WATER AND STARCH RATES FOR COATING COTTONSEED

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Abstract

The USDA-ARS ginning laboratory at Lubbock in cooperation with Cotton Incorporated has developed a pilot plant process for coating fuzzy cottonseed to bind down the linters and create a free flowing product known as **Easi*flo*™** cottonseed. A number of food and feed grade starch products have been evaluated as material to use for coating whole fuzzy cottonseed to create a free flowing commodity. The amount of water required to accomplish the coating process is the critical cost factor because of drying energy required. The most economical materials found were food packaging adhesive types of corn starch that can be applied at high starch to water ratios to minimize the amount of water that has to be removed in drying.

Introduction

The USDA Agricultural Research Service ginning laboratory at Lubbock in cooperation with Cotton Incorporated has developed a pilot plant process for coating cottonseed to bind down the linters and create a free flowing product known as **Easi*flo*™** cottonseed (Laird et. al., 1977, a,b). There is a large potential market for this product in dairies and other livestock enterprises interested in feeding whole cottonseed because it can be handled with their customary grain and feed handling equipment. The coating material is prepared by mixing starch in water and then heating it above a temperature of about 170 °F to gelatinize the starch. The hot mixture is sprayed onto the seed at a level to give the desired final seed surface characteristics. The starch mixture is sprayed onto seeds coming from a feed hopper at controlled rates. The wet seeds are agitated in special mixing augers after the starch is sprayed on to disperse the starch and provide time for it to fully permeate and soften the linters on the seeds. The wet coating on the seeds is dried and hardened in a belt conveyor dryer with air passing downwards through the seeds. The coated seeds are then cooled in ambient air.

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Objective

The objective of this study is to find a coating material that can be purchased off the shelf, applied inexpensively, and requires a minimum amount of water. A number of forms of starch in food and feed grades are available for coating material. The price for feed grade starch is approximately the same as whole cottonseed so the cost for starch is not critical. A major part of the variable cost for the coating process is energy to dry off the moisture that is necessary for applying the coating material.

Experimental Approach

Five different types of starch were evaluated for use as the coating material. We have not found an objective method for evaluating the quality of the coating so the evaluation of coating quality is subjective in nature. The differences that we are able to evaluate are rather obvious differences in firmness, feel, and appearance, indicating that there is a fairly distinct cutoff point where an adequate coating is developed.

Two independent characteristics of the coating material that are important are the ability to wet and penetrate the linters on the seed, and the ability to dry into a smooth hard coating binding the linters to the seed coat. To reduce costs we want to minimize the amount of water needed to obtain these characteristics. The relative amount of starch required to form a proper coating is important because of the amount of water needed as the carrier. All of the types of starch we evaluated exhibited good wetting and penetrating properties when the solution temperature was 170 to 200 °F. There is a minimum amount of water required for thorough wetting and a minimum amount of starch in relation to the seeds to form a good smooth hard coat. These vary with the type of starch. The critical element is to be able to have a high starch loading per volume of water with a material that forms an acceptable coating. All but one of the materials evaluated form acceptable coatings at starch add-on levels of five per cent or less of the seed weight on a dry weight basis for both seed and starch. Most of the materials make an acceptable coating at about 3.5 % add-on and form a spongy coated material at about 2.5 % add-on.

We found that the linters must be wetted and softened all the way down to the seed coat to form a firm coat or else the coated seeds will have a flexible shell or spongy characteristic that allows them to compress and pack together to cause bridging. Adequate wetting is indicated when the seeds turn black during agitation in the mixing auger. The type of starch and amount of water determine whether a fully hard coat is formed. We found that 0.20 to 0.30 pound of water per pound of seeds is necessary to get full penetration and softening of the linters on the seeds. Vigorous stirring of the seeds after applying the starch solution helps penetration which takes 1½ to 2 minutes. The better starch materials give good wetting at low water levels.

We first determined the starch to water ratio that resulted in a cooked gelatinized mixture that was too thick to pump and/or spray onto the seeds. Some materials formed sticky viscous solutions when cooked and some formed more brittle gels. Either of these conditions can become too thick to pump but the brittle gel is harder to handle. Most of the materials thicken considerably if allowed to cool off and are very difficult to pump. Also they tend to lose their penetrating or wetting power when solution temperature drops below 170 °F. Another concern is the ratio of water to starch that becomes insufficient for hydration when the starch is cooked. We assumed that if this occurred it would show up as dusting off when the coated seeds were handled. We did not see much evidence of this in the tests.

RESULTS - Evaluation of Starch Types

Some typical results for the different starches are shown in Table 1. We have processed about 130 lots of seed ranging from 3/4 to 5 tons per lot. The examples in the table were selected to show the different qualities of coating that were obtained.

Food Grade Corn Starch

Plain Pearl corn starch (Argo, Roquette)

The simplest material used for the coating was ordinary food grade plain pearl corn starch . We tested material from two suppliers. The dry powder went into suspension easily in cold water and remained in suspension up to a ratio of 0.83 pound of starch per gallon of water. It tended to lump rather than go into uniform suspension if the water temperature was above 140 °F. At higher solids concentrations the excess starch would settle out and form a layer on the bottom of the container. When plain corn starch at the maximum concentration of 0.83 pound per gallon of water was cooked to gelatinization it formed a thick viscous and partly brittle gel that required constant agitation to keep it in a pumpable condition. We found that a ratio of 0.75 pound of starch per gallon of water resulted in a more fluid mixture that was easier to handle.

This starch solution would penetrate the linters on the seeds well and form a firm coating at about 3.5 % dry starch add-on by dry seed weight. Plain corn starch formed a spongy coating at 2 to 2.5 % starch add-on. When the 0.83 pound per gallon mixture was pumped on at the 3.5 % add-on rate, final seed moisture content was raised to 31 % moisture, wet basis, from an initial seed moisture content of 8 percent. Drying the excess moisture off at average dryer efficiency required 1.05 million BTU per ton of seed. The plain starch solution could be handled much better if mixed at 0.75 pound per gallon of water but final seed moisture content was raised to 33 % at the 3.5 % starch add-on rate. In this case drying required 1.16 million BTU per ton of seed. A very good firm coating was formed by applying enough of the 0.83 pound per gallon mix to give a 5 % starch add-on. However, this raised final seed moisture content to 37 percent, increasing drying cost. Moisture samples have shown that about 1.5 percent points of moisture may flash off in the spraying and mixing stage before the seeds are put into the dryer.

High gel starch (Maxigel)

This type of food starch is formulated to have a high gel forming characteristic allowing use of a lower amount of starch for a thicker mix. It formed a brittle gel at concentrations as low as 0.5 pound per gallon of water. Higher starch to water concentrations were not fluid enough to flow into pumping equipment. The result for the seed coating application was that it required more water to reach an acceptable starch add-on percentage to form a firm coating. The coated seed product was acceptable but moisture removal cost was higher than for the starches that could be mixed at higher concentration.

Feed grade corn starch

Many of different types of food starches are available as feed grade starch. These are usually generated during startup and run-down of corn wet milling processes. The material fails to meet manufacturing specifications and is sold off at cheaper prices as animal feed additive.

Maltodextrin (Star-dri 15)

This is converted corn starch made for confectionary and dessert uses, but off-spec material is available as feed grade starch. The material did not gelatinize or thicken when cooked in water but formed a thin syrup. It was possible to use relatively large amounts of this material per unit of water. It could be pumped and sprayed as easily as plain water and penetrated the linters when hot. It had a tendency to give a rough crystalline textured coating that did not bind down the linters in a smooth hard coat. This resulted in a less satisfactory, less free flowing product. The coating formed with this material seemed to be hygroscopic and soften or become sticky in high humidity environments while the coatings formed from the other types of starch did not.

Industrial Starch (cel-magnabond)

This is a starch prepared for adhesive applications. The feed grade material could be mixed at high ratios of starch to water. We tested this material at 1½ pounds per gallon which gave a fluid viscous consistency when cooked, that pumped and sprayed well. At this concentration applying enough water for fully wetting the linters gave about 6 % starch add-on. A lower starch to water ratio was sufficient to form a solid coating down to the seed coat. This material is one that allows use of the minimum amount of water for better dryer economy. Several test runs made acceptable product with seed moisture raised only to 22 to 24 % entering the dryer.

Food Packaging Adhesive (Corru-bond A)

This is a starch based adhesive for food grade packaging applications. It can be mixed at high starch to water ratios. At 1½ pounds per gallon it forms a thick viscous fluid when

cooked that can be pumped and sprayed well but at higher pressure than the industrial starch. It has good water minimizing and coating properties. We were able to generate acceptable smooth hard coated cottonseed with 3.5 % starch add-on at wet seed moisture levels in the 22 to 24 % range.

Summary of Test Results

Acceptable quality coated cottonseed was prepared in the pilot plant process using all of the materials tested except the maltodextrin. The two feed grade adhesive starch materials were the most economical because they allow minimal water use thus reducing drying cost. The type and concentration of starch and solution temperature affect the wetting ability of the solution, with solution temperature having the greatest effect. All of the materials become much more aggressive at wetting the seeds when solution temperature reaches 170 to 175 ° F, and quickly lose wetting ability if allowed to cool down slightly below that. Increasing solution temperature over 200 ° F seemed to decrease wetting capacity.

Regardless of wetting, the materials that form good coatings seem to have a minimum starch add-on level necessary for forming a firm hard coat. Some will form a usable coat at about 2 % add-on but usually it is spongy because it is a surface coat rather than penetrating to the seed coat. Inadequate water for full penetration and wetting of the linters will cause a similar spongy condition because of forming a surface encapsulation of the linters. These spongy coats are a problem because while the seeds may be free flowing and non-adherent when loose the cottonseed will pack together under compression in bulk storage and cause bridging. The amount of linters on the seeds, due mostly to varietal differences, also affects the amount of water and starch needed for firm hard coats. It might be desirable to use a 2 % or less add-on to form the coating because the legal definition of cottonseed in commerce is not changed with inclusion of 2 % or less other material. More work will be required to develop a satisfactory coating process using less than 2 % by dry weight of coating material.

Conclusions

A number of food and feed grade starch materials can be used to coat whole fuzzy cottonseed and give an acceptable free flowing product. The most inexpensive seem to be the food packaging adhesive type starches because they can be used at higher starch to water ratios thus minimizing the amount of water that has to be dried off. This minimizes the most costly part of the process. A harder coating can be formed at a given starch addition percentage with plain corn starch. The sugar type of modified starch (maltodextrin) forms a less acceptable, rougher, crystalline coating that also is more hygroscopic.

Disclaimer

Trade names are used in this publication solely to give specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the USDA-ARS nor a recommendation by the department over other similar products not mentioned.

References

Laird, J. W., T. C. Wedegaertner, and T. D. Valco. 1997. Coating cottonseed for improved handling characteristics. Proceedings Beltwide Cotton Conferences. 1599-1602.

Laird, J. W., T. C. Wedegaertner, T. D. Valco, and R. V. Baker. 1997. Engineering factors for coating and drying cottonseed to create a flowable product. ASAE Paper No. 97-1015. 13 pp.

Table 1. Typical results from evaluation of different types of starch for coating cottonseed, and levels of starch add-on by dry weight in relation to dry seed weight. Wet seed percent moisture is assuming original seed moisture content of 8 %.

Starch type	Starch/water ratio, lb/gal.	Starch % add-on	Coating quality	Wet seed %M,wb
Argo	0.75	5	firm	39.5
Roquette	0.75	3	firm	30.2
Roquette	0.75	5	firm - smooth	39.5
Cel-Magnabond	0.75	2.5	spongy	27.4
Cel-magnabond	1.5	5	firm - smooth	26.9
Corru-bond	1.5	2.5	spongy	18.7
Corru-bond	1.25	5	firm -smooth	29.8
Corru-bond	1.5	5	firm	26.9