CLASSIFICATION OF PUFF-PASTRY FATS AND MARGARINES BASED ON DOUGH FIRMNESS[1]

J. LAGENDIJK[2] AND J. VAN DALFSEN[2]

ABSTRACT

A special apparatus, the firmness meter, has been designed for measuring the degree of stiffening and softening of puff-pastry doughs on working-up. These properties can be expressed in numerical values. This apparatus is described and some experiments and results are discussed. On the basis of the measured results obtained, it is possible to make a distinction between the properties of various puff-pastry fats and margarines.

Until recently, little was known about the relation between the physical properties of a puff-pastry dough and its baking behavior. The meaning of "work-softening" and "work-hardening" was not quite clear.

[1]Manuscript received July 21, 1964.
[2]Unilever Research Laboratory, Vlaardingen, The Netherlands.

So far, the work-softening and work-hardening of puff-pastry doughs has been assessed manually after certain resting periods of the doughs, but with the aid of a newly designed apparatus, the firmness meter, more objective assessments can be obtained. Moreover, the physical properties of the dough can now be recorded graphically. The purpose of the measurements carried out with the apparatus was 1) to determine the factors affecting the work-softening and work-hardening of puff-pastry doughs, and 2) to establish the relation between work-softening and work-hardening on the one hand and the baking properties of puff-pastry doughs on the other.

Materials and Methods

The flour used in this investigation was a commercially milled Dutch patent flour of protein content ranging from 11.0 to 11.5%, water absorption 55.0 to 57.5%, as determined at a consistency of 500 farinograph units, and ash content from 0.40 to 0.45%, all on 14% moisture basis.

The temperature of the dough during the whole process of dough-making was 20°C.

Description of the Firmness Meter. As can be seen from Fig. 1, the firmness meter consists of two parts. Part *A* is for clamping the dough and part *B* is a balance system by which the measurements are carried out.

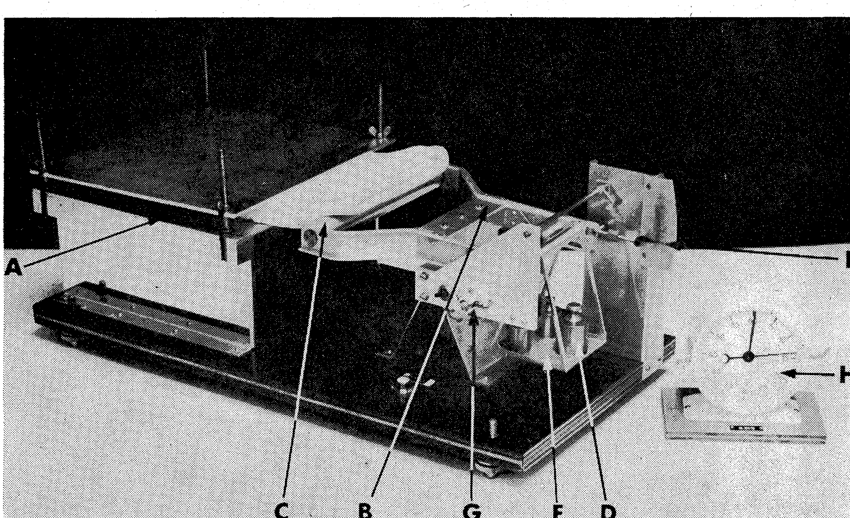

Fig. 1. The firmness meter. A, clamping platform for dough; B, balance system; C, roller of the balance system; D, weights; E, pan of the balance; F, graduation; G, control lamp for full-scale deflection; H, stopclock.

The dough, which is uniformly turned at a breadth of 180 mm. and a thickness of 20 mm., is clamped in such a way that there is a free end of 90 mm. resting on roller *C* of the balance.

Before the measurements are carried out, the balance is first equiliberated by means of weights *D* placed in scalepan *E*, and subsequently an extra weight (weight one-third of that required to obtain equilibrium) is placed in the pan causing the free end of the dough to bend upward.

The deflection thus obtained can be read on the graduation *F*. One scale unit is equal to a difference in height of the pan of 1 mm. The duration of the measurement is limited to 3 min.

If the puff-pastry dough is firm, the measurement invariably yields a reliable value after this period. If the doughs are soft, a full-scale deflection is obtained within 3 min. and it is necessary to record the time at this deflection corresponding with a fall of the pan of 3 cm. The moment a full-scale deflection is obtained within 3 min., lamp *G* switches on. The duration of the measurement is determined by means of a stop clock *H*.

The relation found between firmness and time appears to be linear over a large range.

Both measuring methods can be used for expressing the firmness of puff-pastry doughs numerically.

The power of the extra weight can be calculated according to the simple formula:

$$\text{power} = \frac{\text{force} \times \text{distance}}{\text{time}}$$

The reciprocal value of this power is a measure for the firmness of puff-pastry doughs, which means that the firmness increases with higher reciprocal values. If the firmness is plotted against the time, a descending line indicates a decrease and an ascending line an increase in firmness of the dough.

If puff-pastry doughs of other sizes are used, comparable results can be obtained by converting the data in question according to the formula:

$$\text{power} = \text{A} \cdot \frac{\text{force} \times \text{distance}}{\text{time}}$$

where $\text{A} = 324/\text{V}$.

The numerator (324) is here equal to the volume (cm.^{3}) of the non-clamped part of the dough having the standard measurements and V the volume (cm.^{3}) of the free end of the dough, the firmness of which is measured.

Preparation of Dough and Assessment of Patty Shells. The puff-pastry doughs were prepared in the way described below, which is known as the "French Method." This puff-pastry dough consists of (a) predough and (b) puff-pastry margarine for turning in.

Predough. Introduce 400 g. flour, 80 g. puff-pastry margarine, and about 225 g. water (all ingredients at 20°C.) into a Diosna Kneader. Knead this mixture for 3 min. The amount of water varies from 215 to 230 g. depending on the water absorption of the flour used. This absorption is determined with the Brabender Farinograph (1). Make the dough into a ball.

Turning. Roll out the ball into a starlike shape 15 min. after it has been kneaded. Fold 320 g. puff-pastry margarine into the dough and give subsequently two half-turns in three using a Seewer Rondo rolling machine. (That is, after rolling out to a thickness of 10 mm., fold the dough in three.) After a resting period of 1 hr., again give two half-turns in three. Repeat this after 1 hr. Finally, after the third resting period, roll out the dough to a thickness of 3 mm. and cut out with a standard patty cutter.

After cutting out, allow the patty shells to rest for 1 hr., then bake at 220°–240°C.

The baked patty shells were assessed by giving values for gravity index – mean height (mm.) per 100 g. patty shell – and structure.

Determine the mean weight (W, in g.) of the patty shells after drying to constant weight. Calculate the mean height (h, in cm.) from four measurements at various places of each patty shell.

The gravity index is $(100/W) \times h$.

Results and Discussion

Behavior of Puff-Pastry Dough during Resting Periods. Determination of Firmness of Doughs. To determine the softening or stiffening of the doughs, carry out the measurements at least at the following points of time:

1) Immediately after the first two half-turns;
2) After the first resting period (before the second two half-turns);
3) After second resting period;
4) After third resting period (before cutting out).

An even more detailed picture of these properties was obtained by determining the firmness during the resting periods every 5 min. In every resting period, the curves obtained with Dutch patent flour showed two minima – after about 5 min. and between the 40th and 50th min. The phenomena are due to the behavior of the components of the dough, for after a puff-pastry margarine or fat is worked (rolled out), the hardness (yield value) (2) of the fat increases during the resting period following the working process. The predough softens during the resting period since its resistance to extension decreases and its extensibility increases. The properties of these components (puff-pastry layers and predough layers) determine the course of the firmness curve during the resting period.

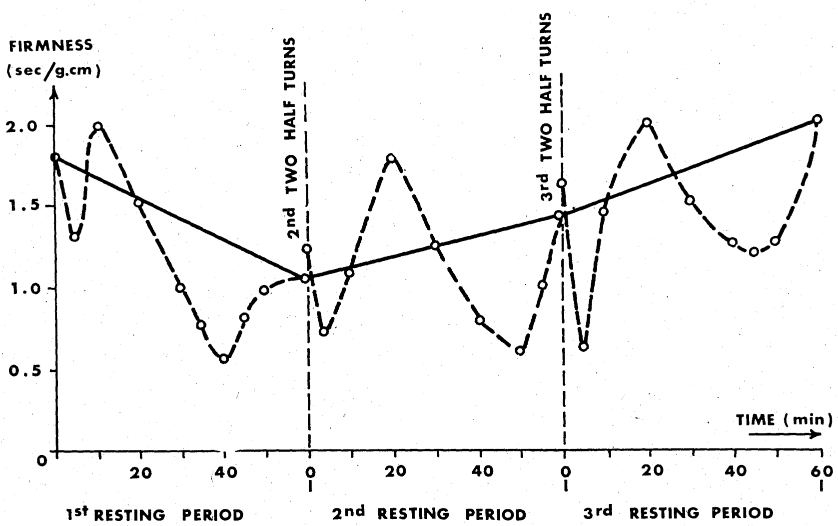

Fig. 2. Firmness of a puff-pastry dough during the three resting periods.

Classification of the Various Puff-Pastry Margarines and Fats. Many experiments have shown that doughs prepared with different types of margarine and fat but with the same flour do not soften and stiffen in the same pattern and, therefore, the puff-pastry margarines and fats have been divided into three dough groups (Fig. 3) and behave in the manner outlined below:

Dough Group	*Resting Period*
Recovering	Soften in 1st; (a) stiffen in 2nd and 3rd, or (b) soften slightly or remain constant in 2nd, stiffen in 3rd
Nonchanging	Soften very gradually in all
Softening	Soften gradually in 1st and 2nd, very strongly in 3rd

Recovering Group. It has been found that the softening of a dough is caused by the relaxation of the gluten. A measure for the relaxation is the values found for extensibility and resistance to extension of the predough.

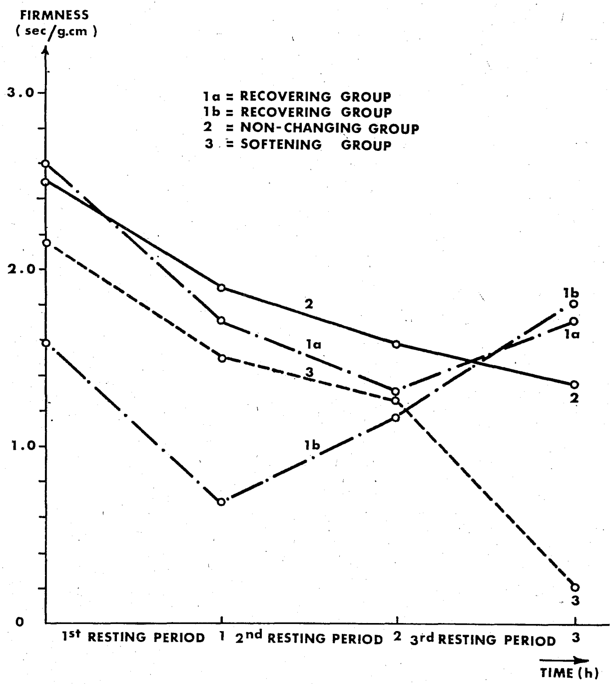

Fig. 3. Firmness of puff-pastry doughs prepared with different margarines.

On turning, part of the margarine fat in the layers is interspersed in the predough; this can be observed with a small piece of dough under the microscope after every two half-turns. The red-orange areas of margarine (colored with Sudan III) in the predough layers extend on working, which indicates that the amount of margarine in the predough increases.

The stiffening of the dough during the second and third resting period can be accounted for by the higher resistance to extension and the lower extensibility of the predough layers during these periods, caused by increased margarine (fat) interspersion.

Nonchanging Group. The margarine and fat interspersion of this group is so slight that the extensibility and the resistance to extension of the predough proceed almost identically in the three resting periods. If no margarine or fat is interspersed in the predough layers, the various turns have no influence on the extensibility and the resistance to extension of the predough, so that the influence of the predough on the softening of the puff-pastry dough remains the same during the three resting periods. The gradual softening of the puff-pastry doughs of this group can be ascribed to the gradual decrease in yield value of the puff-pastry margarine or fat being caused by turning. The decrease in yield value (2) of a puff-pastry fat of the nonchanging group, determined at the end of the resting periods, is shown in the table below.

	Yield Value *g./cm.*^{2}
Before treatment	2,200
After first resting period	2,050
After second resting period	1,970
After third resting period	1,890

Softening Group. The puff-pastry doughs prepared with the margarines of this group do not show the strong softening in the first resting period shown by those prepared with margarines and fats of the recovering group, which is due to a higher degree of interspersion. This causes a slighter softening of the predough and consequently also of the puff-pastry dough (provided the work-softening of the layers of puff-pastry margarine is not abnormally strong).

Because of the intensive interspersion after the third two half-turns, it is no longer possible to speak of the "margarine fat layer structure" normally forming the "skeleton" of the dough. Therefore, the margarine in this puff-pastry dough will no longer resist bending and the structure of the dough approaches that of a biscuit dough.

The photomicrographs of Fig. 4 clearly show the difference in layer structure of puff-pastry dough prepared with margarines of the recovering and the softening group. The layer structure of the former group is still clearly visible, whereas this structure is absent in the case of the latter group of margarines.

Relation between Appearance of Patty Shells and Classification of Margarines and Fats Used. In patty shells baked from puff-pastry

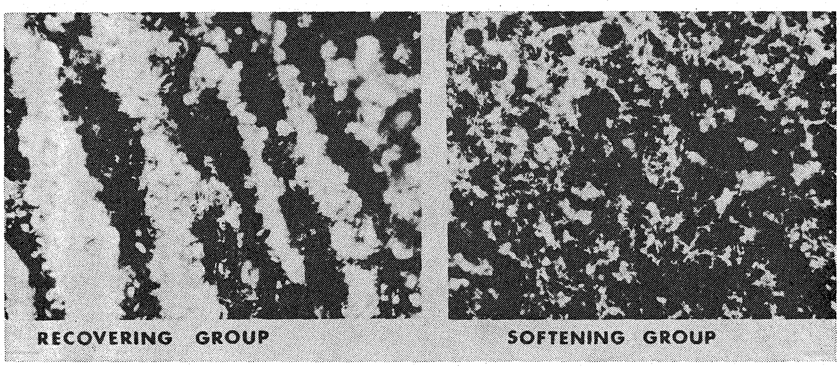

Fig. 4. Cross-sections of puff-pastry doughs after three series of two half-turns (about 150 ×).

doughs prepared with margarines and fats of one of the three groups, it appears that the degree of interspersion has also a great influence on height and structure of the baked product.

In the case of a slight interspersion, which means that the margarine or fat layers remain intact during the preparation of the puff-pastry dough, the patty shells will mostly be satisfactory as regards appearance. This is in agreement with expectations, since the function of the fat layers is to retain the water vapor formed during baking as long as possible, as a result of which the patty shell will rise. The better the fat layer structure, the longer this water vapor is retained, the higher the patty shells and the better the flaky structure will become.

The classification is based on the values found with the firmness meter and it corresponds, for all practical purposes, to that obtained for the margarines when arranged according to the gravity indices of the patty shells (Table I).

TABLE I
RELATION BETWEEN CLASSIFICATION OF PUFF-PASTRY MARGARINES AND FATS AND GRAVITY INDEX OF PATTY SHELLS

Group	Code of Margarine and Fat	Gravity Index	Group	Code of Margarine and Fat	Gravity Index
Recovering 1[a]	A	18.5	Nonchanging	K	21.5
	B	19.4		L	22.0
	C	19.5		M	22.0
	D	19.6		N	22.2
	E	18.5			
Recovering 2[a]	F	19.0	Softening	P	15.5
	G	19.3		R	16.8
	H	20.8		S	16.5
	J	20.1		T	15.9

[a] Recovering 1 = softening during 1st resting period; Recovering 2 = softening during 1st and 2nd resting periods.

It will in most cases be possible to predict the degree of rising of the patty shells from the firmness values of the doughs if the same type of flour is used.

Conclusion

The changes in the firmness of puff-pastry doughs can be measured by means of the firmness meter designed.

The investigation has shown that puff-pastry margarines and fats can be classified according to their physical behavior, and that this classification corresponds, for all practical purposes, to that made according to baking properties.

The difference in behavior depends on the degree in which the dough and fat margarine layers are interspersed, as was confirmed by microscopic investigations.

Acknowledgment

The authors wish to thank Mr. P. L. Kerklaan for carrying out the practical work, and Messrs. J. H. Beun and L. de Snayer for constructing the firmness meter.

Literature Cited

1. AMERICAN ASSOCIATION OF CEREAL CHEMISTS. Cereal laboratory methods (7th ed.). The Association: St. Paul, Minn. (1962).
2. HAIGHTON, A. J. The measurement of the hardness of margarine and fats with cone penetrometers. J. Am. Oil Chemists' Soc. **36**: 345–348 (1959).