make a sufficiently soft dough and use other ingredients in the proper proportions. Durum wheat flours are exceptionally useful for the making of macaroni, largely because of the deep yellow color; also because of the peculiar toughness of the dough which becomes apparent on drying.

The characteristics which distinguish flour of the soft winter wheats from that of other wheats are a lower gluten content and greater starchiness; a whiter color; a softer gluten and a lower capacity for the absorbing of water in the making of dough. In general, the flours from the hard winter wheats are between those of the soft winter and the spring wheats, in these particulars, but there are some hard winter wheat flours which have more gluten than many of the spring wheat flours and the hard winter wheat flours often have a better water absorption capacity than the spring wheat flours. The durum wheat flours do not differ greatly from the spring wheat flours, either in the water-absorbing capacity or in the amount of gluten which they contain.

Baking powder biscuits have, to a large extent, superseded the old sour milk and saleratus product. Aside from the large sales of the baking powders themselves, the self-rising flour industry, where the baking powder is sold in the flour itself has, in recent years, developed enormous proportions, especially in the south. It has been made possible by the manufacture of low-price baking soda and high-grade acid phosphates. Soft white flours are chosen for self-rising flour and baking powder biscuit, partly because the trade using these articles in the greatest quantities is accustomed to a very white flour and demand it, and partly because the mellow gluten of the soft wheat acts promptly in a limited time with these leavening agents and does not require fermentation with yeast to make it sufficiently tender to offer little resistance to the proper expansion of the dough in baking.

Different wheats yield flours containing different proportions of starch and gluten and flours of different shades of color and of different baking qualities. From the manufacturer's standpoint it is highly important for the miller to keep his product and for the baker to keep his raw material uniform. Of recent years the miller has come to make much use of the chemist in selecting his wheat, and both rely upon him to know the character of the flour.

Normal wheat flour is not a dead inert matter, but is in many ways an active, changing, living substance. Freshly milled flour from new wheat bakes very differently than does the same flour after it has laid in storage for a few weeks or months. Bakers and millers have long recognized this and have provided for it in the handling of the material. The amount of storage required depends largely upon the length of time after harvest and apparently also upon the condition under which the grain has ripened and the completeness of its maturity at the time of gathering. During this storage, change takes place in the gluten or in some of the other nitrogenous bodies present, and also in the coloring matter. Under some conditions, too, the flour may become drier and thus have increased absorption. It was to overcome the defect of newly milled wheat flours and supply the demand for white flour and white flour products that modern flour bleaching and maturing processes were devised. It has long been known that when flour has been exposed to the air it quickly loses its yellow color and more recently it was found that when certain oxides of nitrogen and some other gaseous agents are mixed in small proportions with the air which comes in contact with the flour, the yellow color disappears almost instantaneously. The chemistry of the process appears to be a direct combination of the agent with the coloring matter, which coloring matter is carotin: the new product is colorless, while the carotin itself is yellow. When the agent used is an especially purified anhydrous chlorine, applied in the proper manner in minutely accurate quantities, there are changes other than color brought about in the flour which simulate very closely those

changes which flour undergoes in long, favorable storage. Such flours not only produce a whiter bread, but a loaf of better texture and in many cases of greater volume. The gluten of these flours, being mellowed, will not require the extreme fermentation to produce satisfactory results that the same flours when fresh would have required to render their strong, harsh gluten sufficiently elastic not to offer undue resistance to expansion.

Of recent years, especially in England, various chemical salts have been proposed as additives to flour in minute quantities for the purpose of promoting the baking qualities of it. Up to the present time they do not appear to have met with great favor in this country.

Up to the time of the introduction of bleaching, flour making was looked upon as a purely mechanical process. Color as an indication of freedom from impurities became a distinguishing mark of quality and was the impetus for improvement in all departments of milling. Mechanical improvements in this direction, having apparently reached their limits, it was entirely natural that chemistry should step in and furnish the finishing touches. Even though industries manufacturing and using flours have been slower than others to realize the possibilities in this direction it is apparent that much has already been accomplished. We may summarize briefly as follows:

Chemistry assists in selecting and buying the grain; it helps to show the quality of the flour produced. It has supplemented mechanical processes of the mill and accomplished what had long been desired but could not be attained, in the improvement of color and baking qualities of the flour. By the introduction of baking powder products it has made possible many delicacies in the way of pastry and biscuit and has made possible the great self-rising flour industry. It has helped to explain the intricate process of the fermentation of bread dough, has pointed out the way to fit flour for it, and has unlocked doors for investigating problems of bread production, which have, as yet, opened only enough to permit a glimpse of a large space filled with interesting and useful possibilities.

COLUMBUS LABORATORIES, CHICAGO

CONTRIBUTIONS OF THE CHEMIST TO THE BREWING INDUSTRY

By GASTON D. THEVENOT
Consulting Chemist

Before we endeavor to ascertain what influences the chemist has been able to exert on the development of the brewing industry within the last 25 years, we must realize that brewing is not merely a chemical process in which chemical reactions in connection with mechanical appliances bring about all the changes from the raw material to the finished product, but that biological phenomena also play an important rôle. In fact, the biological side is of as much importance as the chemical one, so that the chemist who devotes his energies to the brewing industry must be just as well versed in the biology of microorganisms and bacteriological work as in chemistry itself, besides possessing a thorough knowledge of the practical and mechanical ends of the industry.

The influence of the chemist makes itself felt first in the selection and preparation of the raw materials from which the beer is made.

In the manufacture of malt, marked progress has been made. The old-fashioned methods of steeping the grain and of floor malting have largely been done away with. The introduction of aeration and agitation of the grain during steeping not only permits a thorough cleaning of the material, thus freeing it from the greater number of adhering microorganisms, but also furnishes to the grain some of the oxygen necessary for its ulterior sound germination. Pneumatic malting, which has generally taken the place of floor malting, permits an excellent regulation of those conditions of moisture, temperature and aeration which scientific investigations have found to be

essential for the manufacture of a high-grade product. Lately the germination of the barley, at least temporarily, in an atmosphere of carbonic acid gas generated by its own germination has attracted considerable attention, as it supplies a high-grade malt with a considerable reduction of the loss of valuable substances otherwise incidental to respiration during germination.

Starch being the most important ingredient of barley malt, inasmuch as it furnishes most of the extractive matter as well as the alcohol of the finished beer, it was tried at quite an early date to substitute barley malt, at least partly, by materials richer in valuable starch and, if possible, of a lower cost. Only in the last decades, however, has the introduction of malt adjuncts become practically universal, in this country at least, and rice and various corn products are largely employed in conjunction with malt. The greatest progress has been made in the manufacture of corn products, as they are now made of a very high grade of purity, some practically free from oil, others prepared with great skill in such a way that the cooking process which was formerly necessary can be dispensed with and the material used directly in the mash tun together with the malt without any further treatment at the hands of the brewer. The great purity of these products permits of the manufacture of an extremely clean-tasting beer of special character which appeals greatly to the American consumer and which admirably suits the conditions under which beer is consumed in the United States.

Neglected for a good many years, the influences of the brewing water has of late been made again the subject of a thorough study and the effect of the different mineral ingredients of natural waters on malt, yeast, and beer has been closely investigated. Some of these investigations have led to quite remarkable results which have prompted chemists to treat brewing waters in various ways in order to either remove such mineral constituents as have an unfavorable effect on the character of the beer or add to them those ingredients in which they are lacking and which tend to improve the quality of the product.

An enormous amount of energy has been expended by the chemist on the explanation and scientific control of the mashing process and great strides have been made in this field.

The hydrolysis of the complex starch molecule and the nature of the various cleavage products formed have been made the subject of careful study; painstaking experiments have been carried out, new formulas evolved, and while our knowledge today of the action of diastase on starch is not final we yet have a clear insight into the hydrolysis of starch and are well able to regulate mashing conditions so as to obtain any desired degree of inversion and consequently to produce a beer of any desired composition.

The proteid side of the mashing process has not been neglected. On the contrary, it received all the more attention when it had been recognized what great importance the proteids possess for the nutrition of the yeast, the foam-keeping capacity, stability and brilliancy of the finished beer. Experimental investigations have demonstrated what special groups of proteids or their cleavage products furnish food for the yeast, what groups cause the formation of a creamy and lasting foam, and what proteids are responsible for the appearance of a haze or a turbidity in the finished product. The temperatures and conditions of acidity controlling the changes of the complex proteid molecule under the action of the enzyme peptase have likewise been studied thoroughly so that the brewer, armed with the knowledge which the chemist has provided for him, is well able to regulate his mashing operations and the subsequent treatment of the beer in storage.

Colloidal chemistry has begun to play an important part in all these investigations and with its aid several difficulties have been overcome which for years had baffled all endeavors of the brewery chemist. Thus it has been possible with the

aid of lupulin in colloidal state and peptic enzymes to prevent the appearance of a proteid turbidity in pasteurized beer, even when the latter is kept at the freezing point for a long time or is actually frozen. This is of the greatest importance to the brewer in view of the fact that the American consumer desires above all an absolutely clear and brilliant beer which will retain this desirable appearance even when chilled to the extremely low temperatures at which beer is generally consumed in this country.

The progress made in the fermentation of the beer during the last decades has been of the first magnitude. First of all must be mentioned Hansen's remarkable discovery of the existence of the types of yeast which produce various sicknesses in beer, their isolation, and the study of the conditions under which they thrive, how they differ from the useful or culture yeast, and how their presence in beer may be obviated by the introduction of pure culture yeast propagated from one single cell. Not since the days of Pasteur's wonderful publications has the study of microorganisms been furthered to such an extent as by Hansen's classical investigations which have not only benefited the brewing industry but form the foundation on which rests all future study of microorganisms in general.

As every type of yeast behaves differently during fermentation and produces a beer of different character, the brewer is enabled to select the type best suited to his requirements, to propagate it from a single cell and absolutely free from wild yeasts or other foreign microorganisms, and to retain the character of his beer at all times.

The study of the activity of the yeast during fermentation has also received great attention and the discovery of the enzyme zymase as the agent causing the splitting of sugar into alcohol and carbonic acid has for all times disposed of the various fermentation theories which had been set forth for a hundred years or more. The study of other enzymes has not been neglected and their specific actions as well as their enormous influences in all malting and brewing operations have been firmly established.

Considerable attention is also due the investigations on the decomposition of albuminous matter during fermentation, it having been proven that, contrary to older theories, many by-products of fermentation, aromatic ethers and higher alcohols, such as amylic alcohol, are not cleavage products of sugar but of proteids. The discovery of the formation of the latter alcohol, while of comparatively little importance to the brewer, is no doubt of great value for other industries.

It is of prime importance that beer, through all of its stages of manufacture, be kept as free from contamination as possible, and the sterilization of brewery vessels or all implements with which beer comes in contact therefore received proper attention. A number of very efficient disinfectants have been invented for the purpose. The introduction of ozone as a sterilizer of the air in the brewery cellars and of the water employed for cleaning purposes is one of the latest developments in this field.

As far as the finished product is concerned, its clarification and sterilization have been given great attention. The important rôle which the proteids play in regard to the stability and brilliancy of the beer has been mentioned before. It was part of these investigations to determine what proteids were responsible for a more or less turbid appearance of beer and what means had to be employed to either restrict or prevent their formation during mashing or to eliminate them during the final stages of manufacture. It has been stated that this question has been successfully solved. Mechanical means of clarifying beer by freeing it from most of its suspended yeast cells by means of filtration through cellulose material have been greatly perfected and lately a filtration process has been introduced which removes all yeast cells or other microorganisms

present by forcing the product through porous stone cylinders and which produces an absolutely sterile beer, capable of keeping perfectly unchanged for an almost unlimited period of time. The object of the latter process is really to do away with pasteurization which checks the development of microorganisms in the finished beer in the bottle by heating. The conditions yielding the most satisfactory results in preserving beer by pasteurization have likewise been studied and the methods greatly improved.

The large quantities of spent or waste material derived from brewing operations have, for a long time, attracted the interest of the chemist. The question of the disposal of spent grains was most easily solved and for a long number of years these spent grains have formed a valuable cattle feed. Their value for this purpose has been considerably increased since drying of the wet grains is resorted to, thus resulting in a stable article which can be kept in perfect condition for a long time and which is even suitable and actually used for export.

The enormous quantities of carbonic acid gas escaping during fermentation, which amount to several hundred thousand tons per year in all of the breweries of the United States combined, were next given attention. Part of this gas is now, after suitable washing, compressed and sold in liquid form, while another part is utilized on the brewery premises for charging the fermented beer with the gas required to impart to it the necessary life and to insure a sufficient head of foam. The latter process, the carbonating of beer, has been largely introduced and has resulted in a very great saving to the breweries in which the system is installed.

The third waste product which has attracted the attention of the chemist is the yeast, of which very large quantities are discarded and run to waste after each fermentation. Analysis showed that yeast is extremely rich in valuable proteids and phosphates, and many chemists have endeavored and quite a number have succeeded in manufacturing from the waste yeast an extract which in taste and nutritive qualities is at least equal to meat extract. By others highly valuable cattle feed has been prepared from yeast and it is to be expected that in a relatively short time almost all of the yeast now going to waste will be diverted into useful channels.

In the above paragraphs the achievements of the chemist in his relation to brewery operations could merely be touched upon. As in all sanely conducted manufacturing enterprises, it has been and is the chemist's ideal to get at the bottom of, and explain in a strictly scientific way, the principles underlying all phases of the entire operation and to evolve means of cheapening the manufacture of the final product. At the same time I wish to emphasize that it is the aim of the brewery chemist to assist in producing a sound and healthful article in which the factors of purity and quality are of paramount importance and rank first before all other considerations.

CONTRIBUTIONS OF THE CHEMIST TO THE PRESERVED FOODS INDUSTRY

By R. I. BENTLEY

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A little over a century ago Appert, a French chemist, was awarded a prize by his government for discovering a process for preserving foods without the use of preservatives. Appert's process of hermetical sealing is the same in principle as that in use today by food preservers the world over.

The industry has grown to such wonderful proportions that the annual output runs into billions of packages and nearly every known variety of meat, fish, vegetable and fruit—to say nothing of various sundries—is preserved in tin or glass. Statistics show that New York City expends \$150,000,000 annually for preserved foods—as much as that city spends for milk, bread

and eggs combined for the same period. This gives some conception of the volume of the business and the extent and variety of the field that it covers.

A chemist having made the industry possible, it would be presumed that chemists would have more or less to do with the preserving of foods from that time on—but in the early days of the industry, in our country at any rate, preservers of foods had little or no scientific knowledge. Their business for the most part was done in a very small way. There was an air of mystery about the processes and each preserver very jealously guarded the methods which he had acquired by experience, or by purchase from some one who had the experience. Under such conditions the keeping quality was the primary consideration in the mind of the preserver—if the flavor or appearance received any consideration, it was merely secondary.

It is a question whether, up to 20 years ago, it ever occurred to a preserver of foods that he could make use of a chemist or bacteriologist in his business. It is a question also, if it had occurred to him, whether he could have found a man, excepting at very large centers, who could have assisted him to any material extent. It is also a question whether, without special knowledge of the industry, a chemist could accomplish much until some insight and knowledge of the business was acquired. If the chemist and bacteriologist gave any attention to manufacturers prior to 20 years ago, they confined their attention to industries other than that of the food preserver. The food preserver, however, having now started to avail himself of their services, is making up for lost time.

Reference will be made to the application of bacteriology to the industry as well as to that of chemistry. The two sciences are so closely related and interwoven in the preservation of foods that it is difficult to discuss the one without referring to the other. If an apology is necessary, your attention is called to the fact that the presentation of this subject is not by one of your profession.

It is impossible within the limits of this paper to go very much into detail, or to present any statistics for your consideration. In this general discussion, therefore, the application of chemistry and bacteriology for the benefit of the industry will be mentioned, and illustrations of such application will be given.

Chemistry has enabled the food preserver to get the best materials suited to his use. A very simple illustration is that of salt—used to a large extent in the preservation of vegetables. Formerly, the preserver considered it a matter of economy to use the cheapest grade of salt that could be purchased. The chemist has shown him that some salt on the market contains injurious materials and that its use affects both the quality and appearance of products. Chemistry having already determined what grade of salt is best suited to his use, on its delivery the chemist determines whether the preserver has received what was selected. In the item of solder also, chemistry has enabled the preserver to get those proportions of metals which are best suited to his use, and on delivery the chemist tells him whether he has received what he ordered.

The application of bacteriology has enabled the preserver to scientifically determine the best methods of processing. The bacteriologist has ascertained the forms of organisms which cause trouble and by means of cultures of the same and inoculation experiments he has determined definitely what times and what temperatures are necessary for sterilization in order to preserve the different products.

The preservers of corn probably had the first experience with bacteriology as applied to the industry, for they had more or less trouble with what was termed "sour corn." Ordinarily corn that was not properly processed would develop what the trade terms "swells," *i. e.*, gases would be formed to such an extent that the heads of the tin cans would swell out—hence the name "swell,"—and ultimately burst; but in the "sours"