tek talk

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Tomato Products

INTRODUCTION

Years of experience has established beyond any doubt that a ***high-shear colloid mill*** can be an extremely useful piece of equipment for the processing of a wide range of ***tomato-based products***. Many of the physical properties of the finished product can be dramatically improved by processing with this type of equipment.

However, it is essential that the mechanisms involved be closely examined in order to take maximum advantage of the potential benefits that are available. One must select the precise processing conditions very carefully in order to avoid the undesirable side-effects that can occur if the colloid mill is improperly applied. *Bematek* engineers have the know-how to ensure that optimum milling efficiency is achieved in such applications.

The major reason for applying a mechanical processing device to a product is to improve the properties of the finished product. Among the physical characteristics of tomato products that can be enhanced through proper application of a *Bematek* colloid mill are:

- lower Bostwick reading (i.e. higher viscosity)

Note: *This device is discussed later in this article.*

- reduced serum weeping
- better mouth-feel
- intensified color
- higher yield

Prior to discussing the specific techniques for addressing each of the above parameters, it will prove helpful to take a closer look at the physical changes that take place in a ***tomato dispersion*** (i.e. a mixture of tomato solids in water) during mechanical processing. Therefore, the next section of this article discusses the molecular-level changes that occur in a tomato dispersion during milling.

TOMATO CHEMISTRY

For our purposes, aside from the water, a tomato dispersion contains three critical components that can respond to the mechanical energy applied by a colloid mill in a manner that enhances the final product:

- The ***tomato pulp*** consists primarily of water-insoluble particles that are nearly-spherical in shape. These particles are the site of the ***carotene pigment*** that gives the tomato its red color. Both the color and the texture of the final tomato dispersion depends both on the ***size*** of these particles and the ***uniformity*** with which they are dispersed throughout the product. If the tomato pulp particles are left too large, the finished product will have an excessively rough texture. On the other hand, if they are reduced too much in size, the final product will become too smooth. Furthermore, failure to disperse this particulate matter uniformly throughout the tomato dispersion results in random patches of intense red color in a weakly-colored orange bulk material. Only through proper application of the high-shear colloid mill can one hope to break down and disperse these pulp particles to just the right degree, so that a uniform, deep red color and a texture that leads to the desired ***mouth-feel*** can be achieved.
- The second insoluble solid present in a tomato dispersion that is of major importance is the ***fibrous material*** that comprises the bulk of the tomato solids. Because the high concentration of these fibers in the tomato dispersion forces them to be tightly packed together, the fibers have a natural tendency to link together to form a ***lattice network*** structure. It is this lattice network structure that gives the tomato dispersion its body by trapping any free ***serum*** and reducing ***weeping***. Any alteration of these fibers and their lattice network structure will profoundly effect both the viscosity and the serum retention properties of the finished product. Since a colloid mill imparts such a high level of hydraulic shear energy to the tomato dispersion, it cannot help but have a major influence on the fibrous lattice network structure.

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TOMATO CHEMISTRY (cont.)

At one time the mechanical shearing of tomato dispersions produced erratic results. In many cases, the expected benefits were realized, while some other attempts led to disaster. Eventually, it was found that the method of converting the whole tomatoes into paste was the culprit. Specifically, tomato products that were prepared from a ***hot-break*** paste responded as expected, but those that used a ***cold-break*** paste could not be successfully milled without some difficulties. The reason for this difference relates to the third of our major components.

- ***Pectin*** is a naturally-occurring polysaccharide that dissolves readily in water. At high enough concentrations, an aqueous pectin solution can be extremely viscous. In fact, in the concentrations normally encountered in tomatoes, a gel is formed. This has the two desirable effects of ***increasing product viscosity*** and ***tying up any free water***. Both of these effects are accentuated by the more complete solubilization of the pectin brought about through high-shear milling. So far, this whole topic seems to work in our favor, but there is a lurking problem. Tomatoes also contain an ***enzyme*** that is capable of altering the pectin and rendering it incapable of exerting its beneficial effects. This is exactly what happens if a ***cold-break paste*** is used in a process involving a colloid mill. However, this enzyme is destroyed during the preparation of a ***hot-break paste***, and the pectin remains free to perform its normal beneficial functions. For this reason, any tomato products that will be milled must be made from a hot-break paste or severe weeping may occur in the finished product.

FIBRILLATION

Many types of processing equipment are capable of ***breaking*** the tomato fibers into shorter lengths. Unfortunately, all this accomplishes is to reduce product viscosity and increase serum weepage, because the short fibers are no longer capable of the inter-linking that is necessary to form the lattice network.

However, it has been found that a colloid mill is capable of causing an entirely different phenomenon. Proper milling of a tomato dispersion can actually ***fray the ends*** of the tomato fibers without causing any substantial reduction in overall length. This effect gives us the best of both worlds. The tomato fibers can still form their original viscosity-building, serum-retaining lattice structure, but now the frayed ends permit the fibers to absorb additional liquid through a ***wick effect*** at the fiber ends. Now, serum is not only trapped within the voids between the fibers in the lattice, but additional fluid is trapped within the individual fibers because of the frayed ends. The end result of this ***fibrillation*** process is an enormous ***increase in viscosity***, accompanied by a marked ***reduction in weeping***.

Before getting too excited about the prospects, it is extremely important to be aware that the fibrillation process does have its limitations:

- Too high a shear rate will destroy the fibrous lattice network by breaking the fibers and reducing the mean fiber length in the dispersion. As explained earlier, the trapped serum released during this process will show up as fluid weeping.
- Too low a shear rate will neither break nor fibrillate the tomato fibers, and no viscosity increase will result from the milling process.

To complicate matters further, even if one applies too much mechanical shear, the viscosity of the bulk material may still continue to increase because the total number of frayed fiber ends will increase dramatically. Consider that a single fiber with two ends will have four exposed ends when broken in half. Imagine the magnitude of the effect of breaking each fiber into hundreds of pieces! In short, the greatly increased number of fibrillated fiber ends will result in many times more serum absorption, and the apparent product viscosity will increase substantially. Unfortunately, any remaining free liquid will be quickly released as weepage because there is no longer a fibrous lattice network to trap it. The net result would be a product with clumps of very viscous tomato dispersion mixed with an unacceptable amount of free liquid.

Clearly, the exact milling conditions must be chosen with an eye toward balancing these two opposing effects:

- *The maximum possible viscosity increase cannot be achieved without also producing an unacceptable level of weeping.*

The trick is to find a set of conditions that generates a worthwhile decrease in ***Bostwick reading***, while minimizing any undesirable side effects such as weeping. As is often the case in processing systems, attempting to achieve too much in one area will have a detrimental effect on another property. Based on decades of experience in this area, *Bematek* manufactures colloid mills that are specially designed for optimum efficiency in the processing of tomato products.

EXTERNAL FACTORS

By now it should be clear that this entire process is very sensitive to the chemical and physical structure of the tomatoes. As with any other organic material, the details of this structure may vary considerably from one batch of product to another. The exact chemistry and relative proportions of the various components will be influenced by such growing factors as:

- climate
- weather
- soil
- fertilizer
- pesticides
- length of growing season
- tomato variety

Obviously, there is no way that all of these factors can be held exactly constant from one crop of tomatoes to the next, and the finished product quality will often be adversely impacted by the slightest variation in any one of them. However, a certain degree of batch-to-batch product consistency can be maintained by adjusting the milling conditions (i.e. rotor speed, rotor/stator gap setting, feed pressure, etc.) to counteract any undesirable changes in product characteristics caused by these uncontrollable factors. Such flexibility is one more major benefit of using a colloid mill to process tomato-based products.

Monitoring of ***product quality*** is, in large measure, a subjective process. Each manufacturer has developed his own standards for:

- color
- texture
- body
- weeping
- mouth-feel

Frequently, the evaluation is conducted by one person who has been performing the task for many years, and he can usually tell at a glance whether or not everything is acceptable. This makes it impossible to publish any specific standards for most of these physical properties. However, the tomato industry has established a standard for measuring the ***viscosity*** of tomato products. This device, which is called a ***Bostwick Consistometer***, measures the distance in centimeters that a fixed volume of product will flow in a time span of thirty seconds. The product is carefully packed into a confined area of the Bostwick, and then a spring loaded door is snapped open as a timer is started. Due to the height of the test volume of product, it will begin to flow across a flat, level surface that is graduated in centimeters. After thirty seconds, a reading is taken. With such a method, a lower Bostwick reading implies a more viscous product. Unlike the results from other viscosity measuring techniques, a ***lower Bostwick*** number is better!

A final point must be made regarding the handling of these products after they are discharged from the colloid mill. Some of the viscosity increase that is realized through milling can be lost if any significant shear is applied to the product immediately after the milling process has been completed. This can occur with such devices as: mixers in holding tanks, transfer pumps, and restrictive heat exchangers. Although this effect will not be a problem in a properly designed system, the desire to minimize any ***post-milling shear*** to the product must be considered during the design phase of the processing system.

PRODUCT TYPES

The following categories of tomato products can all benefit from the proper application of a colloid mill.

- Tomato Paste
- Tomato Catsup (or Ketchup)
- Tomato Sauce
- Tomato Juice

However, each of these products has its own special set of requirements. The processing techniques must be adapted to the specific type of tomato product being produced.

Pastes and catsups can show an ***increase in yield*** of 10-15%, if they are milled at a gap setting of about 0.002", with the appropriate shear rate and residence time. That is, the milled products will have a Bostwick equal to that of unmilled products that contain 10-15% more tomato solids. Furthermore, all of the other product characteristics (color, texture, weeping, mouth-feel, etc.) will be enhanced. This approach can lead to significant savings by allowing one to produce an equivalent product with a lower level of tomato solids.

PRODUCT TYPES (cont.)

On the other hand, one could maintain the original level of tomato solids and use the mill to generate a more viscous product. Clearly, it is possible to choose either maximum ***savings*** or maximum ***product quality*** or any compromise in between these extremes. Only a high-shear colloid mill permits such flexibility in the processing parameters, and only a knowledgeable manufacturer, such as *Bematek*, will be able to supply a colloid mill that is designed to meet such precise requirements. Recall our earlier caution, however, that the additional viscosity improvements gained at even smaller gaps and/or higher shear rates will be accompanied by a degrading of the other product properties.

In general, ***tomato sauces*** will show the same type of response as catsup and paste at gap settings down to about 0.005". However, the lower level of tomato solids in a sauce will render the viscosity increases at smaller gap settings too slight to be worthwhile. In addition, there will be a serious loss of color as the solids are extended too far in the interest of higher viscosity. Tomato sauces vary widely in composition, but most can benefit from milling. There are, nevertheless, limitations which must be understood.

Sauces containing less than about ***8% tomato solids*** should not usually be milled. These products do not contain enough tomato fibers or carotene pigment to respond well to any efforts to extend their physical properties. Also, these low-level sauces often compensate for a lower natural viscosity with the addition of a starch. In such a case, milling may destroy any viscosity component resulting from the starch. The net result can be a lowering of the initial viscosity. Finally, some specialized sauces (i.e. pizza sauce) contain many ***tomato seeds***. Milling of such sauces will not only reduce the intended presence of whole seeds, but the crushed seeds will release an oil that imparts a bitter taste to the sauce. If these limitations are respected, the milling of tomato sauces can be of enormous benefit.

Milling ***tomato-containing juices*** at gap settings smaller than about 0.008" is either of no benefit or is actually detrimental. There are simply not enough tomato solids to benefit from the process. However, processing at gap settings in the 0.010" to 0.015" range is frequently done to improve ***product stability*** and to generate a slight increase in ***body***. In juices that are formulated from tomato paste, a more thorough and rapid hydration of the paste is achieved by milling at these conditions. This generates a product with a longer shelf life, without the adverse effects on ***mouth-feel*** that smaller gap settings would create.

COLLOID MILL CONSTRUCTION

Since a tomato dispersion represents a fairly severe application for processing equipment, the ***materials of construction*** for the colloid mill must be chosen carefully. The ***rotor and stator*** should be manufactured from a hard material that can resist ***erosion*** from the ***abrasive tomato fibers***. Furthermore, a positive displacement pump should be used to feed the colloid mill, in order to ensure a uniform and controlled ***residence time*** within the high-shear zone of the colloid mill. Also, all ***wetted metallic parts*** should be of type 316L stainless-steel to avoid rapid ***corrosion*** in the highly ***acidic environment*** of the tomato dispersion.

Finally, it is important that every effort be made to minimize ***entrained air*** in the product stream. Although the high viscosity of these products makes it difficult to totally eliminate all entrained air, it is vital that the level be kept as low as possible. High levels of entrained air will result in ***elevated corrosion rates*** within the colloid mill, as well as ***diminished product quality***.

It has been found that the ***processing temperature*** is not very important to the milling process. Thus, the design of the process line can proceed in a manner that addresses the more critical potential problems, without regard for the product temperature at the colloid mill inlet.

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