Steam Flaking Conditions and Gelatinization in Sorghum Grain

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Summary

Gelatinization was measured in flaked sorghum grain that weighed 16.5 to 47 lbs. a bushel. Samples were steamed from 20 to 50 minutes, and varied in moisture content from 16.9 to 20.9% as they entered the chamber. Gelatinization was measured by an enzymatic gas production technique and compared with an extruded sample assumed to be 100% gelatinized. Each 1 lb. a bushel decrease in weight between 16.5 and 38 lbs. increased gelatinization 3.65 percent. Each 10 min. increase in steaming time increased gelatinization only 1.5%. Changes in grain moisture between 16.9 and 20.9% only slightly influenced gelatinization percentage. Between 20 and 28 lbs./bu., each pound decrease in bushel weight decreased the capacity of the 18" x 24" Ross roller mill 9 lbs. per minute.

Introduction

Although steam flaking probably is the most popular method of processing sorghum grain in commercial feedlots, reliable, simple methods to control quality of processed sorghum grain are scarce. Benefits of steam flaking depend on "gelatinization" of the grain starch molecule.

Several methods have been proposed to measure gelatinization. Among them are microscopic observations on loss of starch birefringence (the halo of light around the starch granule), and starch uptake of certain dyes. Such methods presume that if one break occurs in a granule, that granule is "gelatinized." More sensitive methods measure the activity of starch-digesting enzymes on starch granules. The more highly gelatinized the granules, the faster the enzymes act.

While enzymatic tests for gelatinization are precise, feedlots need simple, easily applied methods to use on a day-to-day basis. Thus, the relationship between gelatinization (measured by enzymatic gas production) and weight per bushel was examined. The influence of moisture in the grain entering the steaming chamber, and the time the grain remained in the chamber also were studied. Finally, the relationship between gelatinization percentage and roller mill capacity was examined.

Experimental Procedure

Elevator run, number 2 red milo weighing 57 lbs./bu. was cleaned, accumulated in a 200-ton hoppered bin, and used for all the studies reported here.

Grain was steamed in a Ross 960, 96-cubic-foot stainless steel, steam chamber with a capacity of about 4,300 lbs. Eight steam tubes ran through the chamber at five levels. Steam was supplied by a 40 hp, marine boiler operated at 70 to 90 psi. When released in the steam chamber, it raised the grain temperature to 210 degrees F.

The Ross heavy duty mill with rolls 24" long by 18" diameter, corregated with 24 Stevens cuts per inch was powered with a 40-hp electric motor. An ammeter was available to measure current draw. The mill was mounted directly below the steam chamber. Rate of grain discharge from the chamber into the mill was regulated by a feeder roll and adjustable feed gate.

Starch gelatinization was estimated by digesting the starch to glucose with an enzyme (amyloglucosidase), converting the glucose to carbon dioxide with yeast, and collecting and measuring the carbon dioxide.

Bushel weights were made by moving a long-handled ladle the full length of the rolls at a uniform rate then pouring the flakes into a 1-pint test cup from 3 to 4 inches above. The cup was leveled with a standard strike-off board, and the test weight taken immediately.

Experiment I. Bushel weight of flakes was varied by adjusting the mill feed rate and roll pressure to maintain the mill amperage draw at 75% of full load. The 15%-moisture grain was held in the steam chamber 25 min. Final flake bushel weights varied from 16.5 to 47 lbs.

Experiment II. Retention time in the steam chamber was varied from 20 to 50 min. while flake bushel weight was held constant at 24 lbs.

Experiment III. Water was added to grain in a horizontal mixer to produce grain moistures of 16.9 to 20.9 percent. Flake weight remained constant at 24 lbs.

Results

Experiment I. Gelatinization, as measured by gas production, increased as flake bushel weight decreased (figure 1). Bushel weight must lower some before there is any appreciable gelatinization. However, between bushel weights of 38 and 16.5 lbs., the relationship of bushel weight to gelatinization percentage is linear. Because flake weights outside those limits are unusual, flake weight alone may estimate gelatinization percentages accurately (correlation coefficient, -.996).

The equation for the line in figure is: % gelatinization = 156.1 - (3.65 x bushel weight). Thus, if you produce a 25-lb. flake, gelatinization percentage = 156.1 - (3.65) (25) = 64.8%. Each pound increase in flake weight decreases gelatinization by 3.65%.

Gelatinization percentages measured by enzymatic methods are somewhat higher than when estimated by commonly used microscopic methods. A starch granule ruptured at one site is considered gelatinized by microscopic methods. However, more gelatinization still can take place.

Optimum gelatinization is generally considered 30 to 50% when measured by microscopic methods. The optimum range will be higher when measured by such enzyme methods as gas production.

To estimate gelatinization percentage from flake bushel weight, the grain must be weighed under carefully controlled conditions (as given in Experimental Procedures). Flakes that have passed through air lifts or other conveying equipment will be broken, at least to some extent. That increases their bushel weight, but does not decrease gelatinization percentage.

The relationship between bushel weight and mill capacity is shown in figure 2. Each 1-lb. decrease in bushel weight reduces mill capacity 8.98 lbs. per minute. The equation: lbs. per minute = -143.01 + 8.98 (bushel weight) describes the relationship. Thus, for a bushel weight of 25 lbs., the mill capacity was -143.01 + 8.98 (25) or 81.5 lbs. per minute. The 18" x 24" rolls are smaller than those used in most commercial feedlots. However, good working data can be developed for individual flakers by measuring mill capacity while producing flakes of various bushel weights and plotting the results on a graph.

Experiment II. Between steam-chest retention times of 20 and 50 minutes, each additional 10 minutes in the chamber increased gelatinization 1.5%. Other workers have shown that short steaming times (5 to 10 minutes) produce unacceptable flakes. According to our data, however, little is gained by steaming more than 20 minutes. However, unusual grain conditions might call for longer steaming to soften the grain for adequate flaking.

Experiment III. Increasing the moisture content of grain entering the steam chamber had no consistent influence on gelatinization. Extremely dry grains, however, might give different results.

Figure 1. Relationship between bushel weight of flaked sorghum grain and percent gelatinization measured by enzymatic gas production.

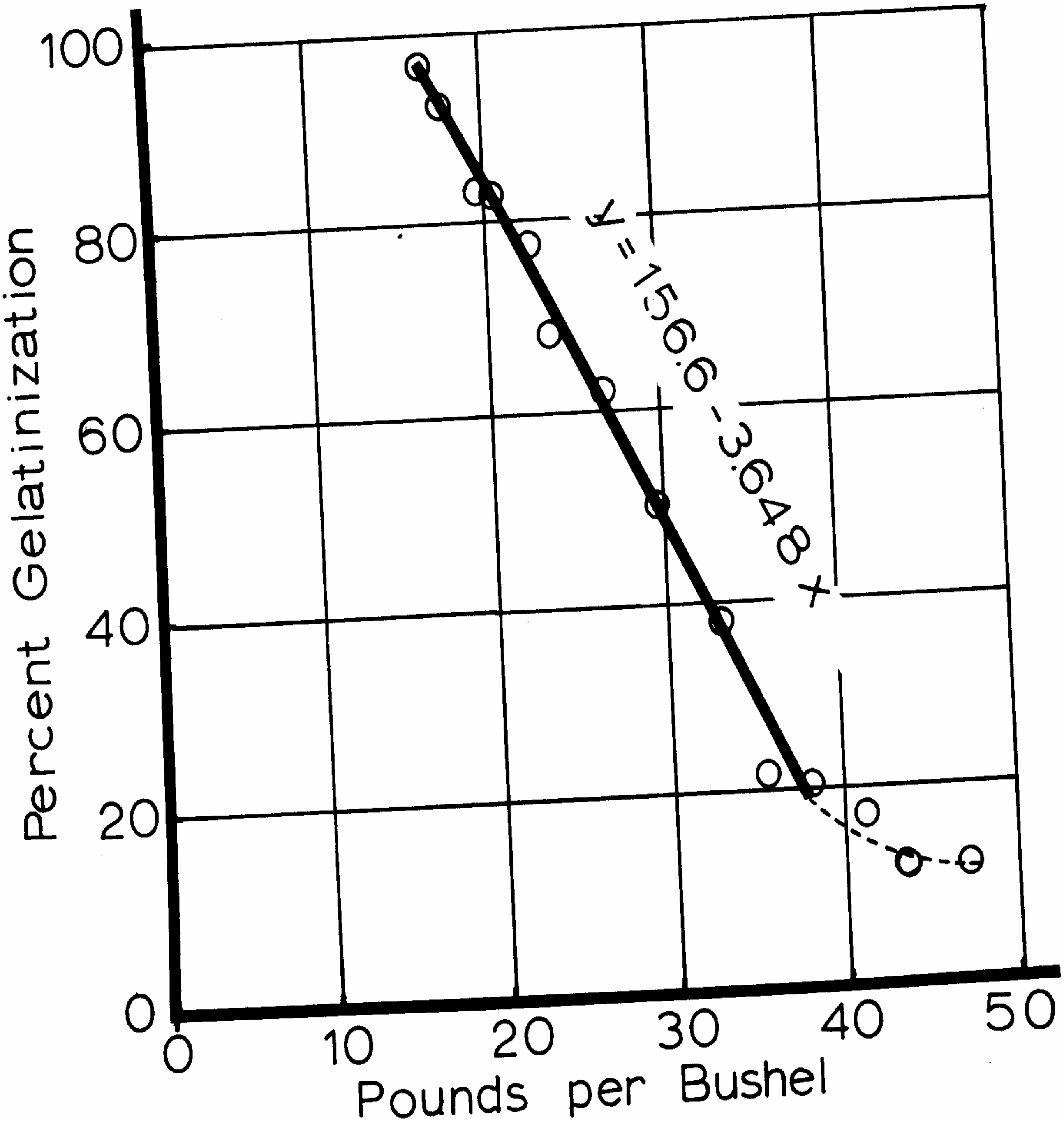
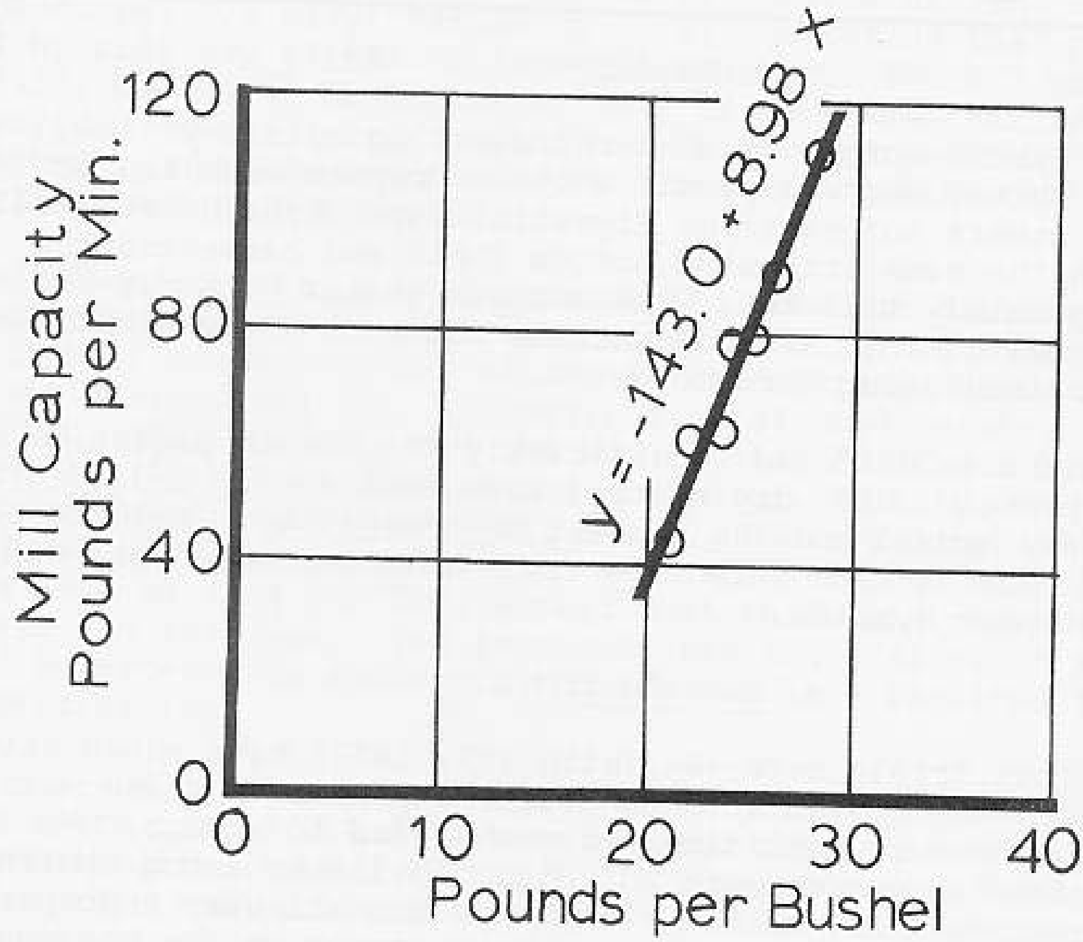


Figure 2. Relationship between bushel weight of flaked sorghum grain and roller mill capacity.



Our results indicate that bushel weight is an excellent quality control for estimating gelatinization percentages of flaked grain. However, bushel weights must be taken carefully. Steaming time (more than 20 minutes) and moisture percentages in the original grain had little effect on gelatinization.