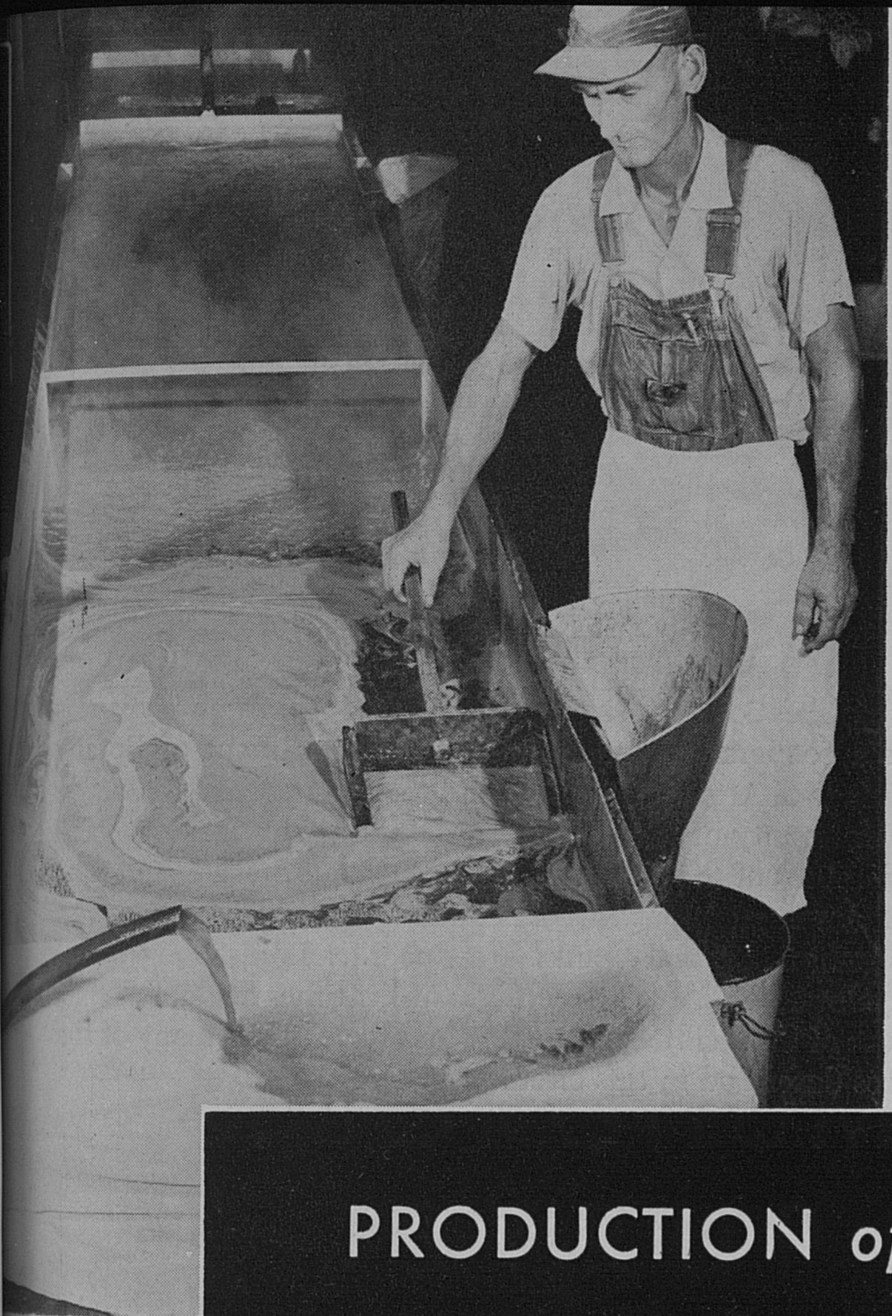

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PRODUCTION of SORGHUM SYRUP

By

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COOPERATIVE EXTENSION SERVICE

Agriculture and Home Economics

FOREWORD

This publication on the production of sorghum syrup is issued as a cooperative endeavor by the Department of Botany of the College of Arts and Sciences and the Cooperative Extension Service, University of Kentucky. The author expresses appreciation to members of the Agricultural Experiment Station staff who made various suggestions in connection with the preparation of the manuscript. Special thanks are due Mr. Louis Songster of Hardin county, who gave so willingly of his time, his knowledge, and the use of his facilities for testing and developing many of the procedures described in this circular.

Production of Sorghum Syrup

By Carl E. Henrickson

The yield of finished syrup from each acre of sorghum planted is determined by many diverse factors. Even under identical growing conditions, different varieties usually yield different quantities and qualities of syrups. Other factors such as the type of growing season, degree of uniformity of stand, soil fertility, and processing techniques make it impossible to predict accurately the number of gallons of finished syrup which should be expected.

In Kentucky about 100 gallons or more of finished syrup to the acre is usually obtained, but many producers are averaging above 140 gallons per acre. The duration of the syrup-making period is generally 50-60 days. It usually starts about September 1 and continues until about November 1, although occasionally if weather conditions are favorable, it may extend almost to Thanksgiving.

THE PROCESSING PLANT

Many farmers can raise a good field of sorghum, but few possess the equipment and skills necessary to produce a good quality syrup from the crop. While there is still a limited market for dark, strong syrup, it is the light-colored, mild-flavored, clear syrup which is desired by most consumers. Therefore, a profitable future in the sorghum industry depends upon the establishment of modern processing plants with adequate equipment and proper supervision to produce a high quality syrup. For efficient operation it appears that a plant is required which has an annual capacity of 10,000 gallons or more of syrup. A plant this size may be owned by an individual or by a partnership. It may process sorghum raised only by the owners or it may also process the crops of adjoining farms. Processing may be done on the basis of shares or on a flat rate basis. Production of large quantities of syrup opens avenues of marketing which are denied the small producer. The principles and recommendations discussed in this circular have proved commercially feasible in large scale production. However, many of the practices employed may also prove beneficial to the small producer who will probably continue for many years to serve the local market.

Location and Size of the Plant

It is possible to discuss here only in a general way some of the factors which should be considered in the erection of a plant. First, choose a site where space is not at a premium. The physical plant requires considerable room, and there must be sufficient yard space for the storage of cut stalks. The best location is as close to the sorghum fields as possible yet where electric power and a plentiful supply of water are available. The plant probably functions best when divided into three separate units. The first unit is a crushing shed which houses the extraction mills and their power sources. The second is a permanent structure containing the actual processing equipment. This building should be well ventilated to bring about rapid dissipation of the steam which is given off by the evaporating pans. A well-screened structure will also prevent the entry of the myriad of insects which will be attracted to the sugary syrups and wastes. Another permanent building, or an isolated section of the processing plant, should be provided for the bottling and storage of the syrup until it is marketed. Unless the bottling and storage space is separated from the processing plant it will be subjected to great amounts of moisture. In addition, the introduction of contaminants into the syrup may be caused by air movement stirred up by the personnel and machinery of the processing area.

An abundant supply of clean water which meets State Health Department requirements is a necessity. Thorough washing of the plant and its equipment after each day's operation is essential to maintain cleanliness. Special care should be exercised in the washing of the evaporating pans to remove caramelized syrup which might impart undesirable discoloration in later batches of syrup. When a boiler is used to operate the evaporators, a large quantity of water will be needed. If a boiler is not used, other means of supplying hot water for cleaning purposes should be provided.

Electric power is necessary to illuminate the plant for continuous operation and for the operation of the many pumps which are likely to be found in a modern installation. Three-phase current is highly desirable, but even large mills can be operated electrically on single-phase current if a phase converter is used. It is feasible, however, to power the crushing mills by some type of combustion engine.

EXTRACTION PROCEDURES

If the supply of sorghum is sufficient, the output of the plant is limited either by the rate that juice can be carried through the evaporation pans or by the rate at which the raw juice can be extracted. In good growing years the processing is usually the limiting phase, while in dry years the mill may not supply sufficient raw juice to insure continuous operation of the processing plant. Therefore, considerable thought must be given to the obtaining of the proper balance between the mill and the processing plant.

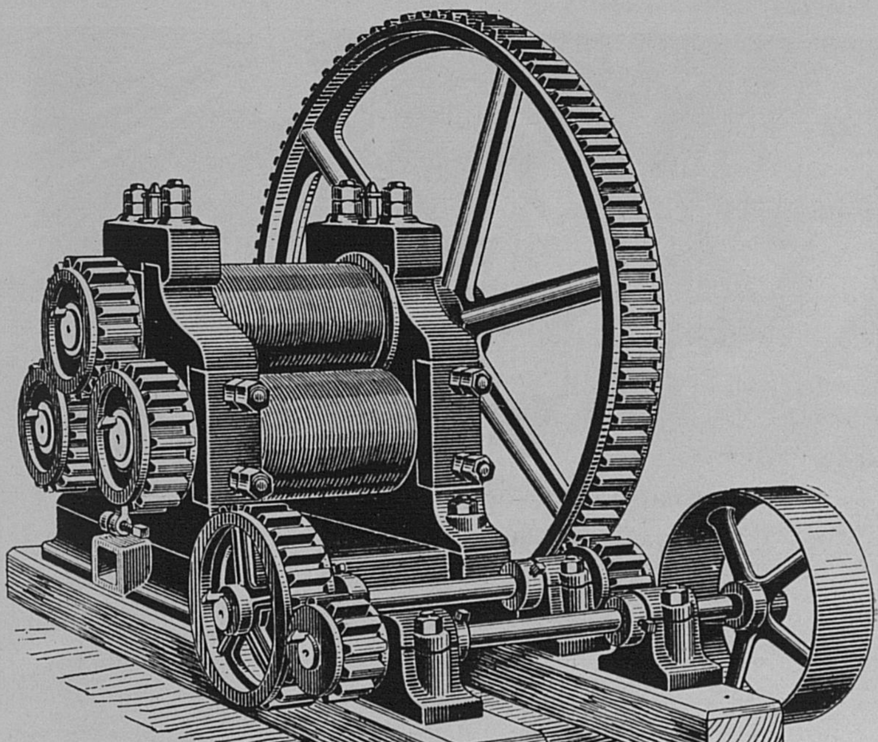

Fig. 1.— A typical three-roller horizontal mill. The juice flows from underneath the mill into a preliminary sedimentation tank before it is piped into the processing plant. (Drawing from U.S.D.A. Farmers' Bulletin 1791.)

To extract the juice, the stalks are passed through a mill (Fig. 1). A modern processing plant of the size mentioned previously will be best served by some type of three-roller, horizontal mill driven by an electric motor or a combustion engine. By appropriate gearing arrangements, power take-offs on tractors or gasoline engines can be used as power sources. Local power companies or R. E. A. offices are usually very cooperative in estimating electrical requirements and providing general information. The size of the mill or the number of mills employed will, of course, be determined by the size of the processing plant. The larger sorghum processing plants will usually have one or more three-roll power mills with feed rolls at least 24 inches in length and 12 inches in diameter. It requires very little additional labor to feed a mill of this size than a smaller mill and the percentage of juice extracted from the stalks will usually be higher.

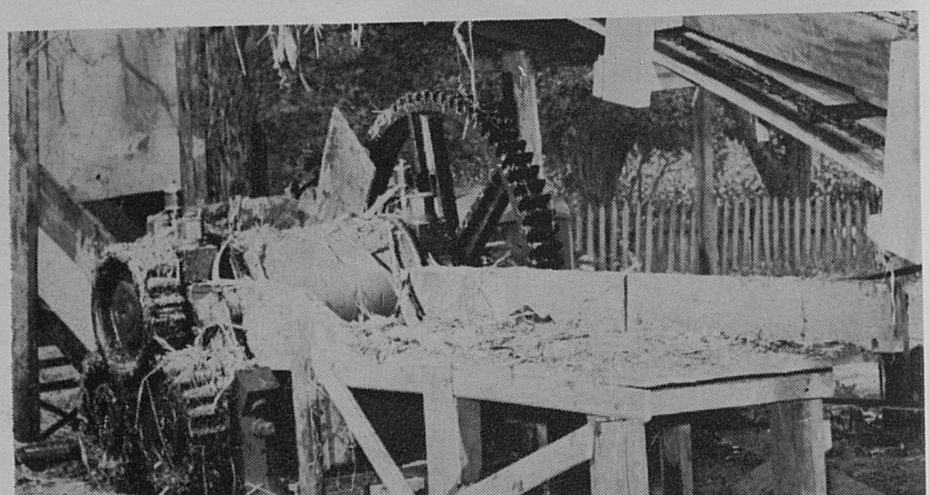

Fig. 2.— The feed table shown here enables the operator to feed stalks into the mill with efficiency and safety.

The supplying of a constant quantity of stalks into the mill is usually not a serious problem if a feed table (Fig. 2) is built. The large mills would probably be of a type used to crush sugar cane. The mills are usually very sturdy and are unlikely to become overloaded. Because the processing season is short and the amount of syrup produced depends upon the quantity of juice extracted, it is imperative to have reliable and efficient milling equipment. Regardless of the size or type of mill, it is important to get 50-60 percent extraction. This means that 100 pounds of stripped and topped stalks should furnish 50-60 pounds of juice if the stalks are not unusually dry. Many of the smaller mills used in Kentucky are probably not yielding more than 40 percent extraction. The value of high percentage extraction is illustrated in Table 1.

Table 1.— Percentage of Extraction of Juice, Weight and Value

Percent Extraction	Pounds of Stalks	Pounds of Juice	Pounds of Syrup	Value ($0.15–1 lb)*
40	2000	800	140	$21.00
45	2000	900	158	$23.70
50	2000	1000	175	$26.25
55	2000	1100	193	$28.95
60	2000	1200	210	$31.50
65	2000	1300	228	$34.20

* This figure (0.15) is purely arbitrary and is used here merely for illustrative purposes.

Care in the adjustment of mills will increase extraction of juice and will decrease breakage of parts. The information on setting the rollers which is presented in U. S. Department of Agriculture Farmers' Bulletin 1791, "Farm Production of Sorgo Sirup," appears applicable to most of the three-roller mills used in Kentucky. Usually a clearance space of approximately three-eighths inch between the front roll and the large roll permits easy feeding of the stalks. The stalks will ordinarily be squeezed fairly dry if a clearance space between the last small roll and the large roll is about one-sixteenth of an inch. The large roll should usually revolve about 10 to 12 times per minute in the average small power mill. When the extraction percentage seems too low, it may be advantageous to pass the crushed stalks through the mill a second time; however, more particles of plant material will usually be introduced into the juice.

With any mill the recommendations of the manufacturer regarding adjustment and speed should be followed. It is a practice among some of the larger producers to have a standby mill in case of mechanical failure. New mills are expensive, and used mills are hard to find but are sometimes obtainable from dealers of used milling equipment in the sugar cane and sorghum-producing regions of the South.

In a large processing plant the removal of the crushed stalks may become a serious problem. A conveyor can be of great convenience in removing the crushed stalks some distance from the mill or in loading them into farm wagons for disposal. These stalks can be used directly as feed for livestock. Another arrangement utilized is the delivery of the stalks by conveyor to an ensilage cutter from which it is blown into trucks for transport to silos. The ensilage produced from the crushed stalks is highly regarded by some farmers, but its feed value, because of loss of sugars, is not as high as that made from sorghum taken directly from the field. If the quantity of crushed stalks is large, it may be profitable to contract for their removal.

Recommendations for the location, layout, and size of smaller farm operations are discussed more thoroughly in U. S. D. A. Farmers' Bulletin 1791, previously mentioned.

FILTRATION AND SEDIMENTATION

As the raw juice runs from the mill, it should pass through one or more wire screens to remove the larger pieces of suspended matter, such as stalk fragments, which are formed during the milling. After this crude filtering, some of the smaller suspended particles should be allowed to settle out in a large tank before the juice is piped to the processing plant. Among the materials settling out during this preliminary sedimentation process are many of the soil particles which were introduced into the juice from the surface of the stalks during crushing.

To avoid picking up sediment when the juice is drawn from the tank, the drain, or intake pipe if a pump is used, should be kept at least 2 inches from the bottom of the tank. So much material is deposited here that often it is necessary to clean the tank several times each day. Effort expended in the removal of suspended insoluble matter, however, will be repaid by the increase in quality of the syrup.

When the raw juice reaches the processing plant, it should be run into tanks of at least 250-gallon capacity and allowed to settle without agitation for at least 2 hours. The sediment formed consists of proteinaceous matter, complex carbohydrates including some of the starch, and other fine particles. The sedimentation tanks may be drained by gravity or pumped, but again the outlet should not be closer than 2 to 3 inches to the bottom. The tanks should also be fitted with drain plugs on the bottom so that they can be easily washed each time they are drained.

Starch

Although much of the material which could cause trouble during processing is removed in filtration and sedimentation, other suspended materials remain in the raw juice. Among them is the starch which is one of the chief causes of difficulties encountered in processing sorghum syrup. These difficulties include clabbering and scorching which result in the formation of a dark-colored syrup with a burnt flavor. These undesirable properties are probably brought on by the slow boiling or failure of the juice to "cook down" on the evaporators. There is good evidence that color formation is a product of time and temperature. Therefore, it is advantageous to keep the syrup at high temperatures for as short a time as possible.

While the juice is in the sedimentation tank, it should be tested to measure the starch content. High starch content can usually be assumed if the crop is overripe, grown during a dry year, or if the stalks are short, "woody" and seemingly low in juice. If the starch content is high, it can be reduced while the raw juice is in the sedimentation tank or after the juice has been evaporated to the semi-syrup stage. In both methods, the lowering of the starch content may be accomplished through the use of starch-digesting enzymes.

Starch is found in the juice in the form of microscopic grains. These grains are insoluble in water but when heated to about 150°F they swell and rupture, and become gelatinized. The gelatinized form is more rapidly digested than is the granular form, but the latter form can be broken down by using larger quantities of the digestive enzymes. The granular form is found in the raw juice while the gelatinized form is found in the semi-syrup. Malt extracts can be purchased which contain enzymes capable of converting starch from its insoluble form into the simple, soluble sugar units from which the starch molecule is built. Since starch is made up of large numbers of glucose units, the end product of this digestion is the formation of more glucose in the juice. This will of course contribute to the total sugar content of the juice. Not all the starch, however, is converted completely. These intermediate products between starch and glucose are called dextrins.

A rough check for the quantity of starch present in the raw juice can be made by placing about a teaspoon of juice in a white saucer or dish and adding two or three drops of a special starch-indicating iodine solution.[1] A straw color, resulting from the dilution of the darker iodine solution, means that starch is absent or present in small quantities. This is a sign that starch will probably not cause trouble in the processing, but it is not proof that it will not. A positive test (blue-black color) at this time means almost certainly that characteristic difficulties caused by the starch will appear in the processing. A producer who finds the juice to be high in starch but who is not prepared to treat the semi-syrup will be able to improve the quality of his syrup by treating the raw juice in the sedimentation tank with diastatic malt or other starch-digesting enzymes. About one-fourth to one-half pound of 275-300-degree Lintner diastatic malt syrup per 50 gallons of raw juice should be sufficient. The treated juice should be held at least 2 hours. Treatment of the starch in the semi-syrup stage is preferred by many producers, and the procedure is outlined on page 15.

One should take advantage of the best means to reduce the starch content of the juice prior to the final evaporation. The syrup thus produced will usually be clear, light in color, and delicate in flavor.

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[1] This solution can be purchased through chemical supply companies or can be prepared by many druggists. It is made by dissolving 1.5 grams of potassium iodide in 100 ml of distilled water and then dissolving 0.3 gram crystalline iodine in that solution.

Sugar Content of the Raw Juice

Another simple test that can be run on the raw juice is the determination of the approximate sugar content of the juice. This is done most readily through the use of a hydrometer marked in degrees Brix (Fig. 3a, b). A hydrometer is usually a

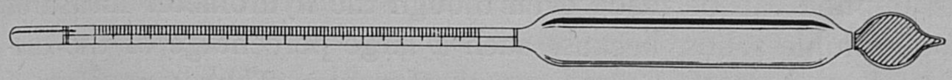

Fig. 3a.— A typical hydrometer used to measure the approximate sugar content of the juice, the semi-syrup, and the finished syrup. Because of the small size of the figures, the scale values are not indicated on the instrument in this drawing.

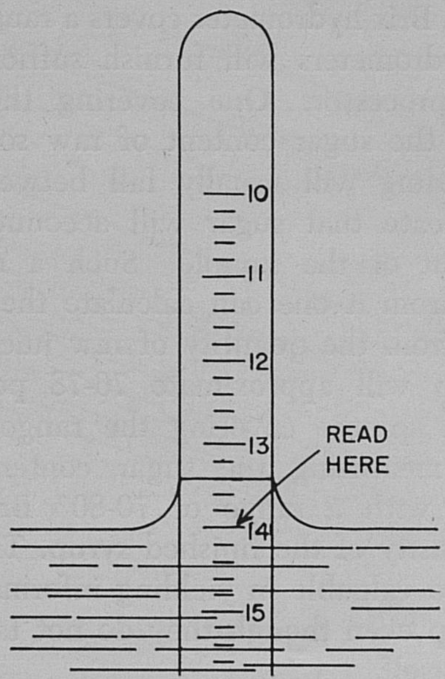

Fig. 3b.— This shows how to read a hydrometer in use.

cylinderical glass tube with a narrow graduated glass stem. These hydrometers are similar in appearance to those used to test wet-cell batteries or antifreeze solutions. The lower end is weighted so that the hydrometer will sink to a predetermined depth in a solution with a known density. When a hydrometer is placed in a solution, it sinks because of gravitational attraction until the solution's bouyancy prevents it from sinking deeper. Therefore, the depth to which the hydrometer will sink is determined by the density of the solution. At the point on the graduated stem which is level with the surface of the solution the reading is made. The Brix hydrometer is graduated in such a way that the reading can be assumed to indicate the percentage by weight of sugar present in the juice at a specified temperature. This assumption can be made even though the hydrometer measures total soluble solids, because such a large percentage of the dissolved solids in the juice consists of sugars. Thus a reading of 0° Brix would mean that no sugar was present, and a reading of 50° signifies that 50 percent of the weight of the solution is due to the presence of sugar.

Ordinarily each Brix hydrometer covers a range of 10 degrees. Three of these hydrometers will furnish sufficient information for the average processor. One covering the range 10-20° Brix will measure the sugar content of raw sorghum juice. In raw juice the reading will usually fall between 14-18° Brix. These figures indicate that sugar will account for 14-18 percent of the weight of the sample. Such a determination is very useful since from it one can calculate the estimated yield of finished syrup from the quantity of raw juice at hand, since the finished syrup will approximate 76-78 percent sugar by weight. A second spindle covering the range of 30-40° Brix can be used in measuring the sugar content of the semi-syrup. The third with a range of 70-80° Brix can be used to measure the density of the finished syrup. The Brix hydrometers, therefore, are valuable in yielding information concerning the juice and syrup even though they do not take a direct part in the processing itself.

EVAPORATION OF THE JUICE

Semi-Syrup Stage

In the modern installation the raw juice moves from the sedimentation tanks to the semi-syrup pan. In Kentucky this is a recent innovation and is unknown to many producers. As the name implies, the water content of the juice is here reduced so that the concentration of the sugar becomes approximately one-half that of the finished syrup. Because the finished syrup should be 76-78° Brix, the juice should be drawn from the semi-syrup pan when it is at approximately 38-39° Brix.

In practice a modified Stubbs pan has proven very useful in reducing the raw juice to a semi-syrup. A pan of this design is pictured in Fig. 4. This particular pan is gas-fired and is very efficient. By regulating the burners, fast, controlled heat can be supplied to the different sections of the pan. The pan could be further modified by being jacketed or provided with coils, and steam if available would provide the heat. There is little doubt

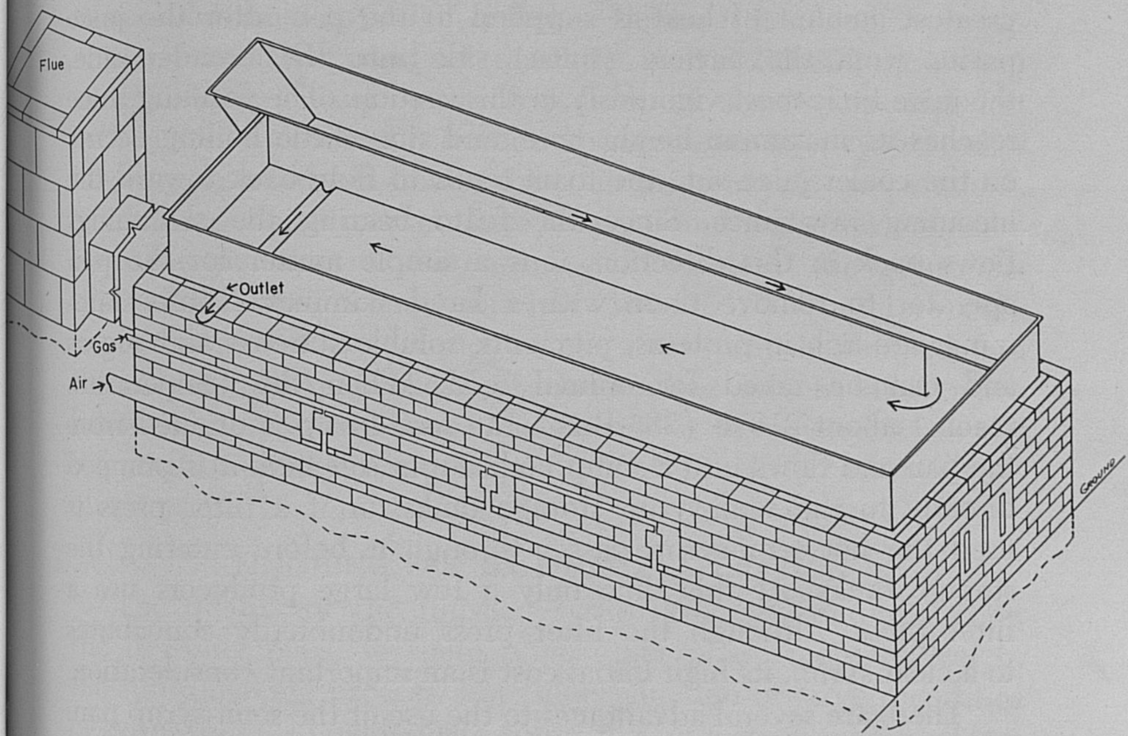

Fig. 4.— A gas-fired semi-syrup pan (in this instance, 22 feet by 48 inches). The juice enters at the left end of the narrow section of the pan and then flows toward the right. It then enters the wide part of the pan, and as it flows toward the drain on the left approximately one-half of the water is evaporated.

that a steam-heated pan of this type would give superior performance, perhaps at a lower cost of operation. With both gas and steamheated pans it is possible to control the heat so accurately that the uncompartmented pan can be used.

Both galvanized iron and copper pans can be used successfully, but stainless steel pans show promise in the production of high quality syrups, particularly when steam is used to heat the pans. It is possible that galvanized steel and copper pans induce more color formation than do stainless steel pans. In addition, stainless steel is exceptionally easy to clean.

For proper operation of the modified Stubbs semi-syrup pan it is essential that the end into which the raw juice is introduced be about one inch higher than the opposite end. The raw juice is pumped from the sedimentation tanks into the low temperature end of the pan, then moves continuously around the pan until it is drained at the completion of its U-shaped path. Since the greatest amount of heat is supplied to the pan after the juice passes from the narrow (juice) side into the broader side, the juice boils most vigorously in this section. The foaming juice reaches its maximum height here, and since little boiling occurs on the cooler juice side the foam tends to flow back toward the incoming raw juice. Since the foam bearing the skimmings flows back in this direction, it is a simple matter for the pan operator to remove them with a hand skimmer. These skimmings are rich in proteins, pigments, soluble starches and sugars and can be saved for animal feed. When the temperature reaches about 218°F (38° Brix), the semi-syrup is drained from the pan and flows into a sump tank. From this tank it is pumped directly to the semi-syrup storage tanks, or if a filter press is used the hot semi-syrup passes through it before entering the storage tanks. At this time only a few large producers use a filter press. Although the filter press undoubtedly contributes to a clear syrup, its high initial cost is an important consideration.

There are several advantages to the use of the semi-syrup pan. One of the most important is that it is possible to remove much of the skimmings at relatively low temperatures without the danger of cooking them into the finished syrup. This is a very real danger for if large amounts of skimmings and sediment are introduced into the finishing-off pans the agitation of the boiling syrup disperses this undesirable material in fine particles throughout the syrup. These suspended particles are almost impossible to remove from the finished syrup. Another reason for the use of the semi-syrup pan is that it concentrates the juice sufficiently so that it may be safely stored in covered tanks overnight without spoiling. This helps insure continuous operation of a plant through the working day. It is impossible to store raw juice more than a few hours without fermentation beginning. In addition, the large percentage of water in the raw juice makes for inefficient storage. In a plant which produces 400-500 gallons of syrup a day there should be several semi-syrup storage tanks.

Perhaps the greatest worth of the semi-syrup stage is that at this point starch digestion can be carried out efficiently and more completely. If diastatic malt extract is used, it is necessary to cool the tanks to 160°F or below before it is added. Approximately one-half pound of diastatic malt (275-300° Lintner) is thoroughly mixed with 50 gallons of semi-syrup and left 8-10 hours or over-night. Recent developments in enzyme studies have made available heat-stable diastatic enzyme preparations. Several companies market these enzymes and make recommendations for their use. These enzymes are stable at the gelatinization temperatures of most starches (150-175°F). Therefore, they can be added almost as soon as the semi-syrup is pumped into the storage tanks because of the cooling which takes place between the pan and tank. Their action is terminated when the temperature of the syrup rises to about 190°F in the finishing-off pans.

FINISHING PAN OR FINAL EVAPORATION

The quality of the finished syrup is largely determined in the finishing pans, so there is no other phase more critical in the syrup-making process. For the production of large quantities of syrup there is no adequate substitute for a steam pan. A steam pan which has been used with success is pictured in Fig. 5. Here again galvanized steel and copper can be used, but stainless steel appears to be superior in production of light-colored syrup. The pan is jacketed underneath and steam is supplied through valves placed at intervals along the pan. For the pan diagramed in Fig. 5, steam is furnished by a 25 hp. boiler and enters the pan at a pressure of 35 pounds per square inch after having passed through a pressure regulator.

As in the semi-syrup pan, the finishing pan is tilted, with the cool end approximately one inch lower than the finishing-off

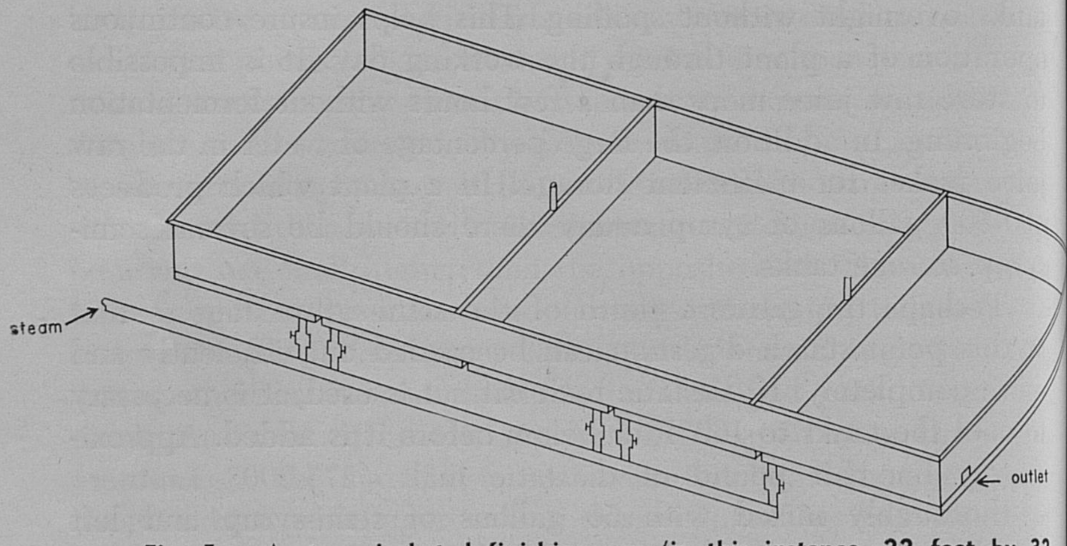

Fig. 5.— A steam-jacketed finishing pan (in this instance, 22 feet by 32 inches). In some processing plants the pan is not compartmented as shown here but is of a continuous-flow design with a series of baffles at the end of the pan where the syrup is drawn off.

or high temperature end. This means that the semi-syrup is fed into the cool end to a depth of about 2½ inches and is reduced to a depth of about 1½ inches before it is drawn off. Water is evaporated from the syrup until the syrup reaches a temperature of 226-227°F (depending upon variety) on a candy maker's thermometer. This temperature is critical and must be accurately measured. If the syrup is drawn off at temperatures above or below this point, the quality of the syrup will suffer. To avoid darkening of the syrup it should not be allowed to remain at this temperature but should be drawn off immediately (Fig. 6).

The thermometer is perhaps the most valuable instrument used in sorghum processing, and one of the highest quality should always be used. Syrup that boils at this temperature (226-227°F) will have a Brix reading of 76-78° when cooled to room temperature. At this density, fermentation in the finished syrup is highly improbable. Even though the equipment itself is rather complicated, inexperienced help can quickly learn to make good syrup under normal operating conditions.

STABILIZING AND BOTTLING PROCEDURES

From the finishing pans the hot syrup may follow either of two courses. It may be bottled without further handling, or it may be mixed before bottling with medium conversion corn syrup to prevent crystallization.

If the first course is carried out, the syrup is pumped or drained from the finishing pans into large, clean tanks of about 250-gallon capacity from which it is dispensed into containers. Before entering these tanks the syrup should be reduced in temperature to 100°F or below. This reduction in temperature will occur automatically by the length of the run if the bottling plant is isolated from the processing plant as suggested earlier.

The second alternative which involves stabilization is carried out if analysis of the syrup or experience indicates that crystallization in the finished syrup is probable. Analyses show that, because of the naturally occurring ratios of the various sugar constituents of the juice, sorghum possesses the stability char-

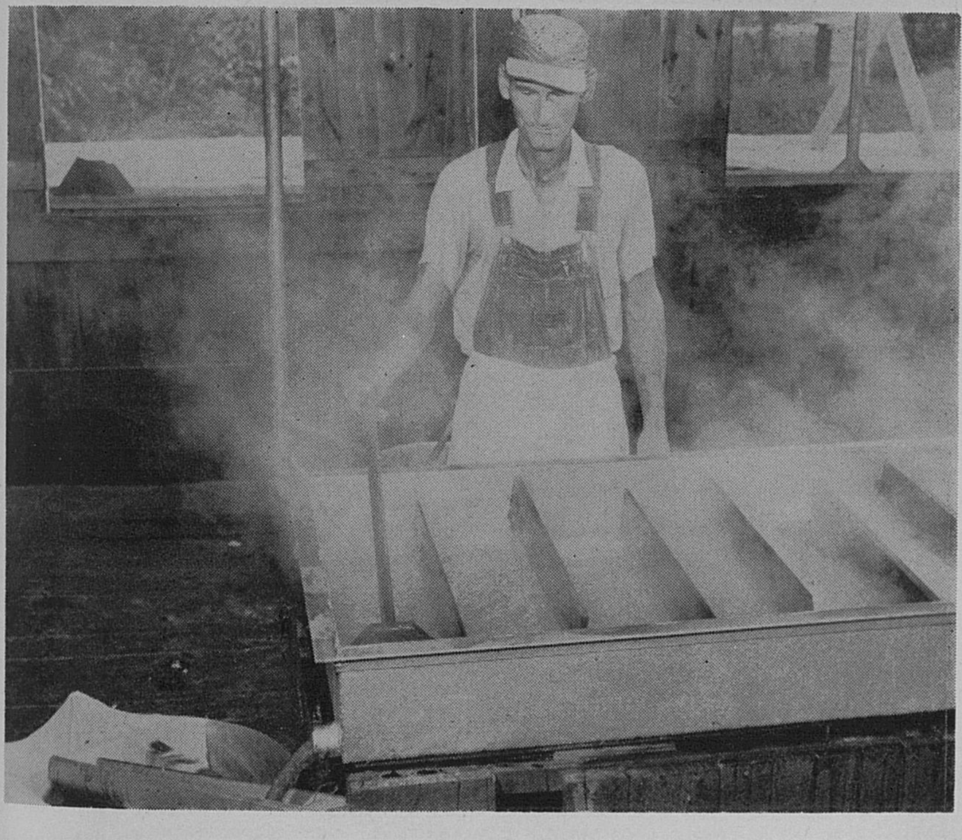

Fig. 6.— Here the finished syrup is draining from the finishing pan. As the syrup drains off, it undergoes its final filtering before bottling. The operator of this pan controls the rate of flow of the syrup through the series of baffles at the "finishing-off" end of the pan with the aid of a wooden "hoe."

acteristics requisite to a syrup. This stability is chiefly due to the almost equal ratio of sucrose and invert sugars (dextrose and fructose) present in the juice. If the sucrose percentage or dextrose percentage rises above certain levels, either may crystallize out. In Kentucky, dextrose crystallization is uncommon, but sucrose crystallization occurs frequently. Sucrose crystallizes more often in syrup from some varieties than in others and also in syrups made from upper portions of the stalk or from overripe stalks.

Light frosts and the holding of the cut stalks before milling will reduce the hazard of sucrose crystallization. It is also possible to lower excessive sucrose content by the addition of the enzyme invertase which hydrolyzes some of the sucrose to its components, the sugars dextrose and fructose. This will of course tend to equalize the sucrose-invert sugar ratio and increase the stability of the syrup. It should also be recalled that the practice of digesting the starch in the juice to dextrose by use of diastatic enzymes also will be helpful in preventing sucrose crystallization if the level of sucrose is high compared to that of the invert sugars.

The most widely practiced method of stabilizing the syrup, however, is by the addition of various amounts of commercial corn syrups which are very rich in dextrose. These corn syrups should not be confused with the flavored "corn syrup" of the grocery store. They are made by hydrolyzing corn starch and contain for the most part dextrose but also some maltose and intermediate products of incompletely converted starch. If these corn syrups do not make up more than 20 percent of the final product they seem to impart no detectable taste or undesirable characteristics such as the crystallization of excess dextrose. Whenever corn syrup or other stabilizers are added to the sorghum syrup, federal and state laws regarding labeling must be observed.

It should be realized by producers that the use of stabilizers such as corn syrup should be discontinued when sufficient knowledge is available to make possible the production of sorghum syrups in which stabilization is not a problem.

In a processing plant with a pan of the size described in

Fig. 5, the hot finished syrup can be run from the pan into a 50-gallon tank and hot, medium-conversion corn syrup can then be added and mixed. It is important that the mixing of the syrups be complete, otherwise crystallization may occur later in the incompletely mixed portions. Also, both of the hot syrups should be free of all crystals or further crystallization will usually result as the syrup cools. From the mixing tank the blended syrup is piped to the dispensing tanks of the bottling and storage units.

As a matter of cleanliness, it is advantageous to have the dispensing tanks open on the top but covered with heavy muslin or similar material whenever they are in use. The syrup is dispensed into glass containers by the use of a molasses spigot (Fig. 7). The containers are immediately capped and placed in suitable

Fig. 7.— The syrup is dispensed into glass containers through a molasses spigot. The muslin-covered dispensing tanks insure cleanliness until the syrup is bottled.

cardboard shipping boxes. The use of glass containers has been found to stimulate sales tremendously if the syrup is of high quality, since the product is clearly visible to the purchaser. It is obvious that an inferior syrup, whether canned or bottled, can not compete for sales against a clear, light syrup which appeals to the buyer's eye and taste.

It is good practice to record the lot numbers of the runs of syrup with accompanying notes on processing procedures. It is also helpful to code the containers and shipping boxes in the event that trouble occurs later in storage or on the seller's shelf. In this way the source of a certain difficulty can sometimes be traced and corrected. If the syrup must be stored for considerable lengths of time at the processing plant, the storage facilities should be such that extremely rapid temperature fluctuations are prevented, and also that enough space is available so that the syrup need not be moved more than absolutely necessary.

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