloride, water, DNA, RNA, protein.' How easy it is, in 1990, to read such a statement and fail to realise the enormous amount of work that sentence represented in the 1960s!

The results of this study were complex: although, as might be expected, internal solute concentrations increased as a_w decreased, potassium and phosphate were greatest at 0.92 a_w, while sodium, chloride, magnesium and amino acids continued to increase at a lower a_w (0.90). Of the solutes examined, only sodium and chloride ions were found at lower concentrations in the cells than in the media: intracellular sodium and chloride concentrations were proportional to, but much lower than, the NaCl concentrations in the medium. The intracellular concentrations of potassium and amino acids, on the other hand, were a function of a_w, and appeared to be closely related, suggesting a common mechanism controlling the accumulation of these solutes.

Christian and Waltho (1964) went on to postulate that the decrease in potassium and amino acids below 0.92 a_w was a product of 'a marked disturbance of metabolism'. Further, unpublished data showed that respiration was markedly inhibited under the same conditions, suggesting that deficiencies in respiration were likely to be responsible for the observed changes in solute ratios, and for limitations on the ability to grow at lower a_w levels.

FURTHER STUDIES ON *SALMONELLA ORANIENBURG*

S. oranienburg, used in several earlier studies, was dusted off again in the mid 1960s. Christian and Waltho (1966) examined the effect of amino acids on respiration, using the Warburg manometer - from personal experience, a most versatile piece of laboratory equipment, and among the most exasperating to use. This study started from the observation by Christian (1955a) that aproline added by itself to a minimal medium of reduced a_w stimulated growth of *S. oranienburg* only a little, but its presence was necessary to permit much greater stimulation by several other amino acids. Given his hypothesis that respiration may be a limiting factor in the growth of bacteria at low a_w, the influence of proline and other amino acids on the respiration of *S. oranienburg* was examined.

Twenty three amino acids were tested as substrates for respiration, both in the absence of salt at 0.998 a_w, and with salt added (0.970 a_w). About half the compounds were utilised as a carbon source, but at reduced a_w respiration was slow for all but proline. It was also found that proline stimulated respiration by other nonhalophilic bacteria as well. At this point Christian and Waltho came close to an understanding of the unique nature of proline as one of several amino acids providing ionic balance to potassium in various species cells at reduced a_w.

Christian and Hall (1972) stated 'Proline may stimulate respiration at low a_w by overcoming the effects of shrinkage or plasmolysis ...by promoting accumulation of high levels of osmotically active ions and molecules within the organism'.

The penultimate paper in this series was by Christian and Hall (1972). They looked at the accumulation of potassium and amino acids during respiration of *S. oranienburg*. Radioactive proline uptake increased linearly with decrease in a_w, and was partly converted to glutamate and deaminated compounds. Its role as a unique internal solute remained unclear to them. Finally, in a paper read in Baka (Christian, 1981), previously unpublished data on specific effects of solutes on non-halophilic bacteria were collated and studies suggested that might explain further the response of microbial cells to reduced a_w.

COLLEAGUES

During John Christian's days at the bench, the Microbiology Group at this Division was large, the envy of those trying to carry on now. Bill Scott, the great pioneer in this field, has already been mentioned. Bill Murrell, Duncan Brown, Ron Leach and Barry Bloomfield all influenced John, and were influenced in turn. Betty Stewart (nee Marshall), Helen English and Jan Hall (nee Hinch) all provided him with valuable support. The late Judy Howard (nee Waltho) deserves special mention: she and John Christian were a formidable combination, both at the bench and at recreation. Together they wrote five papers, and provided us with a thousand one liners, sadly most now forgotten. Judy Howard has not been.

I make no claim to having influenced John Christian's thinking or work, but wish to acknowledge his influence on me. He supervised and greatly improved my M.Sc. thesis. Together we wrote two papers on xerophilic fungi, minor publications in his portfolio, but very significant to me early in my career. He kindled my abiding interest in fungal water relations. With his help, I passed this on to my colleague Ailsa Hocking, who studied the internal solutes of xerophiles for her Ph.D. Together with other colleagues, we in turn have helped develop the field of food mycology, including the development of enumeration and identification methods for xerophiles, and xerophile taxonomy.

A WIDER INFLUENCE

As I have recently remarked elsewhere (Pitt, 1990), it is difficult to measure the extent of John Christian's influence at the present time, but it has already been profound, and it will continue. His career as a bench scientist concluded early, as he took on the job of administering the Division, first as Associate Chief, and then as Chief. As well he became in a sense an evangelist, spreading the message that water activity is not just a fascinating parameter to be studied by the pure scientist, but a most valuable concept in the understanding of food spoilage by microorganisms. More, it is an extremely valuable criterion for the safe storage and transport of foods of all kinds. A knowledge of the concept of water activity, the water relations of microorganisms and the a_w of foods, is a fundamentally sound approach to food safety.

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Dr J.H.B. Christian's Contribution to International Food Microbiology

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John Christian's contribution to the science of food microbiology in the international arena has been widely recognised.

He has written numerous papers and reports and co-authored or co-edited books on food microbiology, food safety and microbiological standards for foods.

In addition, he has been an invited lecturer at symposia and courses on every continent. From 1962 till the present, he has lectured on aspects of food microbiology in Venezuela, North America, Japan, the Philippines, Malaysia, Singapore, Thailand, Egypt, UK and Continental Europe. He has been an editorial adviser to the UK Biodeterioration Information Centre, on the editorial board of the Academic Press Food Safety and Technology Monograph Series, and is still on the editorial board of the International Journal of Food Microbiology. Recently he has become vice-president of the executive committee for international symposia on the properties of water in foods. For over ten years, John has been the Australian delegate for the International Union of Microbiological Societies (Bacteriology), and for the International Committee on Food Microbiology and Hygiene. For a number of years, John has been selected as a member or chairman of the International Commission on Microbiological Specifications for Foods (ICMSF), and of a number of expert committees associated with the Food and Agriculture Organisation of the United Nations (FAO), World Health Organisation (WHO), International Atomic Energy Agency (IAEA) and Codex Alimentarius Commission (Codex). He has brought his knowledge of the physiology and ecology of food-poisoning and food-spoilage microorganisms to bear on the problems of food hygiene that affect trade in foods. Through his international activities, John Christian has influenced the thinking and approach of bodies concerned with food safety and microbiological quality both at a national and international level.

CODEX COMMITTEES

The Codex Alimentarius Commission was established to implement the joint FAO/WHO Food Standards Program. The purpose of this program is to draw up standards protecting the health of consumers while at the same time ensuring fair practices in international food trade. The Codex Commission promotes co-ordination of work on food standards by governmental and non-governmental organisations on an international scale, and aims to establish standards that are accepted by governments on either a regional or a world-wide basis. The Codex Commission has a number of subsidiary committees including commodity and general subject committees (e.g., food hygiene), and expert groups (e.g., quick frozen foods). Expert FAO/WHO committees also provide advice and recommendations to Codex.

John Christian has been an Australian delegate of the joint EEC Codex Alimentarius Group of Experts on the Standardisation of Quick Frozen Foods and, for 11 years, of the Codex Committee on Food Hygiene. Any Codex proposed standard for food commodities that includes provisions relating to hygiene, or to microbiological sampling to verify satisfactory hygiene, is examined and requires endorsement by the Codex Committee on Food Hygiene. John was also a member of the Food Hygiene Working Party on detection of salmonellae in egg products and, later, chairman of the Food Hygiene Working Group on Microbiological Criteria for Foods.

WHO EXPERT ON FOOD HYGIENE

In the late 1960's and early 1970's, awareness of microbiological health hazards arising from the consumption of contaminated foods resulted in national and international intensification of food hygiene programs. Efforts to develop international microbiological specifications for foods were underway. For instance, in 1972, the United Nations Conference on the Human Environment recommended increased support for the joint FAO/WHO Food Standards Program in developing international standards for microorganisms in foods. In 1974, John Christian became a member of the WHO Expert Advisory Panel on Microbiological Aspects of Food Hygiene, and, in 1975, was chosen to be this panel's chairman. As explained in WHO documents, members of such expert groups serve not as representatives of governments or of other bodies but are selected 'on their ability and technical experience'. The results of the wide-ranging considerations of this WHO Committee were published (WHO, 1976) in a document which discussed 13 bacterial agents of food-borne disease as well as viral and rickettsial agents, and mycotoxins. Sources of the organisms, methods of their detection, mechanisms by which human disease is caused, and preventative measures to limit human illness were outlined. The document also discussed the hazards arising from faults in processing, storage and formulation of foods, and stressed the importance of processing failures in food prepared in homes and in food service establishments in causing human disease.

Several difficulties were recognised in applying microbiological specifications to foods, particularly for foods in international commerce. There was a lack of published data on the microbiological content of different foods over a period of time that could serve as a basis for establishing satisfactory microbial limits. The microbiological methods used should be internationally uniform and sampling plans should be based on sound statistical methods (e.g., ICMSF, 1986). Microbiological monitoring of foods could only be considered as part of food hygiene programs. Critical points in the food production chain that could lead to unacceptable microbiological contamination or health hazards need to be known, and adequate steps and measures introduced into a system to control these critical points. In addition, the public health implications of new techniques in food production, processing and distribution of raw and processed foods requires continual assessment. For such new foods or processes there is unlikely to be an available data base to use in setting microbiological limits.

The aims of microbiological examination of food are to protect the health of the consumer and ensure quality. The tests should be applied at those points in the chain of food production that offers the maximum benefit in terms of health protection and quality. The best methods will achieve the desired result at the lowest cost. The document suggested that, while no economic analysis had been published, the then new concept of Hazard Analysis Critical Control Point (HACCP) be considered as a procedure of achieving efficient microbial control.

FAO/WHO EXPERT CONSULTATIONS

The controversial nature of microbiological sampling plans, methods of analysis and limits led to a need for the development of recommendations by an independent expert group before microbiological criteria for foods could be considered by the Codex Alimentarius Commission. John Christian was the first consultant appointed by WHO in the field and the consultation was followed by a series of joint FAO/WHO meetings of consultant experts on the microbiological aspects of food. He has been a member of this group since 1974. The task was to consider the need for microbiological specifications for food, the methodologies to be used, and the principles that should be used in establishing and applying microbiological criteria. Four reports were published between 1975 and 1980.

The most significant conclusions of these reports were summarised by John Christian (WHO, 1983). A microbiological criterion should be established and applied only where (i) there is a definite need for it, (ii) it is shown to be effective in protecting human health by providing a safe, sound and wholesome food, and (iii) it is practical and technically feasible by good manufacturing practice. The components of a microbiological criterion include (i) the organism itself, (ii) reliable, sensitive and preferably internationally recognised methods for detection and enumeration, (iii) microbiological limits based on data appropriate to the food and type of criterion, and (iv) a statistically-based sampling plan that is administratively and economically feasible. The microorganism selected in the criterion should be widely accepted as relevant (pathogen, indicator or spoilage organism) to the food. The mere presence of some food-poisoning organisms (e.g., *Clostridium perfringens*, *Staphylococcus aureus*) may not indicate a hazard. If the microorganism chosen is an indicator organism, it should be clear if the test is to indicate an unsatisfactory processing practice, or to indicate the possible presence of a pathogen.

Of the foods in international trade that were considered, microbiological criteria were proposed only for egg products, pre-cooked frozen shrimp and prawns, food for infants, ice mixes and edible ices, and non-carbonated natural mineral waters. Microbiological criteria were not recommended for raw poultry and red meats in international trade. There appeared to be no microbial criteria that could help protect consumer health by adequately distinguishing between acceptable and unacceptable batches of raw meats.

Most foodborne disease resulting from 'the consumption of meats and poultry are a consequence of inadequate cooking of the product and/or improper handling of the products after cooking'. Many of the organisms most important in causing food-poisoning occur in or on the live animal (e.g., *Cl. perfringens, St. aureus*). The prevalence of salmonella on raw meats and poultry is more likely to reflect the incidence in the live animal before slaughter than adherence or otherwise to a code of hygiene practice.

The eradication of salmonella from raw meats and poultry cannot be achieved by the imposition of microbiological criteria on the finished product, but only by elimination of salmonella from the live animal before slaughter, or by an approved post-slaughter treatment to kill the organism.

Incidentally, while a number of post-slaughter treatments (hot water, acetic and lactic acids, and irradiation) have been shown experimentally to reduce the incidence of salmonella on meats, none, as yet, has been used commercially.

CONSULTANT IN FOOD IRRADIATION & HYGIENE

The International Consultative Group on Food Irradiation was established in May 1984 under the aegis of FAO, WHO and IAEA to evaluate global developments in the field of food irradiation.

John Christian has been the chairman for three meetings of task forces to consider the use of irradiation to ensure hygienic quality of foods (1986), to evaluate the potential role of irradiation in combination with other processes (1987), and to recommend on the need for microbiological criteria for foods to be irradiated (1989).

Since some foods (e.g., raw red meats and poultry) even when produced under conditions of good manufacturing practices may contain human pathogens (e.g., salmonella and campylobacter), food irradiation can provide a more complete assurance of safety.

Packaged raw poultry was recommended as having first priority for irradiation among food commodities. Only foods produced under good agricultural or manufacturing conditions should be accepted for irradiation. Every care should be taken to minimise contamination with, or growth of, microorganisms during food production, and adequate quality control procedures must be maintained before irradiation is applied. Microbiological guidelines could be used for some foods to give some assurance of good manufacturing practice (e.g., aerobic plate counts for raw red meat and poultry).

However, guidelines should not be used as limits for regulatory action but failure to meet guidelines should direct attention to improvements in the manufacturing process and the re-establishing of good manufacturing practice.

ICMSF

Perhaps, the greatest enjoyment and sense of achievement that John has had in his international commitments have come from his membership of the International Commission on Microbiological Specifications for Foods (ICMSF).

John has been a full member of this Commission since 1971, part of its editorial committee since 1976, and chairman since 1980. ICMSF was formed in 1962 by the International Association of Microbiological Societies (now the International Union of Microbiological Societies). Members are selected because of their expertise in food microbiology and not as national delegates.

The ICMSF is a scientific advisory body that appraises the public health aspects of the microbiological content of foods. It evaluates evidence about the microbiological quality of foods, considers whether microbiological criteria are necessary for any food, proposes such criteria if needed, and suggests methods of sampling and examination.

The ICMSF aims to provide comparable standards of judgements in different countries and to foster safe movement of foods in international trade.

John Christian was involved in four of the five major books published by ICMSF on the microbiological quality of foods.

The first book was published in 1968 in recognition of a need for agreed methods for the isolation and enumeration of microorganisms in foods, and has been updated (ICMSF 1978).

The objectives of the second book, published in 1974 and recently revised (ICMSF, 1986) were to provide statistically-based sampling plans for foods in international trade, and to devise specifications that could be applied at points remote from the place of production. It introduced the concept of sampling case - a classification of sampling plans based on the relative severity of the microbial hazard, and on the expected change in microbial numbers in the time between sampling and final consumption. It also described the use of 2- and 3-class sampling plans.

The 'Microbial Ecology of Foods' in two volumes (ICMSF, 1980) provides a wide coverage of all the important aspects of food microbiology and is a source of information for all who must interpret the results of microbiological analysis of foods. Volume 1 deals with the physical and chemical factors (e.g., pH, a_w, organic acids) that affect growth and survival of microbes in food. Volume 2 is a comprehensive treatise on the microbiology of 18 food commodity groups. It describes the important properties of the food that affect microbial content, the initial flora and how the flora is influenced by processing and storage, and the means of controlling food processes and thus the microbial content.

The fifth book (ICMSF, 1988) extends the development of the control of the microbial safety of foods.

End-product microbiological criteria do not provide a high degree of protection at the point of production and processing. Control of operations through all stages of food production, processing, storage, and preparation are needed to ensure the quality and safety of foods.

The Hazard Analysis Critical Control Point (HACCP) concept is developed in this book as the most rational and efficient approach to controlling microbial hazards throughout the food chain.

A number of general areas (e.g., design of food areas, design and use of equipment, cleaning) which may be critical control points in the handling and processing of foods are considered along with examples of the application of HACCP to specific foods which have been chosen to represent a variety of processing technologies. The principles of the HACCP approach are carried through to the handling of foods in retail stores, food service establishments and even in the home.

John Christian, by his writings, lectures, and work on international expert committees, has helped to bring a realistic, rational, and scientifically valid approach to the problems of microbiological contamination, standards and safety of foods in national and international trade.

His influence on the principles to be applied in ensuring the microbiological quality of foods will be felt for a considerable time.

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The NHMRC and Food Microbiology

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A paper presented at the Dr J.H.B. Christian Testimonial Symposium organised by AIFST/ ASM and held at The University of New South Wales on Tuesday, 12th of June 1990.

It is a great honour to be asked to speak at a testimonial symposium to honour the contributions of John Christian to food microbiology in this country. In the short time I have available I will attempt to provide some insight into the changes that have occurred in the area of microbiological standards at the national and international levels, and to indicate the significant influence of John Christian on these activities.

Food legislation was not among the powers vested in the Commonwealth when Australia was federated in 1901. Each State introduced legislation to control the manufacture and sale of food and food law in Australia is still administered under Acts and Regulations of the six States and the ordinances of the Australian Capital Territory and the Northern Territory. Only in the past two years has some semblance of uniformity in these Acts and Regulations appeared through the Food Standards Code.

The Royal Commission on the Constitution in 1929 confirmed that the States had powers to legislate with respect to health. A Federal Health Council was created to secure co-operation between Commonwealth and State Health authorities on health matters and in 1936 this Council became the National Health and Medical Research Council (NHMRC) with terms of reference that included medical research. The NHMRC advises Commonwealth and State Governments on matters of public health legislation and administration and has over 50 expert committees to advise it in specialised areas. One of these expert committees, now called the Australian Food Standards Committee, has assisted in the achievement of some degree of uniformity in food legislation in Australia, including microbiological standards.

The first reference in Council reports to food legislation was at the 34th Session in November 1952, when Council accepted Public Health Committee recommendations concerning uniformity of food and drug regulations. In May 1943 the notification of food poisoning was discussed with respect to gastroenteritis in infants and food poisoning due mainly to organisms of the *Salmonella* group. However, these diseases were not made notifiable on a national basis. In November 1949 Council was advised of an outbreak of food poisoning due to canned fish imported into New South Wales.

In November 1952 Council encouraged liaison with the Chamber of Manufacturers, the Council of Australian Food Technology Associations (CAFTA) and the State Food Advisory Committees or their equivalents in attaining uniform standards in food and drug legislation. It was recommended that the Commonwealth Department of Health establish a secretariat for the exchange of information between the Commonwealth, the States and various trade organisations to improve information flow to all interested parties. The establishment of a technical committee on food additives was recommended, as was the appointment of technical study committees to assist the Public Health Committee.

The then Food Standards Committee (FSC) had its first meeting in March 1955 and identified as its purpose the recommendation to Council of model regulations prescribing standards and packing and labelling requirements for food. These model regulations were expected to be adopted without significant change in all States to achieve uniform food legislation throughout Australia. The FSC was to be concerned only with regulations having national importance and would not concern itself with the manufacture or sale of food, nor with the policing of these, functions that would remain with State Departments of Health.

Microbiological standards first appeared in FSC reports in 1959 in a draft Standard for Ice Cream and Related Products referred for comment to State Health Departments. The microbiological standard included in the Standard for Ice Cream and Related Products and approved by Council in October 1962 for adoption into State legislation was as follows (Smith 1978):

> 'Ice cream, flavoured ices, ices or ice blocks containing any milk or milk products must before freezing be heat processed. They shall not contain any pathogens nor *E.coli* (type I) in one millilitre nor more than 50,000 microorganisms in one millilitre, when determined by the prescribed method.'

In October 1960, Council recommended that further importation of desiccated coconut from a source originally contaminated by *Salmonella* should be prohibited until processes ensured no further public health hazard.

The Commonwealth Department of Health examined the problem and subsequently a Standard for Coconut, approved by Council in October 1964, contained a requirement that desiccated coconut 'shall contain no pathogenic organisms'.

Other microbiological standards included in NHMRC standards about the mid-sixties covered skim milk, farm butter (the product obtained from unpasteurised cream), cream and cream products, and yoghurt.

The NHMRC approved in October 1965 a recommendation to establish an *ad hoc* Food Microbiology Sub-Committee to assist the FSC with the preparation of microbiological standards for frozen foods for inclusion in a general Standard for Frozen Foods. The Sub-Committee in July 1966 informed the FSC that:

- 'At the present time, no information is available on the bacteriological content of frozen foods for sale in Australia nor of the epidemiological significance of this type of food in food poisoning outbreaks.
- It is important that, before forming any standards, this information should be available.
- The only frozen foods requiring a bacteriological standard to protect the consumer are frozen, pre-cooked foods, egg pulp, offal and fish products.
- As an interim, the standard proposed in a paper titled "The Microbiology of Specific Frozen Foods in Relation to Public Health - A Report of an International Committee" by F.S. Thatcher, published in the *Journal of Applied Bacteriology* in August 1963, might be taken. However, the Sub-Committee could not support its introduction on any scientific grounds at the present time.
- When a standard is involved, the Sub-Committee should be asked to suggest techniques for applying this standard.'

In 1966, following the importation of contaminated frozen, pre-cooked prawns, the NHMRC retained the Food Microbiology Sub-Committee (FMC) and extended the terms of reference to include consideration of bacteriological standards for all foods for which general standards were prepared. At its second meeting in January 1967, the FMC recommended as a matter of urgency a bacteriological standard for pre-cooked prawns. This was endorsed by NHMRC in April 1967 (Smith 1978).

Since the initial meeting in 1966, the FMC has had a total of 37 meetings up to March 1990 during which they have elaborated standards on a range of products for inclusion in NHMRC standards, as well as three codes of practice.

In the early days FMC was confronted continually with the problem of the lack of information on the microbiological status of Australian foods based on standard methodology, and the lack of information on the epidemiological significance of specific foods in food poisoning outbreaks. The report of the 7th FMC meeting held in Canberra on 17 March 1970, my first, contained some interesting matters:

- The FMC considered that its terms of reference were too restrictive and recommended that they be broadened by substituting 'criteria' for 'standards', a distinction that will become clearer later.

- The Chairman 'apologised for the apparent obtuse and repetitive format which was found necessary as a compromise to suit all Committees.'

- The FMC decided that it did not have enough information on the microbiology of oysters and decided to seek national information that would aid it in this task.

That compilation, examined by FMC in November 1971, provided the foundation for the oyster standard and was a useful model for subsequent surveys on foods where relevant data was lacking.

- Standard methods were discussed in relation to the acceptability of data on the microbiological quality of foods from different sources; subsequently in March 1973 an approach from NHMRC to SAA led to the formation of Committee AG/7 which later became FT/4, Methods of Microbiological Analysis of Foods, that developed AS1766.

- More importantly, FMC discussed a detailed letter from Dr Bill Scott of CSIRO Meat Research Laboratory concerning his doubts for the *need* for Australia to legislate at that time for microbiological standards. His reasons were, and I quote:

- '...Very little is known of food-borne diseases in this country and hence it is difficult to say how the community would benefit from the introduction of microbiological standards'

- '...Our knowledge of the microbiological status of foods now on sale in Australia is very limited'

- '...There is a need for much more study on standard methods of microbiological analysis for the detection and enumeration of various types of organisms in particular foods. These methods could then be used to collect information on the microbiological status of our foods.'

Dr Scott concluded his letter by saying, and I quote: 'Until we have more progress in the above areas I believe it would be desirable if the Sub-Committee were to suggest only 'recommended limits' for various types of microorganisms in the food products which it is asked to consider.'

'Such limits would then become guides to Government and industry of levels that the Sub-Committee regards as indicative of good practice regularly attainable when the foods are prepared and distributed under controlled hygienic conditions, and which the Sub-Committee believes would be unlikely to expose the community to serious risk of food-borne diseases.'

FMC agreed with the approach but considered it impractical, in view of the impending introduction of Codex standards, and since at that time FSC wanted *standards*, whole standards and nothing but standards!

Doubts about the relevance and need for microbiological standards for foods and, if introduced, what form they should take, have been raised repeatedly in many forums. For example, in an editorial in *Food Technology in Australia,* Dr Christian said (Christian 1975):

> 'If we are to develop useful microbiological specifications for foods, there are many decisions to be made:
>
> - Are they to be legal requirements, demanding pro-

secution for default, or advisory, to be used in conjunction with an educative process we need so badly ?

- Are they to be placed only on foods which have been shown to constitute a health risk ?
- Will they be restricted to the minimum number of tests required to establish safety and quality, or will unnecessary tests be added to complete the picture'?
- Will they penalise a retailer when fault lies in an earlier process, or a processor when the fault in retail handling?
- Will they be enforced consistently or ignored by regulatory agencies as irrelevant or inadequate ?
- Will they increase the cost of food products without increasing demonstrably their safety or quality ?

He concluded by saying: 'There is little epidemiological information available to indicate which foods are mainly responsible for food poisoning in this country. We need much more data.'

And in a paper presented to the 1st Australian Food Microbiology Conference in Sydney in 1977, Dr Christian outlined why end-product microbiological specifications were not then included in Codex Codes of Hygienic Practice, the reasons being difficulties in agreeing on (i) which foods need them, (ii) which organisms are relevant, (iii) what methods of enumeration or detection should be used, (iv) what numerical values are appropriate, and (v) what should be done with foods which fail to meet these specifications (Christian 1978).

Dr Shewan of Torry Research Station, in an address to the Joint AIFST/ NZIFST Convention in 1976, also outlined some problems in the implementation of microbiological standards as being 'the problem of sampling; the standardisation of methods; that they are expensive to operate and add to costs; if they are too stringent they price an article out of the market; and bacteriological criteria for quality are difficult to defend in court.' (Shewan 1976).

Before 1974, FMC spent a considerable amount of effort convincing the FSC, State Health Departments and the Public Health Advisory Committee of the advantages of replicate or multiple sampling based on the recommendations of the International Commission on the Microbiological Specifications for Foods (ICMSF).

On the international scene there were, of course, significant developments with respect to microbiological criteria involving Codex, ICMSF and a number of other bodies, many of which involved a crucial input from Dr Christian. These included the development, through the Codex Food Hygiene Committee, of the *General Principles for the Establishment and Application of Microbiological Criteria for Foods* which were accepted by the Codex Alimentarius Commission in 1981. These principles (Codex 1981) state that a microbiological criterion consists of:

- A statement of the micro-organisms and parasites of concern and/or their toxins. For this purpose, micro-organisms include bacteria, viruses, yeasts and moulds;
- The analytical methods for their detection and quantification;
- A plan defining the number of field samples to be taken, the size of the sample unit and where and, if appropriate, when the samples are to be taken;
- Microbiological limits considered appropriate to the food; and
- The number of sample units that should conform to these limits.

Criteria may be mandatory or advisory. A mandatory criterion is a *standard.* In the Codex Alimentarius it should, wherever possible, contain limits only for pathogenic microorganisms of public health significance in the food concerned. Two types of advisory criteria are described for use in Codex Codes of Practices. An *end-product specification* is intended to increase assurance that the hygiene provisions have been met. A *guideline* is applied at the establishment at a specified point during or after processing to monitor hygiene. It is intended to guide the manufacturer and is not for official control purposes.

The *purpose* of microbiological criteria is also spelled out in the General Principles. It is to protect the health of the consumer by providing safe, sound and wholesome products and to meet the requirements of fair practices in trade.

A number of general conditions are listed, the main one being that a criterion should be applied only where a definite need for it can be demonstrated and where it can be effective and practical. Consideration should be given to:

- Evidence of hazards to health (ie. epidemiological data)
- The microbiology of the raw material
- The effect of processing on the microbiology of the food
- The likelihood and consequences of post-processing microbial contamination and/or growth
- The category of consumers at risk
- The cost/benefit ratio associated with the application of the criterion.

A very important provision is that the number of samples tested shall be as stated in the sampling plan and shall not be exceeded. The interpretation of results and the fate of rejected products also are discussed. Overall, this document has been the cornerstone on which the format and approach for microbiological criteria have been modelled.

The ICMSF pioneered work on the standardisation of methods, and of statistical sampling plans that tried to take account of the distribution of microorganisms in foods and of the variability associated with microbiological methods. They not only published books on these topics, but also on the microbial ecology of a variety of fresh and processed foods, and of the application of HACCP to the food industry, and organised a series of international interlaboratory proficiency testing programs on microbiological methods, many or all of which had an input from Dr Christian.

Dr Christian also was directly involved in at least four FAO/WHO Consultations and Working Groups during the period 1975-81 that provided, for probably the first time, detailed microbiological end-product specifications for a variety of foods, that were subsequently recommended to the Codex Committee on Food Hygiene and to the Codex commodity committees (Christian 1983). The General Principles also arose from these consultations. The reports of these activities, and of course Dr Christian's direct knowledge, greatly assisted FMC in its deliberations on the formulation of appropriate microbiological criteria.

Despite the wealth of information then available on the need for standardised methodology and statistically-based sampling practices, it was extremely difficult to convince state regulatory authorities of their worth, and to explain the futility of continuing with irrelevant and out-of-date regulations such as 'all pathogens shall be absent' with *no* reference to sample number, size, method of analysis and criteria for acceptability. The tripartite sampling procedure enshrined in state food regulations for determining product compliance was a great obstacle for many years to the prosecution of offenders on food microbiological grounds.

I mentioned previously that the report on the microbiological status of oysters provided sufficient information on which the FMC was able to prepare a standard. For many foods, however, such national and reliable information was not available, although CAFTA and the food industry did provide much useful information for some products.

Accordingly in 1972 FMC decided to approach NHMRC to support a project to obtain such data. After due consideration the FMC recommended the following approach to the problem (Smith 1978):

- A survey of the microbiological status of a selection of foods should be carried out over a period of two years to enable seasonal factors to be taken into consideration.
- Results of the survey should be used to determine the need for microbiological standards for the foods tested and, where indicated, to set microbiological standards.
- The foods to be examined should be selected from those which could possibly be a public health hazard but for which little information was available in Australia.
- Several existing microbiological laboratories throughout Australia should carry out analyses for the survey using the

media and methods specified by the FMC.

The NHMRC approved the proposed survey in May 1973 and a grant to cover the cost of expenses associated with increased sampling and transport of samples to State and Commonwealth laboratories for analysis. Priorities were given to ready-to-eat 'take away' foods, processed meats, infant foods and imitation cream and cold mix custards.

In collaboration with the Central Statistical Unit (CSU) of the Commonwealth Department of Health the FMC planned the survey including sampling procedures, questionnaires to be completed at the time of sampling, and specific methods of microbiological analysis.

A pilot survey was conducted in May 1974 to test the questionnaire and the processing system. Four months later the main survey was commenced to examine 26 foods purchased each season of the year by government food or health inspectors in Adelaide, Brisbane, Canberra, Hobart, Perth and Sydney during the period September 1974 to August 1976 (Table 1). In February 1977 FMC examined the survey data and the statistical analyses provided by the CSU. The microbiological status of these foods was remarkably good. It was agreed that most of the problems highlighted by the survey could be overcome by the adherence to a *General Code of Hygienic Practice for the Preparation, Handling, Storage and Sale of Foods for Consumption without Further Processing*. Addenda to the general code could contain specific codes for individual foods with end-product microbiological specifications, if appropriate.

The Phase 2 survey (Table 2) was conducted in 1978-79 and covered 27 foods, some of which contained bacteria of public health significance at levels of concern, while others showed levels of bacteria indicative of poor hygiene control. Phase 3 (1981-82) covered a further 24 foods (Table 3), and Phase 4 (1986-87) covered 19 foods (Table 4). These surveys have concentrated on foods that are consumed without further heating and therefore without likely reduction in bacterial levels. Undoubtedly the surveys have provided important information on the microbiological status of a variety of foods available in the Australian market place. They have highlighted foods for which more information still is needed, as well as those that appear to be satisfactory, and provide an interesting comparison to those foods whose microbiological quality is well understood and from which data from industry generally is available.

Currently the *Food Standards Code* contains microbiological standards for 15 categories of food products containing about 61 food types (Table 5). All of these standards are now in line with the Codex principles for microbiological criteria, and three Codes of Hygienic Practice are based on Codex codes with local modifications.

The FMC today not only provides expert advice on the need for microbiological criteria for foods as requested by AFSC, but considers food microbiological matters in the wider context and sends recommendations to AFSC on a range of matters, not only about standards. The surveys, initiated by the FMC and funded by NHMRC after recommendations by FMC and support by FSC, showed that NHMRC Sub-committees indeed could be *and should* be proactive in standards development, and not just respond when required to do so.

The contributions of John Christian to this historical and continuing scenario cannot be overemphasised. As the Chairman of FMC since 1970 and a member of FSC and AFSC for many years he has overseen or been involved with most of the significant developments in the setting of microbiological specifications at the national level, including the adoption of Codex and ICMSF procedures, involvement in NHMRC, ADPSO, ADFFSC and Australian Codex Panels; he has provided invaluable professional expertise in the design and implementation of the surveys and the analysis of their results; and generally he has provided to FMC first hand knowledge of international thinking and directions from his position as Chairman of ICMSF for over 10 years and a member of key international Committees and Working Parties.

As a humble member of FMC, I have found this leadership to be both inspiring and a very educational experience. In the area of microbiological specifications for foods, and especially for the NHMRC and food microbiology, the name of John Christian forever will be linked.

TABLE 1.
PHASE 1 SURVEY 1974-76

ROTISSERIED CHICKEN
DEEP FRIED CHICKEN
STEWS AND CASSEROLES
IMITATION CREAM (COMMERCIAL PACKS, RETAIL CAKES)
COLD CUSTARD MIXES (COMMERCIAL PACKS OF DRIED MIX, RETAIL CAKES AND TARTS)
PREPARED FISH DISHES
PREPARED SALADS (COLESLAW, BEAN SALADS, POTATO SALADS AND RICE SALADS)
MEAT PIES
CHINESE-TYPE ROLLS
HAMBURGERS
DRIED INFANT FORMULAE
CEREAL PRODUCTS FOR INFANTS
COOKED CORNED BEEF (WHOLESALE UNSLICED, WHOLESALE SLICED IN VACUUM PACKS, RETAIL SLICED)
COOKED HAM (SAME CATEGORIES AS COOKED CORNED BEEF)
DEVON-TYPE SAUSAGES (SAME CATEGORIES AS COOKED CORNED BEEF)

TABLE 2.
PHASE 2 SURVEY 1978-79

DATES AND FIGS
DESICCATED COCONUT
COCHINEAL
SPICES (PEPPER, CINNAMON, NUTMEG, DRIED GINGER, DRIED CHIVES)
FROZEN DESSERT PIES
MANUFACTURED MEATS (FERMENTED SAUSAGES, PATE)
CHOCOLATE BARS, POWDERS
DRY MIX DRESSINGS
INSTANT DESSERT POWDERS
CHEESE CAKES
COOKED PRAWNS
RETAIL PASTEURISED MILK
GOAT MILK
FULL-CREAM MILK POWDERS
SKIM MILK POWDERS
SOFT-SERVE DAIRY ICES
FRESH MILK DRINKS
DAIRY CUSTARD
CREAM
FRESH DIPS
FLAVOURED RETAIL MILK
ASIAN TAKE-AWAY MEALS
SANDWICH FILLINGS

TABLE 3.
PHASE 3 SURVEY 1981-82

CHEESE (SWISS, COTTAGE, RICOTTA, CAMEMBERT, MOZZARELLA, FETA, PARMESAN, ROMANO, BRIE)
PRAWNS (COOKED, CHILLED, PEELED + UNPEELED, SCHOOL + KING; FROZEN COOKED UNPEELED KING)
SANDWICHES (EGG, CHICKEN, HAM, ROAST BEEF, ROAST LAMB, SALAD)
BOTTLED OYSTERS, MUSSELS
DIETARY FORMULA
PRECOOKED FROZEN HOSPITAL MEALS
GOAT MILK

TABLE 4.
PHASE 4 SURVEY 1986-87

SHELL OYSTERS
FRESH PASTA
MINERAL WATER ± FRUIT JUICE
HAND MADE CHOCOLATES
TOFU
SPROUTS (ALFALFA, MUNG BEAN, MIXED)
TAHINI
HUMOUS
HELVA
CAROB
SANDWICHES (EGG, CHICKEN, HAM FILLINGS; BREAD AND BUTTER)
FRESH SOY BEVERAGES
TABOULI

TABLE 5.
MICROBIOLOGICAL STANDARDS IN NHMRC FOOD STANDARDS CODES

FARM BUTTER
CHEESE (CHEDDAR, GOUDA)
DESICCATED COCONUT
CREAM PRODUCTS (PASTEURISED, UHT)
EGGS & EGG PRODUCTS (WHOLE LIQUID, WHITE, YOLK)
FROZEN FROGS' LEGS
FROZEN PRECOOKED FOODS
ICE CREAM, ICE CONFECTION, DAIRY ICE MIX
MEAT PRODUCTS (CORNED, CURED, PICKLED, SALTED, ± PRESSED HAM & SHOULDER HAM, PASTE, PATE, UNCOOKED CHOPPED, FERMENTED MANUFACTURED)
MILK & MILK PRODUCTS (PASTEURISED, UHT)
GOAT MILK
DRIED MILK PRODUCTS
UNCOOKED WET + DRIED PASTA
SEAFOOD (COOKED PRAWNS, FROZEN PRECOOKED PRAWNS, FRESH/FROZEN OYSTERS)
CANNED TOMATOES
TOMATO JUICE, PUREE, PASTE, SAUCE
YOGHURT ± FRUIT

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News From The Division

Death of Clive 'Ross' Tindale

The following tribute by Frank B. Whitfield reflects the sentiments of Ross Tindale's colleagues in the Division.

Ross Tindale died on 11 July 1989 while scuba diving off East Riversong Cay, Swains Reef, Queensland. So ended prematurely a life which began at Darlinghurst in Sydney on 31 October 1946.

Ross was educated at Chatswood Primary School and at North Sydney Boy's High School. He graduated from the NSW Institute of Technology in 1974 with the degree of Bachelor of Applied Science. He lived most of his teenage and adult life on the north shore of Sydney harbour which no doubt fostered his great love for rugby football and sailing.

Ross was appointed to the Division on 26 March 1973. Before joining the Division, he had gained valuable industrial experience by working as an undergraduate chemist, firstly with P.M. Industries Pty Ltd, then with Schweppes (Aust.) Ltd and finally with CSR Research Laboratories.

Firstly as a Technical Officer and later as an Experimental Scientist, Ross worked for eight years with Dr David Ingles on chemical reactions in foods, particularly free radical oxidations and the reactions of biogenic amines with naturally occurring quinones. For Ross the latter studies proved the most rewarding as the results obtained from these studies helped explain some of the difficulties encountered by Ingles and his team in their attempts to analyse biogenic amines in foods.

In 1981 he transferred to the Food Flavours Group to work with Dr Frank Whitfield on flavour problems encountered by the food industry. Such studies were to involve not only the identification of the chemicals responsible for off-flavours and taints in foods and beverages but also the determination of their origins. During the following eight years Ross worked on some sixty industrial problems: the majority of these were investigated during the last three years, after the laboratory commenced its program of contract research. His research efforts were rewarded by the co-authorship of 12 publications on topics in this field. Particularly noteworthy was his work on the causes of chloroanisole induced mustiness in packaged food, and on the origins of chlorophenols in shipping container floors. Ross was promoted to Experimental Scientist Grade 3 in 1984.

Because of his direct involvement in contract research, Ross became well known to many sections of the Australian food industry as well as those industries involved in the packaging and handling of foods. Ross had a natural charm and a friendly personality which, when coupled with his early industrial experience, ideally suited him to the role of consultant and adviser to troubled food processors.

Ross was a quiet achiever who worked steadily without fuss and without boasting of his successes. During the period from 1981 until his death he worked as part of a team which over the years had grown to depend on his laboratory skills. After taking on a completely new area of research in 1984, he mastered the techniques necessary to solve the difficult problems that confronted him. In doing so he earned the respect of all those who worked with him as a reliable colleague able to work on a wide variety of problems.

A tireless and enthusiastic worker in the Food Research Laboratory staff club, Ross was always the first to undertake the difficult and less attractive chores. In his quietly efficient and often laconic way, he had become an expert in catering at the many farewells and other staff club functions. He led by example, and his organising ability and work effort will be sorely missed by all members of the staff.

Ross loved life, and wished to experience to the fullest of his capabilities its various facets and challenges. Typifying this philosophy, at the age of 41, he decided to sail as a deckhand on a windjammer for 10 days simply because it was a part of life that had yet to be experienced.

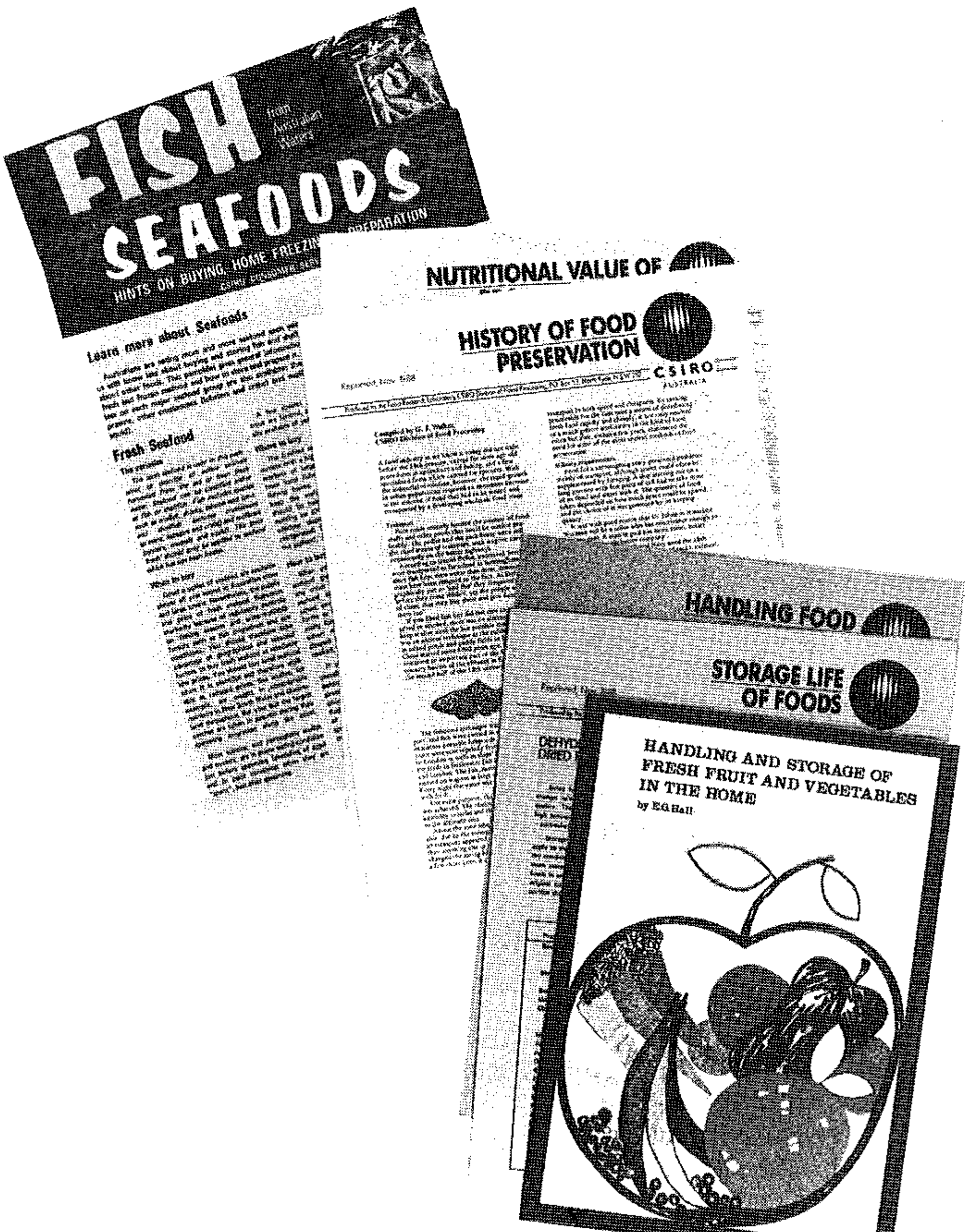
Ross enjoyed being near young people and was always willing to help a visiting student or a new member of staff. He had an abounding eagerness to motivate young people's enthusiasm and would go out of his way to assist the young to the extent of rescheduling his own work. He was a trusted confidant and would willingly put aside his own problems to listen to those of others. Ross was always available to help those who he considered were less fortunate than himself.

Sport was one of his most cherished interests. Ross was invariably one of the first to join a game, whether it was social cricket, lunchtime volley ball or touch football. It was always his wish to pass on the benefits of his sporting talents to others, and one of his greatest loves was the junior rugby team he coached with pride.

Ross Tindale will be remembered for his determination to live up to the high standards expected of him, his willingness to help people and his generosity.

Ross is survived by his wife Prudence, a daughter Amanda and two sons Mark and Brett.

Division of Food Processing Selected Publications



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