

The results furnished by the laboratory show what is taking place at different steps of the process through the factory. These results, however, must be coordinated and applied in order to make them of value. From the results of the routine tests the foremen in the different departments of the plant can correct their respective operations so as to improve the results. At other times some unusual condition or combination of conditions may bring about unfavorable results, which will require special tests and analyses and perhaps more or less research work in order to avoid them. Once a certain kind of trouble has been experienced it becomes easy to avoid this a second time, but in the manufacture of corn-starch and corn syrup, as of course, in other industries, it is the unexpected that usually happens. Consequently, the one in charge of operations must not only keep in constant touch with the laboratory results, but carry on such additional tests and experiments as seem necessary in order to obtain the information which will permit getting the most satisfactory results from the plant.

EXAMINATION AND STANDARDIZATION OF FINISHED PRODUCTS

A complete analysis of the different finished materials serves as a guide for standardization. For example, the gluten feed and corn oil cake meal must be guaranteed to contain not less than a stated minimum of protein and fat and not more than a stated maximum of fiber. These limits will naturally be put at such values that under the individual factory conditions they can always be attained unless for some very unusual cause. It is the function of the laboratory to prove whether or not these guarantees are met, although for that matter the process control will give a very definite idea as to this. The crude oil is analyzed for its content of free fatty acids: if the oil is refined, a still further control must be exercised, both over process and finished product. The starch is tested for moisture and for impurities, which in this case are the other normal constituents of the corn, *viz.*, protein, oil and fiber, which should be present in the merest trace. Corn syrup will be tested for gravity and perhaps acidity. It is interesting to note that pure corn syrup has a trace of acidity, using phenolphthalein as indicator, due apparently to some slight acidity of the dextrins or other inversion products formed in the hydrolysis of the starch. It also has a trace of alkalinity, using methyl orange as an indicator, due to traces of sodium phosphate present in the ash of the syrup. With rosolic acid as indicator, it is practically neutral. In addition the syrup may be tested for its boiling properties as used with sugar in candy making, and its resistance to discoloration when heated. This latter would be noticeably affected were the refining process insufficient to remove all but the most infinitesimal traces of gluten, etc. In short, it is the duty of the laboratory to devise and execute the most rigid and severe tests in order that the syrup may be brought to the very highest state of purity.

SPECIAL AND RESEARCH WORK

No industry is in a really healthy condition unless it is advancing along the lines of improvement of its products or development of new fields for their use. In the starch and corn syrup industry there is still opportunity for abundant research work and there will be found many new uses for the products already made and many new products discovered which can be manufactured from the constituents of the corn kernel. The number of different products is already large, including pearl and powdered starch, various kinds of lump starches, modified starches, soluble starches, dextrins of various kinds, corn syrup, several preparations of corn sugar, refined oil for table uses, rubber substitute, cattle foods and many other products.

As regards improvements in quality, it may be said that the pure food law, which some ten years ago abolished the bleaching of corn syrup with sulfur dioxide, has been most beneficial as it necessitated improvements in the refining process so as to get a

more highly refined product, and to-day corn syrup is whiter even than in the old days of bleaching syrup, and much better. In fact, it is one of the most, if not the most highly purified food product that we have.

In conclusion we may repeat that the manufacture of corn-starch and corn syrup, while almost entirely a mechanical process in its execution, can be guided and controlled intelligently only by the most thorough, rigid and comprehensive system of chemical supervision.

CLINTON, IOWA

THE CHEMICAL CONTROL OF GELATINE MANUFACTURE

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Previous to the present decade, chemical control in the gelatine industry was rather limited. The manufacturer bothered himself chiefly about producing a product that would give a sufficiently strong jelly, and be brilliant enough in appearance to satisfy a trade which was critical about these points only. With the recent awakening to the possibilities of better manufacture and control of all food products, a more exacting chemical control of gelatine manufacture became a commercial necessity. Once this control was established, it became, and still is proving of real assistance to the manufacturer, in addition to developing a product acceptable to the trade. Improved methods introduced have tended to increase yields, improve what is commercially known as test, and conserve by-products, all of which gives the producer greater returns. As a result, what was once looked upon as a necessary nuisance will soon come to be accepted as a necessary source of help.

However, in outlining the precautions taken in this industry, many things will be mentioned under chemical control, that, while properly so designated, are the outgrowth of long practical experience, and cannot be directly credited to the introduction of chemistry. It is remarkable, however, as others have undoubtedly noticed in other industries, how many processes or tests practical men sometimes use, which, on first inspection, seem to be without rhyme or reason, are found to be based on very sound principles, when given a thorough study.

Control work naturally divides itself into three classes: (1) inspection of raw materials and chemicals, (2) control of the manufacturing process, (3) inspection of the finished product.

RAW MATERIALS AND CHEMICALS

Raw materials for the manufacture of gelatine, being by-products of other industries, have been far from being standardized, and the quality has been extremely variable. When the supply of materials was great, corresponding to the demand, and as a consequence, the price was correspondingly low, this variation did not worry the manufacturer so much. Margins were great enough that some variation in yield could be overlooked. As the demand for this material comes to exceed the supply, and it becomes necessary to buy on a competitive basis, the possible yield from such material becomes a vital point. As a result, inspection of such material for its actual value to the manufacturer is continually becoming more important. If the stock is to be used only for glue manufacture, examination ends at this point, but that used for the manufacture of gelatine should be examined for impurities that would render it unfit for making an edible product. For instance, arsenic and other heavy metals that are not permissible in the finished gelatine may be present in such quantities that the stock cannot be used, so it must be turned to the manufacture of glue or technical gelatine. Other stock may contain only such impurities as can be removed by proper processing, and subsequent treatment must, at least in part, depend upon the results of the examina-

tion. Still other stock may be found that shows no impurities and may be processed without any such special provisions being made.

In the examination of chemicals, it is such impurities as just mentioned that require the greater attention, as most of these products have been standardized, and variations in quality are limited. It is easy to conceive how acid used in the process may contain objectionable quantities of the tabooed metals. Water is so common that it is not usually considered a chemical, but in certain manufacturing processes would rightly be considered as such. Although at first thought it seems easy to obtain a water supply that is free from objectionable impurities, it would be interesting to consider the effect the total solids in a water of ordinary purity would have on a finished product, when this water is used for boiling out the gelatine. Gelatine liquor leaves the boiling vats at a concentration of from 2 to 3 per cent. If the water in question contained 15 grains of total solids as mineral matter per gallon, this would add about 1 per cent of an ash in the dry gelatine obtained to that extracted from the stock and coming from the other sources.

MANUFACTURING PROCESSES

The chemical control of the various processes of manufacturing can be made very elaborate. For the sake of economical and convenient operation, however, this control work usually is, as far as possible, worked out to a system of simple tests that can be made by the operators who handle the routine of the manufacture. These operators may not understand the mechanism of the tests, or know what they are really testing for, but are trained to expect certain reactions, and if they do not obtain them, they know all is not well, and the attention of the proper party may be called to the trouble.

This control of the manufacturing process begins with the first treatment of the raw material, which is usually the so-called liming. As this is usually conducted in a saturated solution of lime-water, the strength of the solution requires no control. On the other hand, the stock must be well watched, as over-liming will reduce the yields very materially, while under-liming will likely leave behind certain impurities that should be removed, and, at the same time, require such drastic treatment in boiling that the test will be decidedly injured.

Following the liming comes the washing, wherein the excesses of alkali must be removed to within certain limits, together with other impurities that the lime has dissolved. As it is usually customary to boil slightly acid, this is usually followed by an acid wash, which neutralizes the residual alkali and gives the required acidity. It can be readily seen that, without some control, large amounts of acid may be wasted, unnecessary time and labor consumed in washing, or impurities left behind that should be removed.

The boiling of the stock follows the proper preparation in the wash-mills. The chemical control here is rather limited, the points of interest being chiefly the reaction and the temperatures. High temperature and excessive acidity or alkalinity rapidly hydrolyze gelatine into products of considerably less value.

From this point on through the process, the chemical control diminishes in importance, unless the liquors are to be clarified, or subjected to some other treatment for removal of impurities. However, as the importance of this control decreases, the importance of bacteriological control increases. This is another type of control which will be but mentioned here, that offers a very wide field of application to all points in the manufacture of gelatine, and the possibilities of which we are just beginning to appreciate. But it is especially while gelatine is in these comparatively dilute solutions, and varying in temperature from boiling through an ideal incubating state to the necessary

refrigeration required for its congealing, it becomes an ideal breeding place for bacteria. Hence all possible precautions must be taken to prevent infection and get the material past the danger stage as rapidly as possible.

Another item of importance is the air used in the drying of the gelatine. This is especially so where the air must be drawn from the badly polluted atmosphere of our larger cities. Impure air offers three possibilities: *First*, the dirt that may be collected, giving a gelatine that will dissolve with great turbidity; *second*, infections are frequently picked up in the drying alleys, from this dirt, although the product may have entered them practically sterile; *third*, the chemical contamination due to the absorption of chemical fumes in the air.

As has been mentioned, one of the points that must be carefully watched is the reaction of the material throughout the process; and to see how far-reaching the effects of any one factor might be, we will consider this more in detail.

The well-known influence of acidity on the swelling of gelatine and like colloids points to the importance of such control. The points of maximum and minimum swelling of the stock must be definitely related to the extraction of the gelatine and the properties of the resulting product. The fact that salts again modify this action of acidity only adds other complicating factors. The possible detrimental hydrolyzing action of acid or alkali has already been mentioned. Although the process of boiling out of the gelatine is most probably one of hydrolysis, it must be done under such control as will insure the action going only so far, or the product is deteriorated.

Likewise the wonderful probabilities for the formation of undesirable precipitates must be considered. We may have almost any combination of acid, or alkaline albuminates, mucins, and such substances, together with the inorganic compounds, especially the uncertain phosphates. There are conditions where a very slight change in acidity may bring down any one of these, or more likely, a combination of several. Much work has been done on the preparation of colloidal precipitates along other lines, and the operators have gone to great pains and trouble to obtain such precipitates. Here the conditions are somewhat reversed, and great care must be taken to avoid the formation of precipitates in the colloidal state. One of the great factors in this is that gelatine is a protective colloid, and the tendency is for all precipitates to separate in the colloidal form. This is the case even when precipitation is intentionally produced under careful control, for purification or clarification, making it easier, in most cases, to keep impurities out, rather than to attempt to remove them.

Besides the principal product, gelatine, the by-products must also be considered, and given their proper attention. There may be, depending upon the nature of the stock, a recovery of more or less fat, which is to be properly collected and graded. There will be the residual tankage which has its definite value as fertilizer, which valuation must be made on suitable analysis.

THE FINISHED PRODUCT

Any control work done on the finished product simply amounts to such analytical work as is necessary to check up the work previously done during the process of manufacturing. Physical tests such as the rigidity of jell, the viscosity of a solution, together with the appearance of the product gives data upon which the commercial value is fixed. Besides this, of course, the impurities must be checked up to show its suitability for edible purposes. Frequently, other special tests are demanded, depending upon the use to which the gelatine is to be put, but each case of this sort is a law unto itself, these tests being the outgrowth of some special demand made by the consumer.