AN ELECTRONIC RECORDING DOUGH MIXER

III. Additional Methods of Recording[1]

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ABSTRACT

Two additional electronic methods of recording dough development during mixing are described. The methods eliminate errors in interpreting development curves, because the data are recorded as either the integral of the torque-time curve or as the maximum and minimum torque during mixing. Equipment is described for recording such data in analog and digital form. The methods provide a rapid means of estimating the energy absorption and maximum shear stress of dough, which are sensitive indices of flour quality. The apparatus is useful in the study of breadmaking methods using mechanical dough development.

The energy absorbed during mixing is an important measure of dough quality, and it was concluded that some means, such as electronic integration, was required to eliminate human errors in interpreting the development curves (1,2). While total energy absorbed is dissipated both as heat and in developing the dough, it is one accepted measure of dough strength.

Two electronic methods of recording dough development are described, where either the maximum and minimum torque required, or the energy (integral), is recorded during mixing. The advantages of these methods are rapid analysis and elimination of human errors.

Description of Apparatus

The methods described are applicable to any electronic recording mixer and can be used in place of the recording equipment previously described (1).

Recording Maximum and Minimum Torque. The equipment, based on a digital voltmeter, has been described for a different application (3). In Fig. 1, A, the torsion sensor is connected to an amplifier *b*, whose output is connected to the digital voltmeter *c*. The digital voltmeter has a control which allows it to indicate either the maximum or minimum voltage applied during a period and to hold this reading until reset. The mixer is calibrated by the procedure described for the electronic recording mixer (1). The digital output of the voltmeter, which is proportional to torque, is connected to a

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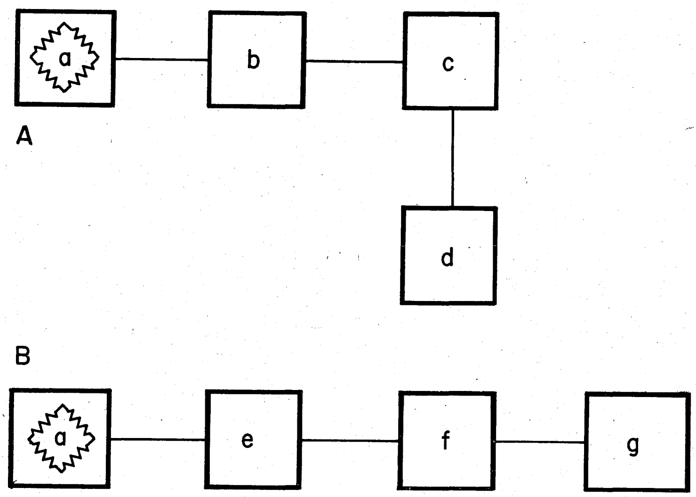

Fig. 1. Schematic diagrams of recording equipment. A, digital voltmeter method: a, strain gage bridge of torsion sensor; b, bridge-amplifier-meter unit (Model 300CF with Type 80 plug-in, Daytronic Corp., Dayton, Ohio); c, Model CM2001, digital voltmeter (Digital Measurements, Aldershot, Hants., England); d, Model DM5020 printer (Digital Measurements). B, integration method: e, integrating strain gage coupler (Type 9825); f, preamplifier (Type 461B); g, recorder (Dynograph, Type RS). (Equipment: Offner Div., Beckman Instrument Co., Chicago, Ill.)

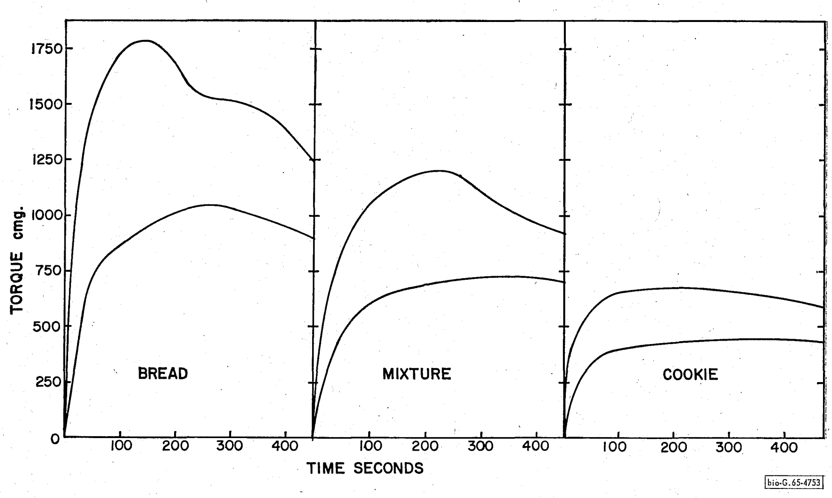

Fig. 2. Typical development curves for 10-g. samples of bread flour, cookie flour, and a 50-50 mixture of the two. Record of maximum and minimum torque during mixing by the voltmeter method.

printer *d* which reads the maximum torque during 10 sec. of mixing and prints the result. Then it switches the voltmeter to minimum operating mode and reads the minimum torque during 10 sec. of mixing, prints the result, and switches back to the maximum operating mode. This continues throughout the mixing cycle. Development curves are then plotted, showing only the maximum and minimum torque required during mixing.

Recording Energy during Mixing. Many devices are available for

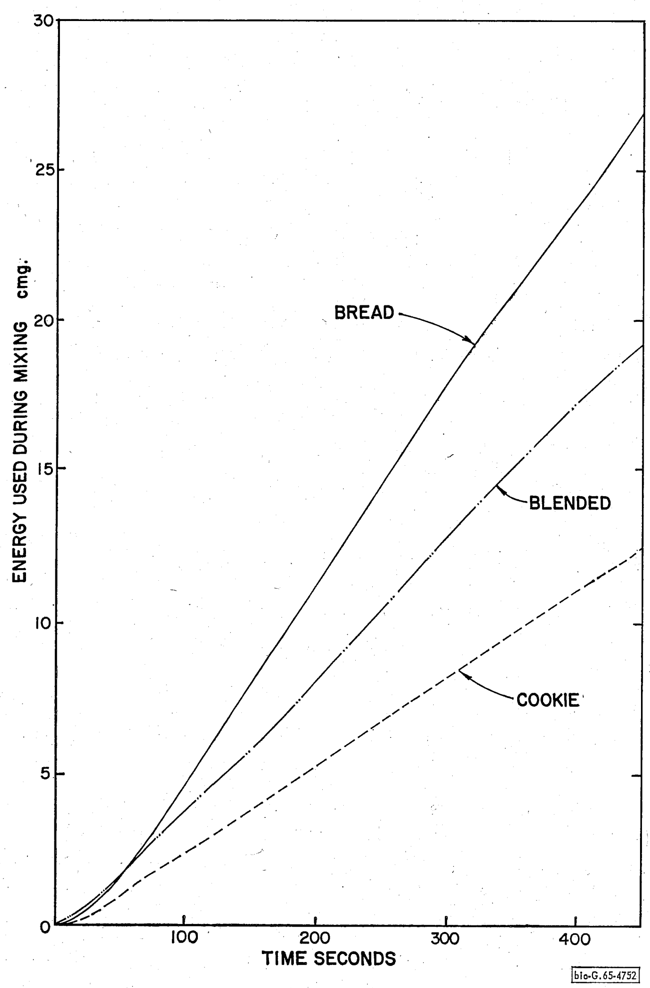

Fig. 3. Integral of torque required during mixing for the same three flours shown in Fig. 2.

directly recording the area under a curve such as the recorder used by the authors (Fig. 1, B). Thus, the total energy absorbed during the mixing process is recorded. The recorder is calibrated by applying a known constant torque to the sensor and noting the integrated value after an increment of time has elapsed. The torsion applied is arranged so that the integrated value does not exceed full-scale recorder deflection in 7.5 min. but does exceed the maximum area under a development curve.

Development curves are plotted (Figs. 2 and 3) for three grades of flour by recording the maximum and minimum torque and the integral of the torque during mixing, using the 10-g. electronic recording mixer (1) and the recording apparatus described here.

Discussion

The results, illustrating the two recording methods, demonstrate some additional advantages of using electronic recording mixers, because methods other than analog recording become feasible. The maximum-minimum and integrated curves are easier to analyze and have greater clarity than conventional analog development curves. This is of great value in both research and quality control applications. Further work is necessary to establish the accuracy of these methods in relation to torque recorded in analog form.

The two methods eliminate the errors introduced by human interpretation of analog development curves. The accuracy and resolution of both methods are high, and calibration can be readily accomplished with the use of gravity weights. The integrating recorder used has a frequency response of 150 c.p.s. The torque signal is varying only at 4 c.p.s. and it is thus integrated accurately. That is, the total energy used during mixing is recorded, not estimated from curves as previously described (2), and the energy absorption per g. of dough can be determined precisely.

The digital voltmeter converts an input to a reading in 20 millisec. Therefore, it will affect the measurement because the torque is changing continuously. The readings obtained are average minimum or maximum values occurring during the 10-sec. recording period. Thus, instead of a dispersed curve, a smooth profile suitable for analysis is obtained. The area under the maximum curve provides an estimate of the maximum shear stress in the dough during mixing, without the use of a hand-drawn curve as previously described (2). This is useful in estimating the design criteria of large-scale mixing machinery where this property of the dough must be known. The total energy can be estimated from the area under the mean of the maximum and minimum curves. The difference between the maximum and minimum is a sensitive index of dough strength, since it is related to shear stress variations in the dough.

Conclusions

Electronically recorded development curves are easier to analyze if the maximum and minimum torque, or integral of the torque, are recorded during mixing instead of continuous recording of the torque. Further work is required to determine the exact relation between energy absorption, heat dissipation, and shear stress in the dough during mixing and other measures of flour quality. It is possible that the integration method may provide a precise means of controlling development in breadmaking. The same principles used in the recording mixer could be scaled up to a production mixer which would automatically stop when a precise amount of energy had been absorbed by the dough. Both the digital and integration methods can be adapted to store the data on punched tape for analysis by a computer. For some purposes this will save considerable labor.

Literature Cited

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