milk, showed that payment on fat content of milk was a much fairer system than payment on volume of milk. In the New Zealand cheese industry this finding was introduced into practice more quickly than in the country where it was established. The work of two American chemists has thus provided the "measuring sticks" for the dairy industry and is the basis of the system of distribution of proceeds from all the dairy farms (except those in the market milk trade) in New Zealand. This work, it is safe to say, has been responsible for the marked success of the co-operative system, as it provided a means for each co-operator to receive his due share of the proceeds of the co-operative factory. Within recent years in New Zealand the chemist has elaborated, for the cheese industry, a rather more accurate system of distribution of the proceeds of cheese manufacture among the suppliers, by application of a test for casein to supplement the Babcock test for fat in the milk.

Analysis.—The chemical analysis of butter is now practised in every butter factory. In the early years of the export butter industry in New Zealand, the water content of the butter was so low that buyers in England could make large profits by reworking the butter and incorporating additional water up to the limit of 16 per cent. Nowadays with the improved churns available and with the assistance of the system of chemical analysis of the butter, the control of the moisture content by the factory operatives is very exact, and this has meant over the years, an enormous increase in monetary return to the dairy farmer.

The salt content of butter is of importance, and has to be regulated according to the requirement of the consumers. The chemical analysis of butter for salt content is now a regular part of the procedure in New Zealand butter factories.

Acidity Control.—The advent of home separation in 1908—1912, introduced a very serious problem. The acid cream from the infrequent collections then practised, curdled when heated in the pasteuriser. The process of neutralisation of the acid, first developed in the United States of America, made pasteurisation possible. The direct application of this process to the New Zealand dairy industry was worked out for the most part by factory-trained workers. Recently the chemist has played some part in clearing up some anomalies in the neutralisation procedure.

The titration of cream for acidity, introduced by chemists in Europe and America, is the basis of the neutralisation procedure. Titration of the buttermilk and butter as a check on the neutralisation is not very accurate. During the past few years control by pH determination has been introduced, giving the factory manager and dairy produce grader a means of checking the accuracy of the neutralisation of the cream, by means of an examination of the butter. Introduction of this system of testing in the Grading Stores, and a check up by chemical investigation on the neutralisation process as practised in the factories, is undoubtedly responsible for the virtual disappearance of "soda flavour" as a source of complaint against New Zealand butter. The finding by chemists in America, supported by practical experience in New Zealand, that butter made from acid creams developed fishiness during long storage, has enabled the butter industry to steer a middle course and provide the British consumer with a sound butter of remarkable keeping quality.

Metallic Contamination of Butter.—Formerly much trouble was experienced with butter subjected to long storage periods, through bleaching and the development of stale and tallowy flavours. The chemist has shown that the chief causes of tallowiness were the exposure of butter and cream to light and the presence of small amounts of copper and iron in the cream and butter. One part of copper in one million parts of butter (1/1100th oz. in a 56lb box) is sufficient to cause serious deterioration during storage. The resultant improvement in the tinning of dairy equipment, or the replacement of tinned copper and iron equipment by nickel, aluminium, or stainless steel are therefore primarily due to the discovery of the harmful effect of copper and iron. The work of the chemist has thus caused a profound alteration in the type of mechanical equipment in the dairy factory, and within recent years the alteration has penetrated to the farms, where the use of untinned brass in milking machine pipes is no longer permissible. The discovery of the influence of sunlight on butter deterioration must also influence factory design. Many of the older factories have been driven to the use of blinds or coloured paint on the window in order to prevent the access of too much light to the cream over the coolers.

Flavour of Butter.—The chemist has succeeded in establishing the chief source of the flavour in good quality butter (diacetyl) and is now engaged in studying the best means of increasing the proportion of this material in the cream without at the same time reducing the capacity of the butter to withstand long periods of storage.

Cheese Manufacture.—The introduction of the acidity estimation in milk and whey by titration with standard alkali, has given the cheesemaker a means of control throughout the cheesemaking process. Cheddar cheese manufacture is dependent on a steady development of lactic acid in the curd through the agency of the added starter culture. The acidimeter makes it possible for the cheesemaker to follow the progress of acidity development throughout the day, and to time the various operations of the process more accurately.

The discovery that undiluted milk has a constant freezing point introduced the freezing point method of detecting added water in milk. Chemical tests developed for the detection of the various disinfectants which have been added to milk by suppliers in order to prevent souring, have enabled the factory manager to prevent the adulteration.

The finding that rennet action on milk is facilitated, and the curd firmed up, by addition of calcium chloride has found application in cheese factories on those occasions when trouble is experienced through unsatisfactory coagulation of the milk. The application of formal titration to the estimation of casein in milk gave the necessary basis for standardisation of the milk for cheese manufacture, during the period when standardisation was permitted.

The chemical analysis of cheese is an important means of control. At the grading stores chemical analyses of composite samples are carried out regularly. By communicating the results and any deductions therefrom back to the cheesemaker the grader is able to assist the maker in the production of a high quality article.

Condensed and Dried Milks.—Means of correcting troubles in the condensed and evaporated milk plant have been provided through the finding that irregularities in the salt balance of the milk can cause coagulation during the sterilisation, and that these can be obviated by addition of the appropr ate salt e.g. sodium bicarbonate, before the commencement of evaporation. The occurrence of sandiness in condensed milk was shown to be due to the formation of large crystals of lactose, and led to a more careful control of the cooling of the condensed product in order to give a crystallisation in fine crystals. The importance of controlling moisture content and of avoiding metallic contamination in whole milk powder, if keeping quality is desired, were also findings of research chemists.

Vitamins.—The recent discovery that the yellow colouring matter of butterfat is related to Vitamin A, and that the green

colouring matter of whey is an important member of the Vitamin B complex are of importance in explaining the valuable properties of milk in the human diet.

Dairy By-products.—The chemist has played a leading part in the development of means of utilising dairy by-products (there is however, still room for a great deal more work to this end). The extension of casein manufacture was dependent on the discovery of new uses for casein, the work of the chemist. Casein now finds its way into the plastics, the adhesives, the paints, medicinals, paper making, and other industries. Recently casein has been used in the manufacture of a substitute for wool, but the value of the new fibre has not yet been established. The manufacture of the casein to be made for this purpose requires a much more rigid chemical control than the manufacture of ordinary commercial casein.

The utilisation of lactose as an addition to cow's milk for infant feeding purposes followed a comparison of the results of chemical analyses of cow's and human milk, and the development of the process of extraction on the commercial scale is the combined work of the chemist and the engineer.

Sundry Industries:

Rennet.—One of the first processes in the manufacture of cheese is the coagulation of the milk by rennet—an enzyme preparation which is usually obtained from the "vell" or fourth stomach of the sucking calf. Early cheese-makers dried these vells and either added a piece of dried vell directly to the vat, or else soaked the vell in whey for a period and added this mixture to the vat, thus obtaining rennet and starter together. As can be imagined, this practice was far from satisfactory. It was almost impossible to standardise the amount of rennet enzyme added, and there must have been tremendous variations in the coagulation times of the milk from vat to vat and from day to day. Apart from this, it was extremely difficult to prevent the vells from becoming contaminated with all sorts of micro-organisms which found their way into the cheese, to the detriment of its quality. No doubt the art of cheese-making in those days was very largely concerned with remedying defects due to the unsatisfactory materials used in the process. With the development of large-scale cheese manufacture, the need for a more satisfactory rennet became urgent.

In view of the antiquity of cheese-making, it is rather surprising that it was not until 1874 that a satisfactory rennet was produced on a commercial scale. This was a liquid extract prepared from vells, and was standardised with regard to its power of coagulating milk. It was comparatively stable and was preservatised to prevent the growth of undesirable flora. With minor improvements, the same type of extract is used by practically the whole cheese industry today.

The manufacture of rennet was commenced in New Zealand in 1918 on a co-operative basis. The process consists of extracting the dried vells with successive washes of preservatised brine solution, the whole course of the extraction being carefully controlled with respect to bacterial content, pH and concentration of enzyme. This control is essential if loss of enzyme is to be avoided and if satisfactory yield of enzyme from the vells is to be obtained. The extract is subsequently activated and filtered, and owing to the sensitivity of enzyme preparations, a constant control of pH and bacterial content is necessary during the whole of the period of storage in the factory.

Annatto.—The dye is extracted from the seed of Annatto (Bira orellana) but in its original form is insoluble in water. The subsequent conversion to a water-soluble form is a chemical process requiring laboratory supervision if a uniform product is to be obtained. This dye solution is clarified in a high-speed centrifuge and is then standardised by colorimetric methods.

It will be seen that these subsidiary industries owe their very existence to the work of research chemists, and that their manufacturing processes require much more in the way of chemical control than do those of the dairy factories themselves. There is a maximum of science and a minimum of "art" in the manufacture of rennet and annatto.

CHEMISTRY IN COLD STORAGE.

J. L. MANDENO

As the subject of chemistry in the meat freezing industry is dealt with elsewhere, this article will deal with the cold storage of fruit only. Although fruit was grown in New Zealand long before 1908, it was in that year that apples were first exported, 1236 bushel cases having been sent to Great Britain. During the 1938 export season 1,542,163 cases of apples and pears were exported. The total production at the present time is almost three times this figure, as nearly twice as much fruit is consumed locally as is exported.

The growth of this industry made it necessary to define the best conditions under which to store fruit both on land and at sea. Hence investigation into the cold storage of fruit has been mainly along these lines, with particular reference to temperature. It is well known that each variety of fruit requires a different temperature of storage, e.g. Sturmer and Cox's Orange Pippin apples, 36 to 38 deg. F.; Delicious apples, 34 deg. F.; Pears prefer a lower temperature and store best at about 32 deg. F.

It is of interest to see why each variety of apple has its own optimum storage temperature. It has been found by Tiller in the case of the Sturmer, for example, that at temperatures below about 38deg. F. wastage is due mainly to internal breakdown and other storage physiological diseases, and the lower the temperature, the less serious is fungal decay. Hence a temperature of 33deg to 35deg. F. has proved to be the most satisfactory for Delicious apples. Another variety, the Jonathan, at low temperatures suffers from internal breakdown and deep scald. Another physiological disease peculiar to this variety is Jonathan-spot, a superficial spotting of the skin. This is generally believed to be associated with high storage temperature, but the evidence is somewhat conflicting. Upon weighing up these conflicting factors, it has been decided that about 36deg. F. is the optimum temperature for Jonathans.

Of considerable importance also in the successful storage of fruit is the relative humidity of the storage atmosphere. If it is too low the fruit shrivels badly; if too high, internal breakdown and fungal decay are encouraged. So far, no critical work on the best relative humidity for New Zealand apples has been done. It is generally believed that about 85 to 90 per cent saturation is the best compromise.

Other factors of importance are the method of wrapping and the amount of air movement and ventilation in the store. For example, a serious form of wastage in Granny Smith apples is superficial scald. This can be controlled very largely by wrapping the fruit in a wrapping paper inpregnated with paraffin oil. Certain types of fungal rotting in pears can be prevented from spreading from an infected fruit to adjacent fruits in a case by the use of paper impregnated with a copper salt.

The storage life of apples is also affected by many orchard factors such as time of picking, type of soil on which the fruit is grown, root-stock and manurial practice. For example, apple trees given a high application of nitrogen produce fruits of poorer keeping quality than those which have a balanced fertiliser containing phosphate and potash as well as some nitrogen.

Work on the above points has been carried out in New Zealand by the Cawthron Institute, notably by Rigg, Tiller and McClelland, and also by the Department of Scientific and Industrial Research on the Research Orchard at Appleby. This work is still going on, some points having been fairly well investigated, while others still require further research.

In the Nelson district in particular, a disease of the apple which was becoming increasingly serious was internal cork. During 1934 the observation was made by Atkinson, of the Department of Scientific and Industrial Research, that the injection of a small amount of boron, in the form of boric acid, into the tree, cured the trouble. This was an important and original observation, and as it formed part of a joint investigation by the Department of Scientific and Industrial Research and the Cawthron Institute, the chemical aspects were then made the subject of study by Askew and others at the Cawthron Institute. This work has shown that many Nelson and some Otago soils are deficient in boron. Now by careful application of borax to their trees, whether by spray applications or soil surface dressings, fruit-growers have been enabled to eliminate this trouble from their orchards.

At the same time borax should not be applied too liberally to the trees, as it is found in the case of Jonathan apples, for example, that if the boron content of the fruit rises above 20 parts per million, fairly severe internal breakdown along with greater ungal decay occurs in cold storage. It appears that an application of not more than half a pound of borax per tree controls the internal cork, while at the same time the storage quality is not materially impaired.

During the last three years experiments have been commenced at the Dominion Laboratory on the gas storage of apples. This method was worked out originally by Kidd and West of the Low Temperature Research Station, Cambridge, England. It was found that apples and pears could be kept in much better condition and for a longer period by allowing carbon dioxide produced by the respiration of the fruit to accumulate in the storage atmosphere. The optimum concentrations of carbon dioxide and oxygen vary for each variety of apple stored, and can be determined only by experiment. If the concentration of carbon dioxide in the atmosphere rises too high, the fruit becomes more susceptible to internal breakdown, and it also suffers from another form of internal browning known as "brown-heart."

With a view to improving the quality of the fruit on the local market, and extending the season for some favourite varieties of apple, experiments are being carried out to determine the optimum conditions for gas storage of these varieties. So far the results indicate that gas storage will be a definite advantage for some varieties, but much work is necessary before results of commercial use can be made available.

The subject of cold storage is wide, and it touches many sciences. The worker is interested in the fruit he is studying, both in the orchard and in the cool store. So far in New Zealand, chemistry has played but little part in the work on the cold storage of fruit, although most of the investigators of the subject have been and are, chemists. The essential work as outlined above must be done first. There is no doubt that for further advance to be made in the elucidation of many of the problems connected with the cold storage of fruit, the chemist must play an increasingly important part.

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CHEMISTRY IN THE WHEAT INDUSTRY

E. W. HULLETT

Bread is the stable food of the white races, and through the centuries there has been a constant struggle to provide enough wheat for so important a foodstuff. With the growth of the world's population there have been periods when grave doubts were expressed as to the possibility of increasing wheat production sufficiently to meet the growing demand.

The plant breeder it was who played the largest part in avoiding a serious wheat shortage. He was able to breed and select new wheats which would resist the dreaded rust diseases or could grow in regions hitherto useless for wheat production. By this work men like Saunders have with their skill, exchanged famine for plenty.

To the credit of the chemist, however, stands at least the provision of artificial fertilisers, which have been of great value so far as quantity of wheat is concerned. The chemist has also been able to assist the breeder in his selection for quality and to round off his work by facilitating the making of a more palatable bread than would otherwise have been possible. It is in this direction that cereal chemists have had their greatest influence in New Zealand.

It must be realised that bread manufacture is an art which, even with the knowledge gained through centuries of experience, is still an exacting one. Variations in the quality of flour would tend to make it extremely difficult for the baker to make consistently good bread. For example, if the flour were from day to day made from different wheat varieties, or even from wheat of the same variety but grown under different conditions of soil and climate, it would be very difficult for the baker to make palatable bread on each occasion. It is then, very important that the miller should make a flour of uniform baking quality. There are however, no satisfactory means of assessing baking quality from inspection of the wheat itself and therefore the miller's task is no easier than is the baker's.

In New Zealand, variation in growing conditions lead to great differences in baking quality of our wheat and although the practical millers, by mixing many lines of wheat at a time greatly reduce the effects of variation in any one line, yet chemists have been able to help considerably in keeping variation at the minimum and so improving the bread made from

New Zealand wheats. This help has been largely in the determination of the baking quality of wheats and flours.

Mr. B. C. Aston, chemist to the Department of Agriculture, had arranged trials of New Zealand wheats as early as 1909, but it was not until 1922 that his Department began a serious study of New Zealand wheats.

Several papers by Mr. L. D. Foster report milling, baking, and chemical tests carried out by the Department of Agriculture under laboratory conditions over the period from 1922 to 1927. The methods for testing wheats were then however, relatively inadequate and it was only towards the end of that period that the literature on wheat testing began to give the beginnings of methods which were later to become more or less reliable. It is of interest to record that because of doubts entertained by practical millers as to the soundness of the experimental milling methods used by Mr. Foster that a trial was arranged in which a comparison was made of flour milled by Mr. Foster with that milled from the same wheat but in a commercial mill. The experimentally milled flour was actually the better.

Earlier than the work of Aston and Foster, were unrecorded attempts by practical millers to use various methods reported to measure wheat and flour quality. Mr. Fred Hall, for example, made good use of methods devised in England by William Jago, who is credited with being the "father of cereal chemistry."

A most valuable result of Foster's work was that it showed the men in the industry the potential usefulness of laboratory testing. No doubt it was his work and that of Dr. F. W. Hilgendorf that prepared the ground for the following developments.

In 1927 the Department of Scientific and Industrial Research succeeded in translating the wishes of farmers, millers and bakers for scientific assistance into a movement which resulted in a research association—the Wheat Research Institute.

During many years Dr. F. W. Hilgendorf, working at Canterbury Agricultural College, had endeavoured to breed better wheats, and it was partly to assist him in choosing wheats of improved baking quality from amongst many selections that it was desired to provide a testing laboratory. The work of testing wheats was by this time well established in Canada, so that with the appointment of Mr. H. E. West, a

Canadian, as chemist to the Wheat Research Institute a valuable step forward was made. West not only brought with him the most up-to-date testing methods but also soon convinced those engaged in the wheat industry that much was to be gained by applying the experimental method to their work. He instituted a regular wheat and flour testing service and also tried to discover any relationships between baking quality and chemical factors such as protein content. A conclusion reached quite early was that with New Zealand wheats such relationships were not sufficiently reliable in particular cases to render unnecessary the use of baking tests.

West also made himself familiar with the practical problems of the industry and gave most valuable help in dealing with problems of wheat harvesting, milling and bread making. The broadest lines of this work still persist but of course its scope has been considerably enlarged. The main problem for investigation is still the development of better testing methods and investigations of special problems which arise from time to time. Hope for progress in this work would be slight but for the continued endeavour to elucidate the fundamentals of breadmaking. Therefore, as time and personnel permit, studies are made on the chemistry and physics of wheat harvesting, storing, milling and baking.

Nor is the practical application of this work overlooked, for the closest possible contact is maintained with the men engaged in the industry. One example of the usefulness of chemistry in the wheat industry is illuminating. In 1936 much of the wheat crop was sprouted owing to a wet harvest. Ordinarily at least 50 per cent of the sprouted wheat would have been discarded or sold at a greatly reduced price, but by careful blending, made possible by the Institute's testing services, almost all of the crop was successfully used. It is estimated that this service alone was worth many thousands of pounds to the country.

During the last two years a new wheat, Cross 7, has been grown in ever increasing quantities. It has received high praise from both farmers and millers and has already led to an improvement in New Zealand bread. The value of Cross 7 would never have been recognised if it had not been made apparent by the experimental tests made at the Wheat Research Institute's laboratory. The practical value of this work is that it will largely remove the necessity for the importation of foreign wheat for the purpose of improving New Zealand flour, a necessity which costs the country many thousands of pounds annually.

In the eleven years that the Institute's laboratory has been working it has become increasingly apparent that only by unrelenting attempts to explain, on the lines of careful experiments, the behaviour of the materials used, can the workers in the Institute be in the best position to give practical service to the industry. Just as the miller and the baker will progress most if they use the services of the chemist to the fullest extent possible, so will the chemist progress in the measure that he submits his own methods to constant critical examination, in the hope of observing and removing their imperfections.

To sum up: the results of the work of those chemists in New Zealand who have applied themselves to the problem of the wheat industry are, firstly, a record of practical usefulness and secondly, the existence of an organisation which has every chance of giving the maximum of help to the practical men in the industry in solving every problem that may arise.

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CHEMISTRY IN THE WOOL INDUSTRY.

PROFESSOR F. G. SOPER

The present time is a highly interesting one to the chemist in many industries, but it is particularly so in the wool industry. Following a great expansion and rationalisation in the industrial revolution, the wool industry for a considerable period appeared to be comparatively unchanging. The present time is however, a time when new effects, new finishes and new properties are being obtained with wool.

The chemist in the wool textile industry is concerned with two kinds of work: on the one hand, fundamental or long-distance research, and on the other, service work in which he serves the needs of the mill in production. The present improvements in wool textiles are due largely to the former. Chemistry is a comparatively young science and one which is now being applied with cumulative success to the elucidation of the way the more complex substances produced in nature are built up from their constituent atoms. Due to the work of Astbury and of Speakman at Leeds University over the last few years, the intimate architecture of wool in terms of its constituent atoms is known, and this knowledge provides a key to the understanding of its methods of processing. Simultaneously there has occurred in the last few years, due to the pure research work of Hardy, Langmuir, Adam and Rideal, a great clarification of ideas as to the nature of surfaces and surface forces, which has been reflected in the new detergents now available for the treatment of wool and which have in turn such a great effect on dyeing and pleasing finish.

The surface of the wool fibre may to-day be modified by reaction with other substances. This modification may not be visible to the eye or detract in any way from the natural pleasing appearance of wool. Thus it has been possible to confer the following properties on wool:

(a) Water repellancy, using Velan—a discovery of Imperial Chemical Industries Limited.

(b) Increased cohesion and increased wear of the fibre by coating with an invisible film of rubber—now being developed by the Wool Industries Research Association, Torridon.

(c) Increased softness of handle.

(d) Permanent moth proofing—resulting from the pioneering work of the I.G. Farbenindustrie Aktiengesellschaft, using substances which though colourless are analogous to dyes.

(e) Unshrinkability, achieved efficiently by various processes.

This is an imposing list of improvements of recent date, the full result of which has not yet been realised.

On the service side, the chemist assists in the control of wool scouring by control of the liquor and by analysis for fat and soap of the scoured wool; in testing wool oils for ease of removal; in water conditioning; in the diagnosis of stains and uneven dyeing, and in general by the standardisation of various treatments necessary in the processing from the raw state to the finished article. In New Zealand, the Department of Scientific and Industrial Research and the Wool Manufacturers have formed a Research Association which is pursuing both fundamental research and assisting in service problems. Such problems frequently involve the co-operation of the textile expert with the necessary mechanical knowledge.

SCIENCE IN THE LEATHER INDUSTRY.

R. O. PAGE and P. WHITE

The manufacture of leather had been so highly developed at the dawn of history, that in the brief period of fifty years during which science has come to the aid of the tanner, no sensational achievements would be expected. Nevertheless the chemist has, in this short time, introduced the chrome tanning process and developed it to such an extent that it has now largely displaced all other methods of tanning shoe upper leather. Probably as important as this spectacular success however, has been the increase in the knowledge of the nature of the processes involved in the traditional methods of tanning for this knowledge has enabled the modern tanner to achieve a control, previously undreamt of, over his product.

Leather chemists, in the course of these fundamental studies, have often been forced to undertake pure chemical research necessary for the development of the applied science and this contribution to pure science has been a notable one. Thus the first application of the Donnan membrance equilibrium to proteins was made by a leather chemist, as was the use of Werner's theory of valency in unravelling the constitution of the complex salts of chromium. Another instance of the eagerness of the tanner to exploit the resources of science is the very early use of the hydrogen electrode, and later the glass electrode, to determine the effective acidity of tanning liquors.

The New Zealand tanner was particularly early in seeking the help of the chemist. Forty-five years ago the local pioneers of the chrome tanning process called in the aid of the Chemistry Department of Canterbury College; the first full time tannery chemist starting over twenty-five years ago, while the New Zealand Leather Research Association was one of the first research associations formed here. Although the number of leather chemists in New Zealand is still small, they have been able to make a notable contribution to the world's store of knowledge. The conception of free and fixed water solubles in leather and the development of methods for their determination has made possible a much more complete understanding of the nature of the combination of vegetable tannins with hide. The importance of the water soluble material and rolling on the wear and water resistance of sole leather has been demonstrated and the effect of oiling on its colour reasonably

explained. Also the seasonal variation of the quality of sheep and lambskins has been established.

In the tanneries, modern methods of scientific control have been introduced, raising the uniformity and quality of New Zealand leathers to a high standard. Chemical methods are used to check the composition of the various process liquors, while on the physical side the importance of temperature control has been recognised.

More recently the drying process has been standardised by the introduction of automatic control of both temperature and humidity. Progress has also been made in the solution of the difficult problem of measuring essential physical properties such as resistance to water and wear in the sole leather and strength, stretch and crackiness in shoe upper leather. Thus science has, in a comparatively short time, helped the New Zealand tanner to make impressive improvement in his products.

CHEMISTRY IN THE PHORMIUM (NEW ZEALAND FLAX) INDUSTRY.

W. A. JOINER

At the outset it may be said that chemistry has not played a very large part in the development of the phormium industry. This unfortunate state of affairs may be attributed to a variety of causes such as lack of organisation of the industry and widely varying market conditions which have made difficult the initiation and prosecution of systematic research. One is, however, forced to the conclusion that had such work been carried out the industry would have been better able to resist competition from other fibres and would not have found itself in the depressed state in which it exists today.

As far back as 1870 the reports of the Commissioners appointed by the Government to investigate the industry indicated an inadequate investigation of the chemistry of the fibre, and little has been done since that time to make good that deficiency.

The results of early chemical investigations by Church and Skey are given by Hector in his excellent monograph "Phormium Tenax as a Fibre Plant," published in the latter half of the last century. Church also published some of his work in "The Transactions of the New Zealand Institute," where also may be found papers dealing with methods of softening the fibre, chemical retting and papermaking. Recently a more fundamental study of the chemical composition of the leaf and fibre has been undertaken. The results of preliminary work in this investigation have been published by Brandt, and it is to be hoped that facilities will be provided for the continuation of this work.

Commercial phormium fibre belongs to the class of hard fibres such as sisal and manila which are its chief competitors. The manila and sisal industries have the advantage of cheap production and better organisation. Against this however, the yield of fibre from the phormium plant is much greater than in the case of either sisal or manila. It is the opinion of some that phormium might be made to yield a finer and softer fibre than the present commercial cordage fibre. If this could be done phormium could then command a higher market price. No doubt these ideas have to some extent been based on examples of fine lustrous fibres prepared by the Maoris. Such fibre was prepared laboriously by hand and Hector states that the yield of fibre made in this way was only about one ton from forty tons of green leaf and that one person could produce only about two to three pounds per day. No doubt much valuable fibre was lost, but it is interesting to contrast this yield with that of one ton of fibre and tow from about seven or eight tons of green leaf by present methods of mechanical

stripping. Attempts have been made to produce by mechanical or chemical means a fibre of quality comparable with that produced by the Maoris, but so far none of the methods proposed have attained commercial importance. A number of varieties of phormium are now known to exist and indeed a number of varieties were recognised by the Maoris. It is possible therefore, that by cultivation of selected strains, various grades of fibre could be produced.

At the present time phormium fibre, after having been stripped and washed is taken to paddocks or bleaching fields and exposed to the weather for some days. This treatment has the effect of improving the colour and texture of the fibre. Some experiments on the chemical bleaching of the fibre in order to replace the weathering treatment have been reported by Aitken.

Although phormium is chiefly valuable as a source of fibre, proposals have been made from time to time to employ it as a raw material for paper pulp or for pulp for the production of rayon. The Imperial Institute, London, investigated its possibilities for the latter purpose. Although it appears that phormium is unlikely to be very suitable for the latter purpose there is reason to suppose that it might prove useful for paper pulp on account of the chemical composition of the fibre cellulose and the physical properties of the ultimate fibres. This is confirmed by reports of tests carried out by the United States Bureau of Standards and by reports of experiments made at the Dominion Laboratory by Maclaurin and Donovan. The commercial development of phormium pulping must rest however, on economic grounds.

The utilisation of by-products from the stripping of phormium has received some attention. Easterfield made some experiments on the fermentation of juice from phormium waste with a view to discovering its use as a source of alcohol. Aston made an analysis of stripper waste and concluded that such waste would be suitable as a fertiliser if well rotted. Before its use could be considered for this purpose it would be essential that waste of this nature could be cheaply recovered and that sufficiently large quantities were available in any given locality.

It is impossible in a short review to give details of all the chemical work done in relation to phormium or to cite all the published work, but the reader is referred for further information to the list of publications given below.

In the future development, one might almost say recovery of the phormium industry, systematic and fundamental chemical work should play a larger part than it has hitherto done. If this is kept in mind, together with the necessity for the cultivation of selected varieties of phormium and for good industrial organisation there is yet hope that the industry may become a valuable asset to the country.

CHEMISTRY OF TOBACCO.

H. O. ASKEW

Tobacco is one of those natural products whose value depends on certain qualities which are known to the producer, the merchant and the consumer, but which are very difficult to describe in words, much less in precise chemical terms. Nevertheless attempts have been made and still are being made by many workers to arrive at some chemical basis of assessing the worth of a particular tobacco for a special purpose. It is well known that different qualities are desired for leaf for manufacture into cigars, pipe, or cigarette tobacco. Therefore no one combination of criteria can be expected to apply to all types of tobacco.

In its progress from the plant in the field to the manufacturer's premises, tobacco is subjected to many naturally varying conditions and all of these have an effect on the final quality of the leaf. Tobacco is extremely sensitive to the conditions under which it is grown; variation in weather conditions, in soil and fertiliser conditions, in the degree of ripeness when harvested, and in the conditions under which the fresh leaf is cured, all have their effect on the quality of the leaf. In the following discussion flue-cured leaf will be dealt with since a great part of New Zealand leaf is of this type.

Growth of the Plant.—While tobacco will grow, and grow well, under a wide variety of conditions, for the production of the light textured type of leaf desirable for use in cigarettes, the climate, the soil, and manurial conditions must be carefully selected. It has been stated that quality and aroma are largely governed by climatic conditions, while texture is governed by soil type. Fertiliser treatment also exerts an effect on the quality of the leaf. This will be considered more fully later.

After the young plant is set out in the field it commences to manufacture protein, sugars, and the more complex carbohydrates such as cellulose. The chlorophyll granules, which give the green colour to the leaves, are active in these assimilation processes. Any cause, e.g. due to deficiency of iron, magnesium, or other elements, leading to chlorosis of the leaves, will prevent these processes from proceeding in a normal manner. During the development of the plant the nicotine content increases until a maximum figure is reached at maturity of the leaf. After the maximum growth rate has been attained, the plant begins to send up a seed-head. Nutriment is then

withdrawn, in the form of sugars and proteins, from the leaves to feed the rapidly developing flower. At this stage "topping" of the plants is done. This consists in the removal of the seed head and stalk down to a height, estimated by the grower, such that the remaining leaves will reach a harvestable condition. Removal of the top of the plant prevents the assimilated and manufactured constituents of the leaves from passing on and thus they are built up into the leaves themselves. This results in a thickening of the leaves, which later will result in a better aroma, elasticity and finish in the cured leaf, due to the accumulation of starch and protein. Gums and oils also are formed in the leaves. Nicotine content also increases. The weather conditions during this stage of growth of the plants may have a great effect on the quality of the leaf. Cold and rainy weather will increase the acidity of the leaf and this is detrimental to the later processes of curing and ageing, which are largely due to enzyme action. On the other hand, excessively hot weather tends to prevent the development of the enzymes. Cold nights however, retard growth and this causes deterioration in quality and flavour. Moderate rainfall with warm weather, especially when heavy dews fall at night, gives the best conditions.

Some time after topping, the lower leaves on the plant begin to show a light yellow mottling; this indicates that the leaf is ready for picking. The best days for harvesting are those that are bright and sunny since on these days there are present more of the desirable products of assimilation, thus leading to improved quality. At this time the leaf will be brittle owing to its being gorged with starch, and this brittleness is used as a test of ripeness.

The usual method of harvesting is by "priming," that is removing the lower leaves as they reach maturity. After suitably tying to sticks for support, the leaves are removed to the kiln to be cured. In this process the leaves are subjected to varying conditions of temperature and humidity. The earliest stages consist essentially of starving the plant at a temperature of about 90deg. F. in a humid atmosphere. This is the "colouring" stage, the aim being to develop a bright yellow colour in the leaf. During this period the enzymes in the leaf hydrolyse the starch to sugars (glucose mainly) and the proteins to simpler nitrogenous compounds, while chlorophyll is destroyed also. The leaf is still alive and thus a large amount of dry matter is used up by respiration; as much as 12 to 20 per cent of dry matter may be lost. A considerable loss of moisture occurs also. Later the temperature is raised