Mixing

Learning Objectives

• Describe the purpose of mixing
• List common types of bread mixers
• Explain what mixing does to the dough and flour components
• Explain delayed mixing method (salt)
• Recognize a properly developed dough
• Describe how temperature impacts bread dough mixing
• Identify common adjustments to mixing (time, speed, temperature)
• Describe bread attributes from over and under mixing
• Name critical quality control production checks for mixing pan breads (dough temperature, dough feel)
• Define floor time and describe its purpose
• Relate knowledge of floor time to finished pan breads
• Explain what floor time does to the dough
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You have quality ingredients on hand, and a formula that has been tested and refined, and it is time to make the product. The first step is mixing all of the ingredients together. Mixing can be accomplished in different ways. For centuries, doughs were mixed only by hand. As technology has advanced, various mixers have been developed to take the place of hand mixing.

The type of mixer used in production depends on several factors: the type of product(s) being made, the amount or volume product that needs to be produced, the rate at which the products will be produced, and the amount of space available in the bakery. Some bakers still maintain the tradition of hand mixing. Manually kneading the dough allows the baker to determine when the optimum dough development is reached. Slight changes in flour due to crop or supplier changes may not be as much of an issue with the hands-on approach. The disadvantage to hand mixing is the limited amount of production. Breads and rolls cannot be made in large quantities with such direct, labor-intensive mixing. For small, retail, artisan bakers, however, this approach may be critical to their finished product attributes.

Spiral and vertical mixers are two options that are commonly used by small to medium-scale bakers. They come in a variety of sizes so they can easily be custom fit to the anticipated volume. Spiral mixers can handle up to 300 pound doughs. The mixing action is gentler due to the low RPMs of the spiral hook in the bowl. As a result, the bowls are typically not jacketed, so susceptibility to warm dough temperatures are a production consideration. Vertical mixers are gauged in terms of quart capacity of the mixing bowl. They can be very small tabletop models with 5 quart bowls, up to larger floor models with 340 quart bowls. Vertical mixers provide great flexibility for the baker since the mixer agitator can be easily changed from a dough hook, to a whip, to a paddle. Additionally, they usually have 3-4 speeds, and a refrigerated bowl is optional. A wide range of products can be made with one mixer.
Horizontal mixers are the most commonly used mixers for medium to large scale production. They can be used to mix sponges or doughs for bread and roll production. Sizes range from 100 pound capacity horizontal mixers up to 3,000 pound mixers for high speed production. In most instances, the bowls of horizontal mixers are jacketed to help control dough temperatures. The mixers can be operated in two speeds: low or high, 30-50 RPMs or 70-100 RPMs. Since the RPMs of the agitator bars are fairly high, heat is generated from friction. The refrigeration system helps offset the heat created from the friction as the dough hits the horizontal agitators and breaker bar. Horizontal mixers can have stationary or tilt bowls. In a stationary mixer the door slides up and down, and the bowl stays in place. In a tilt bowl mixer, the sidewalls of the bowl act as the door. The entire bowl rotates forward to allow for loading and unloading the mixer.
While horizontal mixers are able to mix large quantities of dough, they still take significant amounts of time to mix doughs to optimum development. High speed mixers have been developed to shorten the amount of time necessary to put out a machinable dough. Tweedy and Stephan are two mixers that have been developed to use vacuum and extremely high RPMs to mix doughs. The RPMs can be as high as 1,750, which creates heat. Refrigeration is typically necessary to minimize stickiness from warm doughs. Since the dough is mixed under vacuum, the dough development is monitored on a screen which displays the amount of energy (watt hours) required to mix the dough. The dough sizes are small, 50-770 lbs., but the mix times are short to keep up with high speed production. Liquid ferments typically feed the dough side. The fermented portion of flour will require less mechanical input to properly develop the dough.
Continuous mixers are another form of high speed mixers and are not limited to small batches. The feed of ingredients and liquid ferment are continuous, so there are no distinct batches when using continuous mixing. The formula is achieved through feed rates of various streams into the pre-mixer or kneader: typically flour, water, liquid ferment, salt, and oxidation. The pre-mixer or kneader combines all of the ingredients to form a stiff dough which feeds into the developer head. The developer is a pressurized chamber with several perforated, vertical discs that rotate at very high speeds, 150-300 RPM. As the dough moves through the developer head it is developed through the intense mechanical action, and the dough temperature increases dramatically. Dough temperatures can reach 90-100°F. At the end of the developer head is the depositor or divider, which drops the very soft, warm dough directly into pans.
No matter what type of mixer is used, mixing doughs serves several purposes, such as evenly incorporating all of the ingredients in a formula. This is especially important for the minor ingredients in a formula. Mixing also hydrates all of the ingredients. Once the ingredients are properly hydrated, gluten development can take place. Gluten development allows for proper handling and gas retention. Properly developed dough will trap and retain the gas, which creates bakery products that are light and airy.

There are several stages in mixing a conventional dough. High speed mixers are the exception. Understanding these stages and being able to identify each stage will help with quality control. It is easier to address a problem with the dough while it is still in the mixer.

**Stages of Mixing:**
1. Pick-up
2. Initial development
3. Clean-up
4. Final development
5. Let-down
6. Break down

Pick-up occurs early within the mix, when the ingredients are first becoming hydrated. If the baker stops the mixer at this point, the dough will appear lumpy, wet, and sticky, similar to a biscuit dough. The flour is not completely hydrated, and the ingredients are not yet evenly distributed.

As mixing progresses, the flour hydrates further and the dough appears drier. It also appears progressively smoother due to the physical action of the mixer breaking the chemical bonds between proteins. This is known as initial development. Chunks of dough will be pushed around in the mixer and they will gradually come together forming larger and larger chunks.

Once the large chunks of dough come together to form one large mass, the initial development is complete and the dough has reached the clean-up stage. At this point, the dough reaches its maximum viscosity. The sides and bottom of the mixer have no dough sticking to them. Clean-up can also be heard. The sound of the dough mixing will change from a continuous drumming to a rhythmic slap as the single mass of dough hits the front and back of the mixer. If
the baker were to stop the mixer at the clean-up stage, the dough would appear somewhat smooth on the surface, but it would feel very tight, stiff and elastic. It is common to mix the dough for an additional 2-4 minutes after the clean-up stage.

The final few minutes of mixing are the final development stage. The end point of final development is when the dough is at the proper consistency for handling. This is normally judged by using the gluten film test. A piece of dough is stretched between the hands into a thin, smooth, translucent film. This simple test is an excellent indication that the ideal balance of extensibility and elasticity has been reached. If too elastic, it will not stretch into a film. If too extensible, the dough will have too much flow. Although different products will have slightly different endpoints, they all need the proper balance to retain gas and make quality products.

Students Performing Gluten Film Test

If the dough is mixed beyond final development, it will continue to increase in temperature and the gluten matrix will start to degrade, both of which will make the dough wetter and stickier. Such slightly over-mixed dough is in the let-down stage. Dough can be saved at this point with proper mixing and fermentation
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adjustments. For some bakers, the let-down stage is where the salt is added, and the dough is given two additional minutes of mixing. This is called the delayed salt mixing method.

A severely over-mixed dough will reach the break down stage, where the gluten is severely damaged and the dough begins to liquefy. A dough mixed to the break down stage cannot be repaired. For the baker to save the dough, he or she would have to blend small amounts of the damaged dough into other batches of good doughs.

In determining proper mixing time, finished product quality should be checked routinely to verify the exact mixing requirements. In some cases, the baker may need to mix slightly over or under the end point that was initially set. However, over or under mixing dough beyond optimum will have a significant impact on finished product quality. Under mixed doughs may have lower set temperatures. The cooler dough temperature and under developed protein structure will result in low loaf volume, dense crumb grain, and symmetry issues due to dough resistance in make-up. An over mixed dough will have its own set of finished product quality issues. Dough temperatures of over mixed doughs will be elevated, creating sticky, difficult to process doughs. The dough will flow and proof much quicker. Oven kick will be rapid. The baked loaves may have excess volume and weak sidewalls that are susceptible to collapse. The crumb grain will be very open losing moisture rapidly, which will accelerate the staling process. Excessive pan flow can create sharp edges on the bottom of loaves. The sharp edges can become sharp enough to slice packaging as the sliced loaves are inserted into the bags.

Dough temperature is a key quality checkpoint that mixer operators should check on each dough. Each product will have a desired ending dough temperature. Doughs that are warmer will perform like over mixed doughs and problems in make-up will arise due to doughs being sticky. They will also proof faster. Colder doughs than desired will be stiff. Scaling weights will be inaccurate, the dough will flow less, and the dough will proof slower, like under mixed doughs.

There are several factors that affect mix time, including the type of mixer used. The same formula mixed in different mixers may have difference mix times due to RPM differences in the agitators. Some
large scale bakeries use two or three horizontal mixers for one production line. The motors within the different mixers may have different RPMs so the mix time for each mixer would have to be optimized.

The amount of fermentation will have a dramatic influence on mix time. White pan bread made from a straight or no-time dough will have a much longer mix time than the same type of dough made with sponge and dough. The fermentation in a sponge and dough system will mellow the gluten, and prepare it for development. In a no-time dough all of the gluten hydration and development is done through the mechanical work of the mixer. Longer mix times are more likely to make doughs with higher temperatures. The friction between the dough and the mixer generate heat.

Ingredients can also contribute to the amount of friction between the dough and the mixer. Whole wheat flour generates more friction in a mixer than does white flour. The fine bran particles in whole flour contribute to heat generation, which breaks down at a faster rate. Inclusion of seeds or other coarse ingredients will have the same effect. Absorption, or the amount of water, in a dough system also has an effect on the mix time. It is important to watch and listen for clean-up time. Too much water in a system can extend clean-up time. If there is not enough water available to fully hydrate the flour and other dry ingredients, final development cannot occur.

Floor Time
After mixing, the dough is usually given floor time. This is a period of time to allow the dough to recover from mixing. Dough is at its maximum level of extensibility immediately after mixing. As floor time progresses, the dough becomes less extensible and drier. Floor time can be adjusted to improve handling qualities of mixed dough; a typical floor time is 10-20 minutes. Providing the floor time for a bread dough will reduce the stickiness of the dough, improve machining in make-up, and create a finished product with better quality. The instances of settling, large make-up holes, or poor symmetry will be minimized. In some instances, often in bun production, floor time is not given and the dough is processed immediately after mixing.
Figure 1
Undeveloped Gluten

Developed Gluten - Stretching action of mixer realigns the gluten
Figure 2
Sequence of Dough Manipulation During a Single Revolution of the Mixer Arms in a Horizontal Mixer
Courtesy of Food Engineering - Siebel Publishing Company

1. Pick-up bar carries dough up and over to rear bowl
2. First kneading roller engages and rolls gently into the dough
3. Dough moves forward while first kneading roller rolls over it
4. Second roller engages and kneads dough into different shape
5. Third roller engages and kneads dough in another position
6. Pick-up bar again engages dough and the cycle is repeated