The Wet Milling Properties of Grain Sorghums

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For over 40 years grain sorghum has been mentioned as a possible raw material for commercial starch production (3, 4, 5, 9, 10). Reasons given were similarity to corn in composition, kernel structure, starch properties and ease of starch isolation. Corn Products Refining Co. became convinced of the merit of this claim and in June, 1949, completed a wet processing plant at Corpus Christi, Tex. (7). Products manufactured include starch, crystalline dextrose, oil, and feeds. This company also has an affiliated plant at Regensburg, Germany, where similar products are made from grain sorghum imported from the United States.

It can now be said with some degree of confidence that starch can be made commercially from grain sorghum. In light of the experience of the past 4 years, the ways in which grain sorghum is not similar to corn with regard to wet milling properties can be discussed. In a process having a flow of approximately a million pounds of milled grain a day, small and seemingly minute differences in kernel characteristics may create serious bottlenecks in the production stream, which may impair product quality. The importance of certain structural features of the grain sorghum kernel were not entirely appreciated until manufacturing was actually underway. Many unanticipated problems arose during the first 2 years of operation but close coordination between production, research and engineering departments provided the solution or answers to most of these problems. These investigations have revealed new information on grain sorghum that may be useful in guiding the plant breeder in his search for improved varieties and may stimulate further industrial utilization of this potentially much more important crop.

METHODS

Description of manufacturing process.—Grain is received by truck or rail, cleaned, dried to 12 to 13% moisture if it is to be stored for a long period; or it may be sent directly to the steeps. In the steeps it is covered with process water containing sulfur dioxide and subjected to a softening and leaching action which lasts for 50 to 60 hours at a temperature of 120 to 125°F. Two batteries of 10 steeps each are operated so as to maintain a pH level of 4.0 to 4.2 and a concentration of about 6% soluble materials in the steepwater withdrawn from the battery. Water is passed over the grain by continuously pumping it from the bottom of one steep to the top of the next steep. Water movement across the battery is in countercurrent relation to the age of the grain. The low pH is the result of formation of lactic acid through fermentation of sugars extracted from the grain. Following the completion of steeping, the wet grain is crushed just enough to release the germ without damaging it. Since the steeped germ contains about 50 to 60% oil, it is therefore readily separated from other kernel components by flotation on the suspended starch. Oil is removed from the dried germ by expelling under pressure. The remaining pericarp and endosperm mixture is finely ground to release the starch granules.

The flow of oil and gluten is continued through a second centrifuge at 60 to 65% protein and is sent to where it may be dried separately or mixed with other oil and germ oil cake and dried. The mixture is sold as feed. The starch, after further purification by a second centrifuge, is washed with fresh water or sent to the sugar refinery for hydrolysis to yield pure starch purity is primarily measured by the potassium content which must be below 0.5% in an acceptable product.

Laboratory steeping.—All samples of grain in the laboratory are steeped in a solution composed of 0.5% sulfuric acid and 0.15% sulfur dioxide adjusted initially to pH 3.0 with potassium hydroxide. Three hundred fifty grams of grain (dry basis) is covered with 1500 ml. of the steeping liquid in a 2-qt Mason jar and immersed in a water bath at 122°F. The liquid is circulated with a pump for an hour for a total of 48 hours. Under these conditions the pH of the medium rises rapidly toward pH 4 level 4.2 to 4.3.

Laboratory milling.—Quantitative laboratory milling of steeped grain is accomplished by the procedure previously (14). The four main components of the grain kernel, namely fiber, starch and gluten—are separated by means used in the manufacturing process except that they are separated on a table. All fractions are dried in an oven at 130°F, weighed and analyzed. Yield is calculated on the basis of the raw grain dry substance.

Steeping solubles.—A 100 g. (d.b.) portion of grain in 400 ml. of the steeping medium and undergoes the operations as described above. The entire sample of steepwater are ground for 5 minutes in a Waring blender at full speed. The resulting grist is filtered and the weight determined by drying and weighing an filtrate. Correction is made for the reagents of the original steeping medium. Reducing sugars is determined by the Schoorl copper reduction method.

Starch color.—This is done by visually comparing light one or more starches and white magnesium sulfate between two glass plates on a black background. Starches are placed on the lower glass in such a way that the upper glass the edges of the samples come into contact with; differences in hue or intensity can be readily Starches are arranged in order of relative intensity comparisons. Numbers assigned are relative only when A.O.A.C. polarimetric method (1), fat by carbon tetrachloride in Butt extractors and protein by A.O.A.C. Official Methods (1). Wax is extracted from kernels with Skellysolve B (11). Tannin is determined by Menaul procedure (12) and a ground sample.

DISCUSSION

Structural features of the grain sorghum kernel have shown that its wet milling experience in starch production has been with corn. Therefore, it is interesting to compare some of the similarities and differences between grain sorghum. Probably the most obvious difference is in shape and size. The spherical nature of the sorghum kernel gives it different swelling characteristics than the irregularly shaped corn kernel.