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Ernest William Hicks

1907-59

ERNEST WILLIAM HICKS, who died after a short illness on November 2, 1959, was a man with remarkable and varied talents. An outstanding physicist and an extremely able mathematician, he had been the leader of the Physics Section of the Division since its inception. His knowledge of the mathematics of heat transfer and of diffusion was profound, and he had no equal in the application of this knowledge to food science and technology. During the 30 years he was engaged in food research he was directly concerned with a great variety of studies involving the cooling, freezing, drying, heat processing, respiration and heat production, storage, packaging, and transport of foods. In addition to studies in which the physical aspects were of prime importance, he was an adviser and guide in a large part of the technological, chemical, and biological work of the Division.

Hicks was born at Yarrawonga, Vic., on April 12, 1907, and after attending Wesley College began a course at the University of Melbourne. He graduated B.Sc. with majors in physics and chemistry in 1927, a few days before his twentieth birthday. After teaching science for two years, Hicks began his scientific career in C.S.I.R. early in 1929 as an assistant to Associate Professor W. J. Young of the Biochemistry Department at the University of Melbourne. C.S.I.R. was then beginning one of its first inquiries in food science, a study of the conditions necessary for the satisfactory ripening and transport of Cavendish bananas. This work was undertaken in cooperation with the Queensland Committee of Direction (C.O.D.) of Fruit Marketing, and was started in experimental ripening facilities at the Universities of Melbourne and Queensland. Most of the next three years Hicks spent at the University of Melbourne, and on rail transport studies of experimental consignments. During this time he continued his studies in mathematics and German and graduated B.A. in 1931. He also learned much from Young's interest in the biochemistry of ripening, a process which was greatly accelerated by traces of ethylene in the atmosphere of the ripening rooms (Young, Bagster, Hicks, and Huelin 1932). The successful ripening under laboratory conditions had yet to be translated into satisfactory performance under commercial conditions. This task was undertaken by Hicks, who was so successful that he was seconded to the C.O.D. for about a year from early 1932 to operate newly installed ripening facilities in Sydney. The C.O.D. was eager to secure Hick's services permanently, but in 1933 he was appointed to a permanent position in C.S.I.R. as an "assistant biochemist". He then moved to Queensland, where he worked for a time, under the direction of Professor L. S. Bagster, on further laboratory and field studies of the handling, transport, and maturation of bananas (Hicks 1934*a*, 1934*b*; Hicks and Holmes 1935). In 1934 arrangements were made to enable Hicks to visit England and obtain wider experience in the physical aspects of the cooling and storage of perishables. At this same time, however, the C.O.D. began the construction of new banana ripening facilities in Melbourne, and the assistance of Hicks was again sought. Although it delayed the visit overseas, this further secondment was agreed to as both C.S.I.R. and C.O.D. were particularly anxious for the Melbourne venture to succeed. In these circumstances the then Chief Executive of C.S.I.R., Dr. A. C. D. Rivett, wrote that "if anyone but Hicks undertook it there would be possibilities of failure". After a year of arduous and exacting work, the Melbourne ripening rooms were successfully established and in July 1935 Hicks sailed for Cambridge.

The next 18 months at Cambridge began a new chapter in Hicks's scientific career. He had been inspired by the work of A. J. M. Smith at the Low Temperature Research Station, and welcomed the opportunity of working with him. It turned out, however, that during his first year at Cambridge, Hicks had very little contact with his mentor. In spite of this Hicks immediately began some first class work on the evaporation of water from muscle slabs and beef quarters stored under carefully controlled conditions of temperature, humidity, and airflow (Hicks 1936, 1937). The work with beef quarters showed conclusively that the effects of air speed on evaporation were small and in accord with theory, and that the rates of evaporation decreased appreciably as storage proceeded. The latter important observation, which has since been amply confirmed (Riutov 1954; Hicks, Howard, and Kaess 1955; Hicks 1957), results from progressive depletion of the very limited water contents of the surface fat and connective tissues. After his return to Australia Hicks spent a few months at the Brisbane laboratory and, following the establishment of the Homebush laboratories, transferred there in 1938. The period at Cambridge had provided for Hicks his first relief from the immediate pressure of applied work, and enabled him to develop his mathematical talents in the field of heat and mass transfer. He was himself transformed from the assistant biochemist to the independent mathematical physicist. In 1938 he began a theoretical and experimental attack on the simultaneous transfer of heat and moisture during the cooling of a wet body, and this difficult problem continued as one of his major interests for the next 20 years. Unfortunately the results of his work on this problem have not been published, as he was not able to obtain the agreement between theory and experiment which he always regarded as so important. Extensive records of his calculations and measurements remain, and it is to be hoped that they will provide some basis for posthumous publication of the progress which he made in this field.

Following the outbreak of war in 1939 several new investigations were needed, especially in relation to food canning and dehydration. In all this work Hicks and his colleagues played a major role, and during the next six years his versatility and authority as an applied scientist developed greatly. He was closely concerned with tests of the performance of dryers, measurements of the water relations of foods (Hicks 1944*a*), the permeabilities and properties of containers other than tinplate (Hicks and Mellor 1940; Hicks and Garden 1946; Hicks 1949), as well as the many problems connected with the cooling, storage, and transportation of chilled and frozen commodities. He also made measurements of heat penetration into many different canned foods, and calculated safe processes which were adopted by industry. In 1943 he was a member of a party which reported to the Army on food storage conditions in northern Australia (Finlay, Hansen-Lowe, and Hicks 1945), and in 1945 he was the leader of a small team which made a similar survey under the wet tropical conditions in New Guinea (Hicks, Kefford, and McKee 1945).

Soon after World War II Hicks began studies of the performance of refrigerated rail cars, some of the work being done in cooperation with the N.S.W. Government Railways which were then interested in the design of new cars. In 1947 he visited South Africa, Europe, and North America and obtained particulars of the insulated rail cars used in those countries. Subsequently he studied several types of Australian rail cars, compared their calculated and observed thermal properties, and measured the performances of their coolers under various conditions. His work on rail cars was marked by satisfactory agreement between theory and experiment, and was undoubtedly one of the best examples of work which Hicks himself found rewarding. By first "doing a little arithmetic and then making some measurements" he was able to demonstrate both the correctness of his theoretical predictions and the reliability of his measurements, in respect of cargo temperatures, cooler efficiencies, and precooling rates. For calculations of the precooling rates the mathematics of transient heat flow through composite walls was especially formidable, and Hicks enlisted the aid of J. C. Jaeger who developed some suitable formulae (Jaeger 1950). Calculations and measurements of precooling rates were in such good agreement that Hicks was able to state that the "results indicate that the formulae can be used with confidence for calculations on actual cars" (unpublished manuscript). Hicks's work on rail cars was comprehensive and contributed to improved designs of new cars, and to much more effective use of old cars. He described methods for the calculation of car performance (Hicks and Vickery 1951) and observations on actual performance with chilled (Hicks and Barr 1951) and frozen (Hicks, Smith, and Barr 1955) cargoes. The latter provides a valuable account of the superior performance of roof tank cars with frozen cargoes. A paper on heat leakage (Hicks 1955*a*) deals succinctly with the various sources of heat leakage and the measurement and use of overall heat leakage coefficients, while the factors affecting the performance of the coolers in different types of cars are discussed by Hicks and Barr (1954). A paper reporting rapid cooling of fruit and vegetables in a fan car (Hicks, Stevenson, and Blake 1959) was read just a few weeks before his death. In addition to his work on insulated cars Hicks made a thorough study of ventilated cars. These louvred cars are employed widely in Australia where the mild climate permits their use throughout the year. They operate regularly for the carriage of bananas (Hicks and Holmes, 1935) and other perishables which are cooled during transport to temperatures approaching that of the wet bulb thermometer. Years later he made detailed studies of air flow and cargo temperatures in cars with different louvre designs, and thereby contributed much to the efficiency of cars now in service.

In 1948, following the publication of a paper by Stumbo (1948), Hicks began a mathematical study of the evaluation of canning processes. Up to this time calculations of processes had been logically unsatisfactory as the spores being destroyed were considered as if they were all located at the slowest heating point in a can. Stumbo had pointed out that consideration of finite volumes was necessary. Hicks saw that the logical procedure was to integrate the chances of survival by a spore over the whole volume of the can, and his classical paper "On the Evaluation of Canning Processes" (Hicks 1951*a*) was submitted for publication in 1949. Similar ideas were contained in a second paper by Stumbo (1949) and by Gillespy (1951). Hicks's paper must surely contain the most elegant and advanced mathematical treatment of any paper in food science yet published. For products heating by pure conduction he used exact solutions of the equation of conduction of heat for both the heating and the cooling phases. Precise calculations of the temperature histories during cooling had not previously been attempted, and the validity of Hicks's equation No. 16 was seriously questioned by referees. The derivation of this important equation which Hicks considered straightforward proved to be difficult for some, and it took almost two years and an appeal to high mathematical authority before the paper was published. The implications of the mathematical papers by Gillespy, Stumbo, and Hicks were subsequently revealed to non-mathematical food technologists in a paper (Hicks 1952), which contains some nice understatements about the value and accuracy of his own numerical work. Hicks retained his interest in canning process evaluation and published other short papers providing corrections or improvements to published findings (Hicks 1951*b*, 1958*a*, 1958*b*).

As part of his interest in cooling and evaporation of foodstuffs Hicks maintained a continuing interest in the design and performance of coolers and cool stores. Not a great deal of his work in this field was published formally, but it was here that his greatest contributions to the efficiency of the Australian food industry were made. For many years he was the principal source of the advice which the Division gave to the various branches of the cold storage industry, and was the author of scores of reports on cooling, freezing, and storage facilities throughout the country. In all of this work he was careful to consider all aspects of a problem, and his thoroughness and consideration of likely practical difficulties ensured that his recommendations were sound and manageable. His publications on cold storage problems include a general statement on frozen meats with two appendices on calculations for freezers (Hicks, Howard, and Kaess 1955), calculations for freezing of egg pulp (Hicks, Smith, and Mellor 1949), the design of cool stores (Rostos and Hicks 1952), precooling of fruit and vegetables (Hicks 1955*b*), and engineering aspects of the handling of fruit and vegetables (Hicks 1956). A paper on the design and operation of cool stores for fruit (Hicks 1958*c*) is based on a talk which he gave to an annual conference of fruit growers. This paper, published shortly before his death, is an example of the author's best style, abounding as it does with excellent practical advice supported by principles clearly expounded in simple language.

It is unfortunate that, because of his high standards, much of Hicks's work has remained unpublished. He was always reluctant to publish until he was satisfied that a piece of work was complete. Considering the complexity of the materials and processes with which he worked, his standards may have been unnecessarily high. He was concerned about any observations which could not be explained, and even minor blemishes were suspected of showing that either the measurements were unreliable or that theory was inadequate. He was always anxious that others would not be misled by anything which he published. In recent years he had, to an increasing extent, given a great deal of his time to assisting others, and this restricted publication of his own work. It is especially tragic that time did not permit Hicks to prepare some authoritative reviews, for which his talents and experience were so well suited.

Hicks's contribution to the work of the Division and to food science in Australia was twofold. Great as was the value of his own research work, it was exceeded by the value of the advice and assistance which he gave so frequently and so generously to others inside and outside the Division. This began in the early years of the Division when his knowledge of mathematics and statistics was of great value to colleagues needing assistance with methods for the analyses of results. For the next 12 to 15 years Hicks personally carried out almost all the statistical analyses done in the Division. During this period he undertook hundreds of analyses of variance, computing being performed with a hand-operated machine which he cranked at prodigious speeds. His notes on the interpretation of the analyses were models of lucidity and brevity. For many years also the Physics Section supervised the operation of the Division's 15 to 20 controlled temperature rooms, as well as the small maintenance and instrument workshops. The provision of facilities for experiments under controlled conditions was another type of service rendered by the Physics Section, and this frequently required attention by Hicks to the various proposals which were made. In these matters he was intensely practical, and over the years made many valuable recommendations regarding the design of research equipment. His first concern was always to ensure that the proposed equipment would function as desired, and secondly to ensure the greatest simplicity and economy consistent with the required performance. Not infrequently a colleague would request the provision of apparatus calling for unnecessary precision in control. On these occasions Hicks would patiently inquire the reasons for the degree of precision being sought, and then proceed to consider other sources of error and uncertainty. This would often lead to an immediate decision that less precise control would be adequate, and that design could, thereby, be greatly simplified. Hicks himself regarded this need to "ask awkward questions" as one of his important functions. He always went about these tasks with such detachment and charm that no one was ever offended.

Although Hicks's assistance to colleagues had its origins in his knowledge of statistics and the performance of equipment it gradually became established on a much wider basis. His judgment was so sound and his common sense so fine, that his advice was almost constantly being sought in relation to the feasibility or desirability of experimental proposals in the various branches of science and technology with which the Division was concerned. He was quick to discount the value of his opinions on matters outside his immediate experience, but even in those fields where he disclaimed all knowledge his grasp of the essentials was sure and rapid. As a counsellor, and as a scientist able to communicate ideas within and between several disciplines Hicks can have had but few equals.

For 20 years Hicks was the Chief's deputy and on several occasions he assumed control of the Division during the absence of the Chief from Australia. As with other tasks he was very successful in administration, and, with his ready grasp of facts and figures, prepared budgets with consummate ease. While he never hesitated to give decisions when he knew they were necessary, he was generally cautious rather than adventurous. His approach to administrative decisions was marked by his loyalty to the Chief of the Division whose policies he always endeavoured to interpret and continue. He was careful to seek out the necessary facts when these were missing, and was always anxious to avoid offence through failure to consult or inform others, even when such consultation was unlikely to have any other beneficial result.

For many years Hicks's editorial judgment was widely sought. His wide knowledge of science and technology coupled with an unerring sense for sound argument made him a valued critic in many fields. At the time of his death he was responsible for the internal editing of all publications issuing from the Division.

Hicks's reputation as a scientist and food technologist was world wide. He was an acknowledged leader in the application of refrigeration to food science and technology, and on the evaluation of heat processes for canned foods. He was for some years a member of Commissions 2, 4, and 7 of the International Institute of Refrigeration (IIR) and at the time of his death was a Vice-president of Commission 2. He was also appointed by the IIR as their official liaison officer with the Secretariat of the United Nations Economic Commission for Asia and the Far East. He had been for some years a Charter Member of the Phi Tau Sigma, the Honour Society for Food Science. He was a prominent member of the Australian Institute of Refrigeration and was President of the N.S.W. Branch at the time of his death. In 1959 he was invited by the United Nations Food and Agriculture Organization to act as a Consultant to a Regional Seminar on Food Technology to be held in Mysore, India, and he was hoping also to attend the 10th International Congress of Refrigeration. However, because of a serious illness in 1958, his medical advisers considered it unwise for him to travel abroad in 1959 and Hicks reluctantly abandoned his plans for these visits. Unfortunately within a few months a recurrence of his earlier illness necessitated surgery, and, a few days later, when he appeared to be recovering, he collapsed and died at the peak of his powers.

Hicks was a man of simple tastes and had a completely unassuming manner which enabled all who met him to feel perfectly at ease. On first acquaintance he was often somewhat reserved as, although scholarly and widely read, he would never intrude an opinion. However, as soon as he knew that his opinions were sought, or likely to be of interest, conversation would flow freely. Those who had been unaware of his scholarly talents were always amazed at the breadth and depth of his knowledge, and his facility for discussing complex issues with the utmost simplicity of phrase and detachment of view. "Bob" Hicks was a man whose qualities won not only admiration, but affection. He was without a trace of vanity, and combined an exemplary patience with an extraordinary consideration for the needs of others, and a complete disregard for his own.

He married, in 1939, Elsie Margaret Rowland of Melbourne and she and their daughter survive him. He derived much pleasure from the fact that his daughter inherited his love of mathematics. Walking was a favourite recreation and he spent several vacations walking in some of the rain-forests of eastern Australia. He possessed that aptitude for foreign languages which is often shown by mathematicians, and greatly enjoyed the rather rare opportunities he had for exercising his fluency in French and German. The most outstanding features of his private life were, however, his interests in both music and religion. He was extremely fond of classical and sacred music, but had an almost undisguised distaste for popular light music. Sacred music and its use were favourite subjects for discussion with those of his friends who knew it and understood it as he did. From boyhood Hicks was greatly interested in religion, and during his years in Melbourne formed many enduring friendships with both clergy and lay members of St. Peter's Church, East Melbourne, and at Ridley College, the Anglican Theological College, where he resided as an undergraduate. In after years, it gave him great pleasure to renew these friendships when travel provided him with the opportunity. As well as being a devout and erudite Christian with an astounding knowledge of ecclesiastical history, Hicks was an influential layman in church affairs. Religion was an integral part of his life and in all his activities he always displayed the highest standards of Christian behaviour. He consistently practised the virtues, and was in every sense a good Christian, a good man, and a good scientist whose example will benefit all who knew him.

W. J. Scott

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The Dried Fruits Processing Committee

A Short History by W. R. Jewell

Mr. Jewell was, until his retirement in 1959, the Chief Chemist, Victorian Department of Agriculture. For over 30 years (1929–59) he was a member of the Committee charged with coordinating dried fruit research by C.S.I.R.O. and the State Departments of Agriculture. As foundation secretary, and later as chairman and member, Mr. Jewell has established a unique record of service on the Committee.

THE present Dried Fruits Processing Committee originated in a Committee convened in 1929 by the then Council for Scientific and Industrial Research to consider the question of the sulphuring of dried stone fruits, particularly apricots. At that time, the dried fruits trade reported difficulty in keeping the sulphur dioxide content of dried apricots for local and export markets below the then permitted maximum of 14 grains per pound. This is a very different position from the present one where the problem is to ensure that the sulphur content approximates the much higher existing maximum; further reference to this will be made later.

C.S.I.R. asked the States of New South Wales, Victoria, and South Australia each to appoint a representative to the new Committee, to act along with a C.S.I.R. representative. The States agreed, and the members of this Committee were:

- Mr. A. V. Lyon, Officer-in-Charge, C.S.I.R. Research Station, Merbein, Vic.
- Mr. G. C. Savage, Director of Fruit Culture, N.S.W.
- Mr. George Quinn, Chief Horticultural Officer, S.A.
- Mr. W. R. Jewell, Research Chemist, Department of Agriculture, Vic.

The Committee elected Mr. Lyon as chairman and Mr. Jewell was empowered to act as coordinating officer and secretary of the Committee.

THE PERIOD 1929–33

The Committee held its first meeting on June 11, 1929, under the following terms of reference:

- To discuss the difficulty which had arisen in the past with respect to the sulphur dioxide content of dried fruits.
- To endeavour to arrive at agreement regarding the procedure for the next season.
- To make arrangements for the carrying out of any experimental work considered necessary.

Sulphuring of Tree Fruits

The Committee was satisfied that the irregular methods of sulphuring adopted by growers, particularly in relation to duration of exposure to sulphur fumes, quantity of sulphur burnt, type and size of sulphur chamber, and maturity of fruit, all tended to result in the over-sulphuring of apricots. It considered that, while further investigation was necessary, existing data were sufficient to enable recommendations to be made which could reasonably be expected to give a satisfactory product with apricots in most instances. The Committee issued a recommended sulphuring procedure, which was distributed to growers by each of the Departments of Agriculture concerned.

The Committee also agreed that further experimental work was necessary and outlined a programme of investigations which were to be carried out by members of the Committee. The question of so-called "over-sulphured" dried apricots was so acute that the Committee adopted a procedure, worked out by one of its members, for the removal of excess sulphur dioxide by treatment with hydrogen peroxide; this treatment was successfully carried out on a commercial scale. The Committee also approved a rapid, workshop method for determining the sulphur dioxide content of dried apricots, which could be operated by the non-technical staff of a packing shed.

At its next meeting in October 1930, the Sulphuring Committee, as it was then called, received the results of experimental work completed, revised its recommended sulphuring procedure, and endorsed a further programme of investigations. Experiments had been carried out with peaches and pears, as well as with apricots, and the recommended procedure covered all three fruits.

In 1931, following discussions with the Development Branch of the Prime Minister's Department, the Department of Markets, and the Dried Fruits Control Board, C.S.I.R. decided that investigation of certain problems connected with field methods of processing vine fruits was required, in order to formulate standardized procedures which could be demonstrated and advocated by State officers in the various fruit-drying centres. In view of the success of the Sulphuring Committee, C.S.I.R. decided to request this Committee to undertake the extended programme of work. This was approved by the States concerned and Mr. F. de Castella, Viticulturist, Victorian Department of Agriculture, was added to the Committee, which then became known as the "Fruit Processing Committee".

This Committee continued the work on the sulphuring of dried stone fruits. At its meeting in 1932, it decided that no amendment was necessary to its recommended procedure for sulphuring apricots, peaches, and pears, and it directed its attention to methods of producing "moist-pack" apricots. Reports from overseas indicated that bone-dry apricots were not appreciated and that a moister product was desired on these markets and would realize a higher price.

The production of a moist pack involved some alterations in procedure, including the provision of a higher initial sulphur dioxide content to allow for a more rapid loss, and a moistening process prior to packing to raise the moisture content to 20–25 per cent. Certain experimental work was carried out and subsequently a recommended procedure for the production of moist-pack apricots was approved and then published by the Australian Dried Fruits Association (A.D.F.A.) and the State Departments of Agriculture.

Processing of Dried Vine Fruits

At the meeting in 1932, the Committee also gave its first consideration to the processing of dried vine fruits and of prunes. It arranged for certain trials to be carried out with vine fruits, and for samples of experimental fruit to be sent to England—part to be opened on arrival and examined by members of the trade, and part to be returned unopened to Australia for examination. It issued a report covering suitable varieties of plums for drying as prunes, and a recommended process for producing both dry-boxed and dessert prunes.

THE PERIOD 1933–45

After a meeting in 1933, the Committee did not meet again until 1937, when Mr. Jewell replaced Mr. Lyon as chairman and Mr. D. G. Quinn, who had replaced Mr. de Castella as Victorian Viticulturist and as a member of the Committee, was appointed secretary. Mr. A. G. Strickland, now Director of Agriculture in South Australia, replaced Mr. George Quinn, who retired.

The minutes of this meeting record the Committee's first consideration of emulsified oils as used in dipping sultanas, a matter which was to occupy much of its time in future years. Revised recommendations for processing prunes and for producing moist-pack apricots were also approved at this meeting and were subsequently published by the A.D.F.A. and State Governments. There was another gap of four years before the next meeting in 1941, at which it was decided to appoint Mr. E. C. Orton, chemist at the Merbein Research Station, as an additional member of the Committee. Until his resignation from the service of the Commonwealth in 1952, Mr. Orton carried out the major portion of the experimental work on vine fruits required by the Committee.

During the war years, the activities of the Committee were widened but, naturally, were limited mainly to ad hoc investigations and recommendations required by the Department of Commerce in connection with the supply and packaging of dried fruits for the Services. Attention was directed to establishing moisture limits for various types of dried fruit in different types of container, which would result in satisfactory storage under tropical conditions.

In 1944, Dr. J. R. Vickery, Chief, C.S.I.R. Division of Food Preservation, pointed out that, as his laboratory was engaged on dried fruit problems in relation to Service requirements and particularly to storage under tropical conditions at different moisture and sulphur levels, cooperation between his laboratory and the Committee should be of mutual advantage. This suggestion was readily accepted, and Dr. Vickery was appointed a member of the Committee.

Up to this time, the Committee's investigations were largely concerned with problems involved in sun-drying of fruits, little attention having been paid to other methods of dehydration. Experimental work had been mainly in the form of field, or semi-commercial scale, processing and storage trials, laboratory work being mainly restricted to analysis of samples from these trials for moisture and sulphur dioxide.

There is no doubt that extremely valuable service was rendered to the dried fruits industry during these first 15–16 years of the Committee's activities. Close association was always maintained with the industry through appropriate channels, particularly the Australian Dried Fruits Association. The Committee's various recommended procedures were published by that Association (as well as in governmental journals), were accepted by industry, and resulted in a material improvement in the techniques of drying and in the quality of the dried product. The allocation of specific investigations to individual members of the Committee prevented overlapping and waste of effort and produced results as quickly as possible.

POST-WAR YEARS

After the war, the general character of the work of the committee changed considerably. The impetus given to the dehydration of foodstuffs during the war resulted in a keen interest in tunnel dehydration of fruits in the following years, and the Committee became concerned with problems associated with this type of drying, rather than sun drying.

This, in itself, necessarily resulted in a swing away from field trials to laboratory-scale experiments, as a result of which more and more of the investigations to solve dehydration problems and to enable recommended procedures to be evolved were centred in the laboratories of the C.S.I.R.O. Division of Food Preservation and Transport at Homebush, N.S.W. It became a regular feature for appropriate officers of the Division to be present at Committee meetings by invitation and to describe the experimental work for which they had been responsible.

Changes in Personnel

In 1946, Mr. Jewell resigned as chairman of the Committee (now known as the "Dried Fruits Processing Committee") but continued to act as a member until his retirement in 1959. Mr. C. G. Savage, Chief, Division of Horticulture, N.S.W., was elected chairman and he selected Mr. R. B. Withers, of Dr. Vickery's laboratory, as secretary in place of Mr. D. G. Quinn who resigned; for convenience, it was desirable for the chairman and secretary to be resident in the same State. At about this time, Mr. W. M. Carne, Department of Commerce, was appointed an additional member, in order to keep a close liaison between the Committee and the Department which is responsible for overseas marketing of dried fruits. For a time, Mr. F. H. Colby and Mr. J. M. Davidson, also of that Department, attended meetings held in the State in which they were located.

The Committee, therefore, emerged from the war years with the following constitution:

C.S.I.R. —Three representatives (J. R. Vickery, Homebush; A. V. Lyon and E. C. Orton, Merbein.).

States —Four representatives (C. G. Savage, N.S.W., A. G. Strickland, S.A.; D. G. Quinn, and W. R. Jewell, Vic.).

Commerce Department—One representative (W. M. Carne plus two observers).

Secretary—R. B. Withers (C.S.I.R., Homebush).

About 1950, Messrs. Savage, Lyon, and Carne retired from the public service, and consequently from the Committee. Mr. J. D. Bryden, Special Fruit Officer, Division of Horticulture, N.S.W., replaced Mr. Savage; Mr. F. Penman, Officer-in-Charge, Commonwealth Irrigation Research Station, replaced Mr. Lyon; and Mr. F. H. Colby, Commerce Department, replaced Mr. Carne. Mr. Strickland was elected chairman and brought with him Mr. B. G. Coombe as secretary. In 1956, Mr. Penman succeeded Mr. Strickland as chairman, and he holds that position at present.

Post-war Research

With respect to tree fruits, the Committee has, since the war, been concerned with investigations relating to the dehydration and storage of free and clingstone peaches, apricots, pears, and bananas; the preparation of sugared, or glacé dehydrated fruits; and the packaging and prevention of mould growth in high-moisture prunes. Recommended procedures were issued for the commercial production of dehydrated apricots and pears, and of sugared fruits. In addition, in 1954 the Committee issued a new and enlarged edition of its notes on the drying and processing of tree fruits (Dried Fruits Processing Committee 1954). The notes dealt with the sun-drying and sulphuring of apricots, peaches, pears, nectarines, and prunes, and with packing-house procedures for handling and preparing such dried fruits for market.

With vine fruits, the Committee continued its interest in dipping and drying trials, particularly those concerning the effect of the composition of the dip on drying time. Trials were carried out on the sulphite dip and on the storage of cold dips from one season to the next. The advent of a number of adverse seasons focused attention on problems associated with rain damage of grapes and with the control of moulds and vinegar fly on fruit on the drying racks. A natural consequence of these poor drying seasons was a study of the dehydration of sultanas while on the racks and of the feasibility of tunnel dehydration for sultanas. In 1954, a revised edition of "Drying of Vine Fruits" was approved and issued (Penman and Oldham 1954).

When the Committee was first formed, the major problem was to ensure that the sulphur dioxide content of dried fruits did not exceed the then maximum permissible value of 14 grains per pound. When the moist pack came into general use for dried tree fruits, the position changed completely, the problem being to obtain a sufficiently high concentration of sulphur dioxide to ensure the retention of colour and flavour during the shelf life of the pack.

Experimental work had shown that the sulphur content should be nearer 21 than 14 grains per pound when packed, if a satisfactory shelf life was to be obtained. A report was prepared by the Committee and forwarded to all State Departments of Health, recommending that State food regulations be amended to permit a maximum of 21 grains per pound in all dried tree fruits. All States accepted this recommendation and altered their regulations accordingly.

Basic Investigations

An important development in relation to the problem of controlled sulphuring of fruit prior to either sun-drying or dehydration was the institution, at the request of the Committee, of experimental work of a more fundamental nature than that hitherto attempted, at the C.S.I.R.O. laboratories at Homebush. These investigations were designed to study the uptake and loss of sulphur dioxide during sulphuring and the factors influencing its retention on drying.

Sulphuring equipment was designed and installed at the Homebush laboratories whereby the sulphur dioxide content of the atmosphere in the sulphuring chamber was recorded and controlled at any desired level, under controlled conditions of temperature and rate of air movement. These investigations were commenced about 1954 and are continuing. Results to date have satisfied the Committee that work of this nature can be expected to yield valuable data, which are essential before the factors affecting sulphuring can be properly understood or a reliable commercial procedure recommended.

CONCLUSION

In the foregoing short history of the Dried Fruits Processing Committee it was not possible, nor was it desirable, to describe in detail all its activities. Rather, an attempt has been made to record the highlights and to mention the persons who have so willingly given of their time and energy to its functioning. The author is the only member of the original Sulphuring Committee who has been a member up till 1959. He has seen it develop and expand, and, of all the committees on which he has been privileged to serve, he considers his association with this Committee to have been one of the happiest.

The Committee has given a worthwhile service to the dried fruits industry and it is confidently expected that it will continue to do so. It is an outstanding example of the cooperation which is possible between the Commonwealth and the States, allied with close contact with the industry concerned, with mutual benefit to all.

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A Passion Fruit Centrifuge

By D. M. Kinch*

Presented to the Annual Meeting of the American Society of Agricultural Engineers at Santa Barbara, California, June 1958. Reproduced from the Transactions of the American Society of Agricultural Engineers (1959) 2: 52–4, 57 by kind permission of its publishers, and of the author.

THE use of passion fruit as a commercial crop in Hawaii is a recent development, in which the Hawaii Agricultural Experiment Station has played a large role, by reason of its research on the culture of this fruit and the development of processing techniques and equipment for extracting the juice from it. This paper is a brief report on one phase of this development work, namely, the separation of the juice sacs containing the seed from the rinds.

THE FRUIT

In order to make clear the nature of this separation problem, a brief description of the fruit and its characteristics follows.

The passion fruits (Akamine *et al.* 1954) belong to the genus *Passiflora*. The purple passion fruit, *Passiflora edulis*, is thought to be a native of Brazil. From there it was introduced into Australia where it is thought that the yellow passion fruit *Passiflora edulis* var. *flavicarpa* originated as a sport from the purple fruit. The purple fruit was introduced into Hawaii about 1880 in the district of Lilikoi on east Maui. From there it spread to other parts and picked up the Hawaiian name "lilikoi". The yellow fruit was brought into the Hawaii Agricultural Experiment Station about 1923 from Australia. In the Islands the commercial processors prefer the yellow variety as it has a higher yield of juice and also a slightly stronger flavour which makes it a more potent blending agent with other fruit juices.

The fruit is oval in shape with a major axis of $2\frac{1}{2}$–$3\frac{1}{2}$ in. and only slightly smaller on the minor axis. The rind consists of thick pulpy material somewhat firmer than a grapefruit rind with the outer epidermal layers smooth, hard, and waxy. On the inside surface of this rind, which is generally $\frac{1}{4}$–$\frac{3}{8}$ in. thick, are attached 100–150 embryo sacs which contain the juice and seeds. These sacs are about $\frac{3}{16}$ in. in diameter and $\frac{3}{8}$ in. long and are attached to the rind until the fruit becomes dead ripe, at which time they tend to loosen and lie in a clump in the inner cavity. However, at the stage of ripeness suitable for processing they are still firmly attached. Within each embryo sac a black flat seed is surrounded by an acid juice of most pleasing taste.

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PROCESSING STEPS

Preliminary experimental work showed the need for four basic steps in the processing of passion fruit to obtain the juice. These are:

(1) Washing and inspecting the fruit.

(2) Slicing the fruit to expose the inner juice and seed sacs.

(3) Separating the juice and seed sacs from the rind.

(4) Separating the juice from the seeds.

Washing and inspecting the fruit is carried out using conventional rotary fruit washers and sorting conveyor belts. Cutting the fruit is not quite so simple because the efficacy of the cutting process depends to a large extent on the manner in which the third step is performed. Originally step (3) consisted of trying to shake the seed sacs loose from the rinds by means of various types of vibrating screens. Once the seed sacs were separated from the rind, the fourth step was easily accomplished by means of commercial paddle pulpers and finishers that are used in the processing of such products as tomato juice. However, the method of accomplishing the third step was not at all satisfactory since there seemed to be no commercial food-processing machinery that could be adapted to this particular job.

It was at this stage that the Agricultural Engineering Department of the University of Hawaii was called on to work with the Food Processing Laboratory in developing a procedure and equipment for separating the juice and seed sacs from the rind. It soon became evident that the slicing problem was related to the separating problem and that both would have to be solved together.

THE CENTRIFUGE PRINCIPLE

In the brainstorming sessions on how the separation of the sacs from the rinds might be accomplished, it was inevitable that the principle of the centrifuge should be suggested. In the spirit of "try something" we obtained a centrifugal water extractor—the type of unit used in a commercial laundry. This particular unit had a perforated stainless steel basket, well balanced on a slotted ball-and-socket joint through which it was driven. The ball was mounted on a slender vertical drive shaft which was free to move through a considerable angle. When this basket was spun with wet wash in it, it rotated about its centre of mass and maintained dynamic balance even though the centre of mass did not coincide with the drive-shaft axis. When a charge of sliced passion fruit was placed in the basket and spun, a considerable portion of the juice was extracted through the perforated sides. Four objections to this system soon became apparent, namely:

- About two-thirds of the sliced sections were forced against the basket wall, each in the form of a dish preventing the juice sacs from passing through the perforations.
- In an attempt to get a higher percentage extraction, the speed was increased and this caused some of the rind juice to be extracted, thus imparting a bitter off-flavour to the passion fruit juice.
- Because of the batch-type process some of the sliced fruit remained submerged in its own juice for a while, and the rinds absorbed juice liberated in the cutting operation. This absorbed juice could not be extracted easily, and it contaminated the other juice with some of the rind enzymes, adversely affecting its taste and keeping quality.
- It was realized that from the stand-point of commercial processing efficiency a batch-type process would be highly undesirable.

The more the problem was thought over and discussed, the more essential it seemed to employ a continuous extraction process. Thus a two-fold goal was set up:

- A continuous seed sac extraction process, and,
- High-extraction efficiency without contamination by rind juice or pieces of rind.

CONTINUOUS-TYPE EXTRACTOR

The idea of the centrifuge extractor for passion fruit processing did not originate with the author and his colleague T. N. Shaw (Kinch and Shaw 1954). However, we did systematically explore the limitations of the batch-type centrifugal extractor, and as a result we were in a position to set up the design requirements for a continuous-type centrifugal extractor which would continuously eject the juice into one compartment and the rinds into another. In checking with some food-processing companies as to what had already been achieved along this line, we invariably obtained the answer that a continuous extraction process involving non-fluids had never been very satisfactory.

It was reasoned that the best method of ultilizing centrifugal force to separate the juice sacs from the rind would be to have the rinds in slices with the centrifugal force acting perpendicular to the plane of the slice. This would permit free exit of the juice sac from its attachment to the inner surface of the rind. The design for the fruit cutter was thus largely determined. To achieve this, thin parallel rotating discs mounted on a common arbor were used, and the fruits were fed by means of a tube to the rotating discs where they were then cut into slices $\frac{5}{8}$ in. thick. This rotary slicer was mounted directly above the centre of the centrifuge basket in order that the sliced fruit would drop directly into the centrifuge with no appreciable time lapse between the slicing and the extraction processes.

The next problem was to make the centrifuge basket of such a shape and to rotate it at such a speed that the centrifugal force exerted on the slice of fruit would cause two distinct motions to occur, as shown in Figure 1. First, the seed sacs would move radially outward through perforations in the basket wall away from the slice of rind in the direction of the centrifugal force *G*.

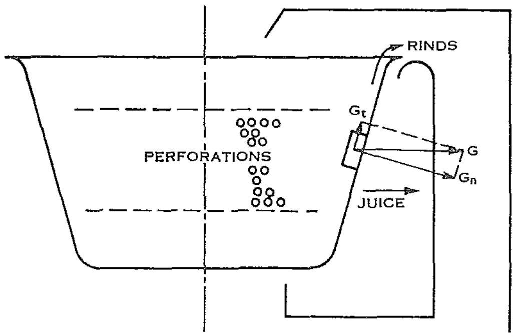

Fig. 1.—Movement of rind and juice in a rotating perforated basket.

Second, the rind slice would slide up the inclined plane of the basket wall under the influence of the tangential component of the centrifugal force, G_t, and would finally leave the basket above the juice-retaining container.

THE ANALYSIS PHASE

After building and testing several perforated baskets having different slopes and rotating at different speeds, we found it was a challenging problem to get the juice to go one way and the rinds to slide another by means of centrifugal force alone. Too high a rotational speed caused the rinds to crush and thus contaminate the juice with pieces of the rind; too slow a speed would cause the slices to pile up in the bottom of the basket; while other rinds entering the basket from the slicer would slide over the ones stuck near the bottom. The latter would absorb juice, reducing considerably the percentage of juice extracted. Too steep a side on the basket would make the operation a batch-type operation. Too much slope, however, would permit the rinds to fly out before adequate extraction had time to occur. After building several baskets with various slopes, it was found that fabricating perforated stainless steel baskets was an expensive way to do research.

The experimental work now moved out of the fabricating shop and to the drawing table and slide rule, where it probably should have started in the first place. However, in rationalizing, we believe that the time spent on the unsuccessful baskets was well spent in that it gave us an appreciation of the problems involved which a mathematical analysis alone could never have done. Notes were kept on the performance of each basket operating under various speeds. A theoretical analysis of the forces acting under each condition was attempted but there was one unknown factor that precluded an answer. This was the coefficient of friction between the rind and the basket wall as the rind slid up the wall.

COEFFICIENT OF FRICTION

The work now moved from the calculating room to the laboratory bench where tests were performed to arrive at a value for the coefficient of friction of a passion fruit rind against perforated stainless steel. We consider this particular part of the experimental work a most important link in the chain of research that ultimately proved that our continuous extracting process would work. To be more specific, the determination of the coefficient of friction gave us the real clue to the basket slope and the rotational speed required for efficient operation.

There was nothing particularly unconventional in this determination of coefficient of friction. Small sheets of perforated stainless steel were thoroughly scoured and soaked in passion fruit juice overnight to simulate the basket wall after considerable sliced fruit had passed over it. The plates were laid on a slope and freshly cut slices of passion fruit were placed near the top of the incline and weighted down with a weight of about $150W$, where W equals the weight of the slices themselves. The sheets were then inclined to an angle at which the slices would start to move down the incline and the average angle was obtained from many trials. The tangent of this average angle was then assumed to be the static coefficient of

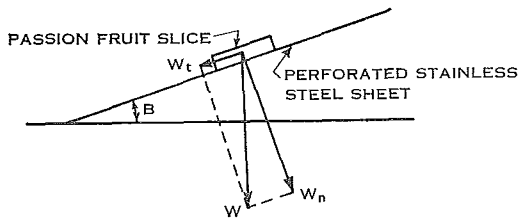

Fig. 2.—Determination of static and kinetic coefficients of friction between rind and steel.

When motion is impending, $\frac{W_t}{W_n} = \tan B_s = 21\frac{1}{2}°.$

When motion is constant, $\frac{W_t}{W_n} = \tan B_k = 16°.$

friction between passion fruit slices and stainless steel (Fig. 2). In a like manner the angle was measured at which continued movement of the passion fruit slices down the incline would occur. By continued motion is meant a slow, constant velocity. The tangent of the average angle of slope was then assumed to be the kinetic coefficient of friction. The static coefficient of friction was found to be tan $21\frac{1}{2}°$ and the kinetic coefficient of friction tan 16°. As the slices do not present a solid surface to the steel, we cannot assume that these values are independent of surface area and weight. It should therefore be stated that the values so found apply specifically to fresh slices weighted down with 150 times their weight on stainless steel having $\frac{1}{4}$-in. punched holes $\frac{5}{8}$ in. apart. The sheet was placed so the direction of punching was downward to eliminate the problem of rough edges around the individual holes.

Since the passion fruit slices enter the basket at the centre and are thrown to the outer basket walls at a high velocity, we felt justified in assuming that the kinetic coefficient of friction was more representative of the conditions encountered on the basket wall. And it is also a well-known fact in machine design that, as the velocity increases, the kinetic coefficient of friction tends to decrease slightly. Considering these facts and also that, while the rinds in the basket were moving at a high velocity, the rinds on the test sheets of stainless steel were moving very slowly—we felt justified in assuming that the actual kinetic coefficient of friction would be somewhat less than tan 16° and that this value would make allowance for a design safety factor ensuring that movement up the basket wall would always take place.

OPTIMUM CENTRIFUGAL FORCE

Obtaining the optimum magnitude of centrifugal force for efficient extraction was a problem distinct from the problem of the coefficient of friction. We then went back to the data obtained with the trial baskets and the original batch-type basket, and from these data made calculations on the centrifugal forces involved. In addition we ran a number of other tests on the original batch-type basket with vertical wall. These tests were

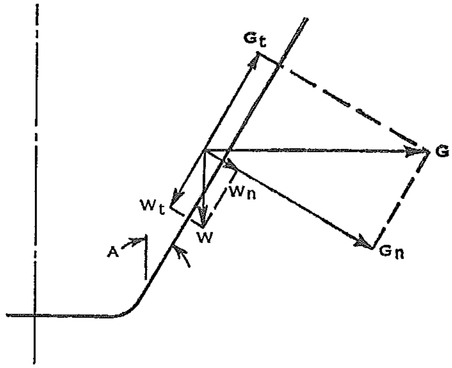

Fig. 3.—Effect of the weight of the rind in the determination of the correct slope of the basket.

run at various speeds to study two things:

- The extent of the crushing of the rinds into the extraction holes.
- The amount of seed sacs left in the basket after the run.

From the data obtained by the above-mentioned procedure, we arrived at a figure of $175W$ as the centrifugal force G that would give excellent extraction of the juice without crushing the rind. This value represented a maximum since the centrifugal force varies directly as the radius. It can be seen from Figure 1 that the actual force on the rind increases as it moves up the basket slope. A basket of effective maximum diameter 19 in. and rotated at 800 r.p.m. would produce the desired centrifugal force.

The design requirement data were now in hand. The force $175W$ determined the relationship between basket diameter and speed, while tan 16° determined the ratio between the force parallel to the basket wall causing the rind to move up out of the basket and the force perpendicular to the basket wall. However, in addition to the centrifugal force, the weight of the rind must be considered in determining the slope of the basket. Figure 3 shows why the angle of slope of the basket wall is not identical with the angle of incline used in determining the coefficient of friction. In other words, angle A of Figure 3 is not the equivalent of angle B of Figure 2. Since angle B is defined by the ratio of forces at right angles to each other, a consistent definition in terms of Figure 3 would be:

$$\tan B = \frac{G_t - W_t}{G_n + W_n}.$$

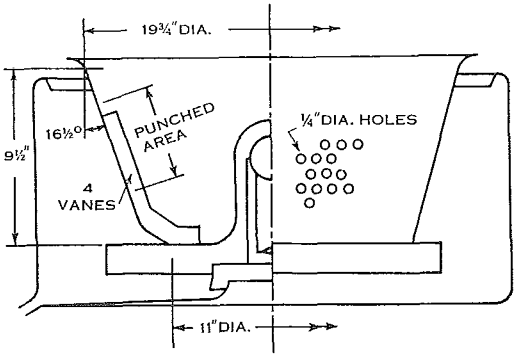

Fig. 4.—Continuous-process centrifuge for the extraction of passion fruit juice.

Writing each of the forces in terms of the angle A:

$$\tan B = \frac{G \sin A - W \cos A}{G \cos A + W \sin A}.$$

Therefore,

$$\tan A = \frac{W + G \tan B}{G - W \tan B},$$

giving the relationship between angles A and B. When $G = 175W$ and $B = 16°$, $A = 16\frac{1}{2}°$ (approx.). However, this difference between A and B is more theoretical than practical as long as the centrifugal force is very large compared to the weight of the rind.

THE TESTING PHASE

Another basket was now constructed, having a wall angle of $16\frac{1}{2}°$. Through a suitable variable-speed V-belt drive, the speed was adjusted so that a force of $175W$ would be exerted on the rinds as they went past the upper series of perforations. The first trials of this basket were disappointing. There was continuous movement of the rinds from the basket, but the juice yield of the extractor was low. For some reason, a considerable amount of juice was going out with the rind. Examination of the rind showed that many of the sections had juice sacs still attached. This was proof that the centrifugal force was not great enough to extract them efficiently. We then set up a "Strobolux" over the basket so that we could observe the rinds at various positions as they were moving up the basket wall. The versatile research value of the stroboscopic principle in permitting us to see and study the action in a rapidly rotating basket was amply demonstrated by this particular application. It was immediately apparent why extraction was not up to expectations. The value of $175W$ was based on the assumption that the rinds would rotate at the basket speed. This was not occurring in actual practice. The rinds moved up the basket wall satisfactorily, but were moving up in a spiral at a rather low speed compared to the surface velocity of the perforated wall. The addition of four radial vanes about $\frac{3}{4}$ in. wide made the basket a series of compartments from which the rinds could not leave until they had risen above the extraction holes. This immediately solved the extractor yield problem, and the rest of the experimental work was concerned only with minor refinements of the receptacle for the spent rinds, and revision of the slicer design to increase its capacity, since it was found that the capacity of the extractor was now far greater than was anticipated.

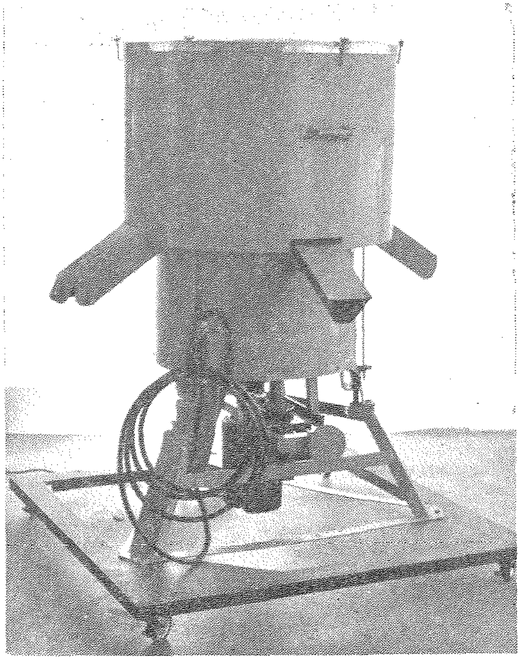

Fig. 5.—Pilot model of passion fruit centrifuge with a capacity for processing of about two tons of sliced fruit per hour.

In the experimental set-up, we have never had a slicer large enough to determine the maximum capacity of the extractor. Since then, however, the design specifications for this continuous-process passion fruit extractor have been released to local industry and a number of extractors have been constructed following our design. The industry has learned from our experience and has built slicers with much greater capacity than our experimental one, and, with the same size basket extractor, capacities ranging up to 3800 lb of fruit per hour with an extraction efficiency of 94 per cent. have been attained.

Figure 4 gives the general configuration and some of the basic dimensions of the latest test model centrifuge, photographs of which are shown in Figures 5 and 6. It is possible that this use of the centrifugal extraction principle may have other interesting applications. At least we can say that this particular application is extremely efficient, and has reduced the total processing costs in the Hawaiian industry by 15–20 per cent.

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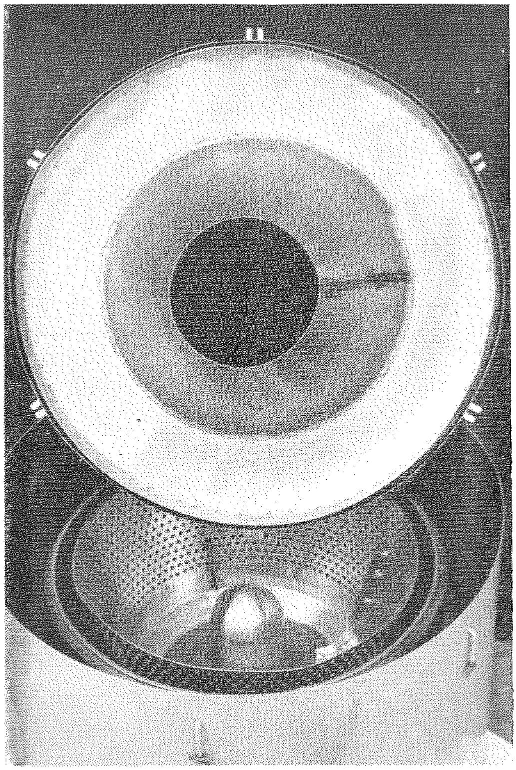

Fig. 6.—Centrifuge basket assembly showing inner juice container, outer rind container, and lid.

NEWS FROM THE DIVISION OF FOOD PRESERVATION AND TRANSPORT

PERSONAL

At the 20th Annual Meeting of the Institute of Food Technologists held in San Francisco, May 15–19, Dr. J. R. Vickery, Chief of the Division, was presented with the I.F.T. International Award. This award is made annually to a member of the I.F.T. who "has made outstanding efforts to promote the international exchange of ideas in the field of food technology". The award consists of a silver salver, suitably engraved, which is presented each year by the two Australian Regional Sections of the I.F.T.

At the Meeting, Dr. Vickery was chairman of the session on the storage of meats, fish, and poultry, and delivered a paper on the development of freezer burn in stored animal tissue.

Dr. Vickery also attended a Pacific Rim Food Conference in Hawaii from May 20 to 24 and took an active part in discussions on the technical and economic problems of increasing trade among countries bordering the Pacific Ocean.

PUBLICATIONS BY STAFF

The Chemical Constituents of Citrus Fruits. J. F. Kefford. *Advanc. Food Res.* **9**: 285–372 (1959).

This review discusses the general composition of citrus fruits and effects upon it of genetic factors, rootstocks, maturity, position on the tree, fruit size, nutrition of the tree, horticultural sprays, and weather conditions. The carbohydrates, acids, vitamins, inorganic constituents, nitrogenous compounds, enzymes, pigments, lipids, volatile flavoring constituents, non-volatile constituents of citrus oils, flavonoids, and limonoid bitter principles found in citrus fruits are then discussed in some detail. Much of the information can be obtained readily from the 22 tables in the review, and a bibliography of 386 references is appended.

The Chemistry and Technology of the Preservation of Green Peas. L. J. Lynch, R. S. Mitchell, and D. J. Casimir. *Advanc. Food Res.* **9**: 61–151 (1959).

This is a comprehensive review of the chemical composition of peas and of changes in their constituents during maturation and processing. Methods of measuring and predicting maturity are discussed, and the unit processes in the preservation of peas from harvesting to canning, dehydration, or freezing are described briefly. Two hundred and twelve references will help readers to study selected aspects of the subject in detail.

A Survey of Fruit Cool Stores. G. M. Rostos. *C.S.I.R.O. Aust. Bull.* No. 282 (1960).

The physical conditions in 23 cool rooms representing 14 different types were studied in some detail. Attention was concentrated mainly on the fruit temperatures in the stores, and particularly on the variation in temperature between different positions in the stacks. Rates of cooling to the storage temperature were also investigated in a number of the stores and weight losses from the fruit were studied in several of them. Various subsidiary measurements, such as coil temperatures, were made in most of the rooms to help elucidate the causes of any significant irregularities in fruit temperatures which were observed.

Most of the rooms selected for study were used for the storage of pears, but some were filled with apples and a few were designed specially for rapid cooling of pears or peaches to be stored for short periods before canning. Included in the survey were several types of natural-circulation rooms, forced-circulation rooms of several designs, and some rooms in which the natural circulation induced by ceiling coils was aided, intermittently or continuously, by fans.

In many of the rooms studied the average fruit temperatures in cases inside the stacks were all within ±1°F of the mean for the whole room. In a few rooms the variations in these inside temperatures were much greater for one reason or another, e.g. overtight stowage or inadequate rates of air flow in a through-flow system. In all the rooms there were variations substantially greater than ±1°F from the mean in boxes on the outer faces of stacks. In the most uniform rooms the range of the extreme temperatures was 3–4°F. In others the range was greater, up to 7°F or even more. The degree of uniformity was practically identical in the best of the natural-circulation rooms and the best of the rooms with forced-circulation. Relatively poor temperature distributions, where they were found, were due to defects in some details of design or operation, and not to the choice of an inherently unsatisfactory cooling system.

Cooling of the fruit to 35°F or lower within three days was observed in stores of all types when the rooms were loaded slowly, and the fruit judiciously distributed. Fast initial cooling was much harder to achieve in rooms which were filled quickly and in all of these a proportion of the fruit cooled much more slowly than was desired.

Large differences were found between stores in the rate of loss of water from the fruit during storage.

Copies of papers mentioned above may be obtained from the Librarian, Division of Food Preservation and Transport, Private Bag, P.O. Homebush, N.S.W. (Telephone: 76-8431, 76-0274).