3
Dough consistency

3.1 Introduction

Water is added at the mixing stage to nearly all biscuit recipes. It functions as a catalyst because it is almost totally removed during the subsequent baking process. Water hydrates ingredients like flour and, if conditions are right during subsequent mixing, hydrated wheat protein changes into a visco-elastic material known as gluten. This is very important in determining the nature of the dough, how the dough behaves in the forming processes and ultimately the structure in the baked biscuit. Water also allows the solution of some ingredients such as sugar and, in the case of chemicals, permits reactions to take place in the dough.

However, the amount of water that is added is related principally to the consistency of the mixed dough and it is the problem of achieving the correct consistency that is the subject of this section.

3.2 What is dough consistency and why is it important?

Biscuit dough forming machinery (the principal processes have been outlined in section 2.3) has been developed over very many years, basically as the mechanisation of techniques that were originally done by hand. Unlike manual techniques, machines are not able to adapt their treatment of dough according to changes in the consistency. This means that for modern dough-forming processes optimum consistency and a continuous maintenance of this dough consistency are essential if the machinery is to perform reliably. The alternative is that plant operators or feedback sensors must continually

adjust the machinery settings to accommodate consistency changes. This is not a satisfactory situation for ideal process control.

Dough consistency is very difficult to define and measure. It is manifest as the softness, stickiness, elasticity and extensibility that can be assessed by manipulating a mass of dough in the hands. This physical condition results from the ingredients of the dough, including the amount of water which has been added, the mixing conditions and the temperature. Generally, the greater the liquid component in the dough and the higher the temperature the softer will be the dough. The liquids are either water (including water in syrups, milk, egg and so forth) and fat. The fats used in biscuit doughs are generally semisolid like butter. Crystals of fat are dispersed in liquid fat (often known as oil when in the liquid state). Fat crystals melt as they are heated so the amount of liquid is a function both of temperature and of type of fat.

During the mixing of the constituents added water becomes distributed in a number of different ways all of which significantly contribute to the nature of the dough:

- It is absorbed into such ingredients as flour and starch. Hydrated wheat protein may be changed into gluten, as was mentioned above, and this gives the dough a cohesive nature. The absorption is time-dependent and coarse particles like oat flakes take longer to hydrate than does powdery flour. The formation of gluten depends firstly on the hydration then on a period of mixing so this is both time- and energy-dependent.
- It dissolves sugars, chemicals and other substances to form solutions. The dissolution of sugars, principally sucrose, effectively increases the volume of the liquid phase by a factor of 0.6 of the weight of sugar and also makes the dough more sticky. The amount of sugar that will dissolve is limited by the saturation of the solution and this is about 67% at ambient temperatures. The solution of the sugar is quicker than the hydration of the flour so a dough at first becomes more sticky and then, as this syrup is involved in the cereal hydration, the stickiness becomes less apparent.

  As the chemicals dissolve, reactions between them and other ingredients become possible and the pH of the dough may change. Generally, higher pH values, as a result of solutions of ammonium bicarbonate and sodium bicarbonate for example, soften gluten and lower the consistency of the dough.
- It contributes to the liquid phase in the mass together with liquid fat. The fat may coat cereal particles in the initial stages of mixing and retard the hydration and the formation of gluten.

Mixing is often a rather crude process involving the blending and working of all the ingredients placed haphazardly together. Furthermore, as mixing proceeds there is a development of heat in the dough which increases reaction speeds and affects consistency. It is therefore difficult to be sure in what

order or to what degree of completion the above mechanisms, that involve the incorporation of water, have reached.

The aim of mixing is to produce a dough which is homogeneous and of a consistency suitable for further processing. The problem is that this consistency is not stable. The stickiness may decrease as the hydration process continues and the firmness of the dough increases due to a phenomenon known as thixotropy. In thixotropic materials the consistency is related to the immediate history of that mass. A good example is toothpaste: this is firm as it comes from the tube but rapidly softens as it is moved over the teeth. Another is tomato sauce which is firm in the bottle but becomes much more fluid after the bottle has been shaken! It is very difficult to measure critically the consistency of thixotropic materials because they have to be worked in a prescribed way immediately before the test is made. For this and other reasons instruments used for assessing dough consistency of biscuit doughs with their great variety of ingredients are generally rather unsatisfactory.

3.3 Why should consistencies of dough change?

The main reason why doughs appear different after what was apparently a standard mixing procedure is that the metering of the ingredients was not precise. The most likely problem is that while the metering of flour is accurate, varying inclusions of scrap dough or biscuit recycle materials can give big changes to the consistency.

From time to time, but not from batch to batch, the water absorption characters of the flour will change. This means that more or less water is needed to give a desired consistency of dough. The factors that affect flour water absorption are principally the flour moisture content, its protein level, and the amount of damaged starch. These properties can be controlled by the flour miller. It is very likely that the water absorption of flour will differ if it originates from different flour mills. The effect of changes in flour water absorption on biscuit doughs will generally be minimal except for those with very low fat and sugar contents such as crackers where the dough water requirement is relatively high. It is possible to use specialised dough rheology instruments to measure flour water absorption values but the biscuit makers are not interested in the flour *per se*: they want to know how the biscuit dough is affected and this involves many other ingredients. It is not common to measure biscuit dough consistency but penetrometers can give empirical results which may be slightly better than the manual squeezing and stretching test used by experienced operators.

Changes in the dough temperature can also affect the consistency. It is common to mix doughs on a time basis. This means that when the mixer bowl is cold the dough will be cooler after a given mixing period. Mixing of developed doughs should be to a final temperature and not to a time: however, the time must be long enough to allow adequate blending and dough develop-

ment. (Please see notes about mixing in each of the recipe sections.) The dough temperature may change in the period of handling before it reaches the forming machinery, it may cool at the edges of a tub left in a cold place or it may be different because it has been used sooner than normal after completion of mixing.

Short doughs have a minimal mixing after the flour has been added. At the end of mixing insufficient time has elapsed for the flour hydration to have been completed. This means that the dough is soft and sticky. Within about 30 minutes of standing the consistency will have changed significantly and although the change continues for much longer the size of the change is thereafter relatively slow. Dough passing through a forming machine that is significantly changing in consistency can be expected to give operation problems so it is highly recommended to stand the dough before use.

The effects of changes in dough consistency are noticed principally on the forming machine. A soft dough will pass more easily through a sheeter and gauge rolls and give a thinner sheet. If the rolls are cold this will chill and toughen the dough, and as the cutter scrap dough is reincorporated the consistency will be toughened because this dough is always more dense than fresh dough. Cutter scrap can therefore be a problem at start-up and certain other times during plant running if not handled thoughtfully.

The most important single parameter in controlling baked biscuit quality is the weight of the dough piece. Heavier dough pieces will give thicker biscuits, paler bakes with high moisture content and the shape may differ. It is an essential task of process control to maintain a correct biscuit weight and this is done by controlling the dough piece weight. If the dough consistency is changing, operators of the forming machinery, whether of sheeting and cutting, moulding or extrusion, will have great difficulty in maintaining constant dough piece weights. There are practically no in-line dough piece weight monitoring instruments so automatic feedback to compensate for dough piece weight variation is not at present a practical option.

3.4 Can the dough water requirement be predicted?

This was discussed in Section 2.2, where the correlation between dough fat and water levels was demonstrated. The conclusions may be summarised as follows:

- All other factors being equal, an increase in the sugar in a recipe will result in a lower requirement for water, provided there is enough water present to dissolve all the sugar.
- Doughs where there is more sugar present than can dissolve in the available water will show a strong softening effect as the temperature rises. This is because more sugar will dissolve and there is a general softening of dough due to higher temperature. Thus short doughs in summer

conditions where the temperature is not controlled will probably need significantly less water. It is well known that the greater the water level in short doughs the better is the structural development during baking, so if the dough is warm and the water level reduced the structural development may be affected. It is therefore good to try to keep short-dough temperatures within the range 20–22 °C at all times of the year.

It would be useful to be able to adjust the dough water level before the completion of the mixing to achieve a desired consistency. Much attention has been applied to this idea. The technique used for assessing flour water absorption using the Brabender farinograph does involve measuring the consistency of a flour/water/salt dough with some water withheld and then adding extra water to a desired consistency. Many experiments were made by the author and colleagues when they worked at Baker Perkins (now APV Baker) using the whole mixer as a type of farinograph. The power taken by the motor during mixing was plotted against time and the shape of the curve noted against a standard when dough of desired consistency had been made. It will be appreciated that the motor is extremely load sensitive so errors of metering give exaggerated results. Also it was found that the ways in which the doughs came together at the early stages of mixing varied and there seemed to be differences in the way the mixer moved the dough from time to time. Generally it was found that the technique was not useful for *controlling* dough consistency; however, the technique was useful for detecting differences between batches of dough. These differences arose principally because of errors in ingredient metering. Such a dough quality monitoring system may be very useful where entirely automatic loading, mixing and discharging systems of dough making are involved.

The author has come across a 'standard' process control test which is used in former USSR countries. This involves the rapid measurement of dough moisture content. The idea is that this is a check on both recipe and dough consistency. From what has been told above and displayed in the charts it can be seen that the value of this test is, at best, marginal.