Test Food Materials On Stretching

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Abstract

In the article proposes a device for determining the structural and mechanical properties of visco-plastic food mass at a stretching, in conditions, excluding the effect of its own weight of the sample. In the study of the influence of the quality of flour, humidity, duration of aging, mechanical processing revealed that during long time aging and mechanical processing a temporary tensile strength is reduced and relative elongation is increased, that is, the dough becomes more plastic. On tensile strain we define the values at which begins the gap of the dough: the dough from flour of the premium humidity of 40% - 550 Pa and a humidity of 45% - 650 Pa; the dough from the flour of the first grade humidity of 40% - 450 Pa and a humidity of 45% - 600 Pa.

Keywords: Dough, uniaxial stretching, rheological properties

Introduction

Food production at the present level, including cconduct more different technological processes, it is impossible without the use of tools (objective) of measurement methods and instrumentation technology for monitoring, regulation and quality management of raw materials and finished products. In this important and responsible role is assigned to rheology as a science dealing with the structure formation of food materials, the study of structural and mechanical properties, the development of methods and instruments for their determination [1-8].

Processing and shaping the dough mass is accompanied by complex physical-chemical, biological and mechanical processes, the study of which allows to organize an effective and objective rheology control, management of production cycle.

The process of forming dough for flour dishes is composed and results mainly from tensile strain and shear flow. Therefore, the definition of structural and mechanical characteristics of the dough at uniaxial tension is of interest to determine the deformation properties and to calculate the kinematic parameters of processing machines and devices.

Existing devices used to define the characteristics of the plastic food mass, can not be applied in the study shaping process of unleavened dough, since it ignores the effect of the mass of material during the time on the size of the test sample [2,4]. Therefore, it was suggested tool for determining the structural and mechanical properties of visco-plastic food mass at a stretching in conditions excluding the effect of its own weight of the sample.

The purpose of the study is to determine the structural and mechanical properties of visco-plastic food mass at a stretching.

Materials and methods

Determination of rheological properties of dough under uniaxial tension

For the study of the rheological characteristics of the dough during forming is regarded in our case - unleavened dough. Under the unleavened dough understand semi-finished product from which subsequently made various dishes flour and bakery products.

To determine the rheological properties of the dough at uniaxial tension we have created a device for measuring the stretch dough (Figure 1) [9].

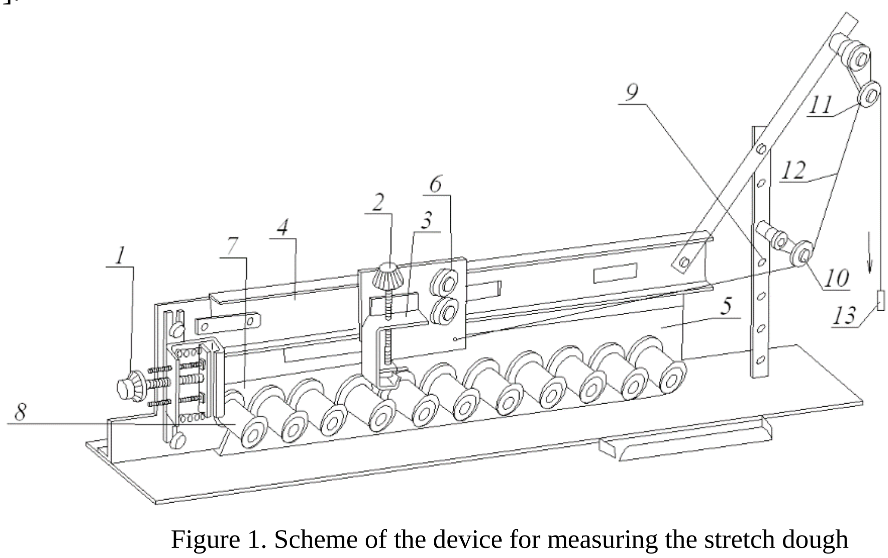


Figure 1. Scheme of the device for measuring the stretch dough

1,2 - spring clips, 3 - movable clamp, 4 - metal frame, 5 – base, 6 - twisting rollers, 7 - graduated scale, 8 – rollers, 9 - folding rack, 10, 11 – rails, 12 – thread, 13 - cargo.

Device for measuring the tensile dough contains fixed and movable clamps for the test sample, each of which is in the form of spring clips 1,2. The movable clamp 3 is fixed to the guide metal frame 4 fixed to the base 5 by means of twisting rollers 6, the device for counting values moving the movable grip is made as a graduated scale 7. Maintenance the test sample is made by sequentially assigned on basis of the device support rollers 8. The loading mechanism consists of a folding rack 9 on which are fixed the rails 10,11 for tensioning thread 12 with cargo 13 and that attached with movable clamp 3.

The device works as follows: test sample diameter of 5 mm, length 50 mm, its ends are placed in a nest of movable and fixed clamps and mounted by means of spring clips 1,2. When releasing of cargo 13, in loaded mechanism movable clamp moves along the guide metal frame 4 by twisting rollers 6. The sample is stretched along the axis of support rollers 8.

Moving the movable clamp continues to rupture of the sample. Tensile of test sample was determined by the index graduated scale 7.

Deformation of the dough is subjected to a constant size of 5 mm diameter 100 mm maximum absolute elongation of the specimen 300 mm.

For investigations in the laboratory were prepared samples of the dough humidity of 40% and 45%.

We used premium grade flour (gluten 32%), the first grade flour (gluten 28%). Amount of wet gluten was determined by washing it from the dough [10]. Extensibility gluten over the ruler determined by the method of determining the quality of wet gluten. For this, from completely of washed, wrung and weighed gluten take a sample of mass 4g and give it a spherical shape with a smooth surface without tearing. With both hands clutching gluten from both sides pull along the length of ruler to rupture [10]. Gluten is considered unsatisfactory strong - up to 10 cm extensibility, satisfactory strong - more than 10-20 cm extensibility, good - over 20 cm extensibility.

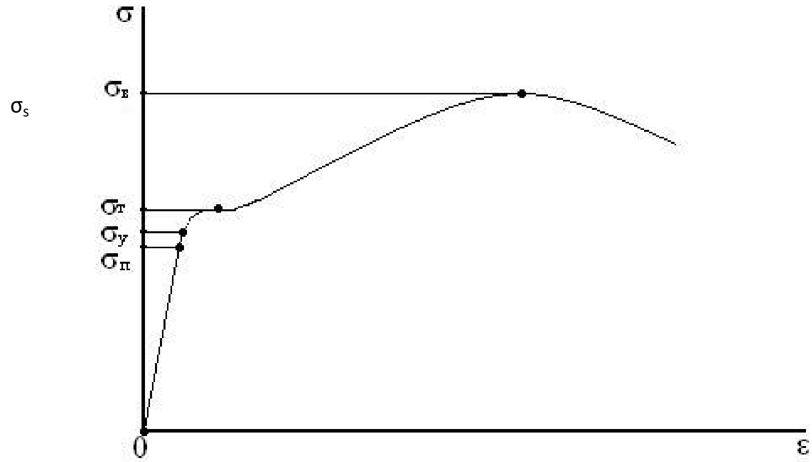
A uniaxial tensile sample of the finished dough shaped into a cylinder with a diameter of 5 mm and a length of 100 mm. The sample is subjected to a smooth immersion by tensile load of 0.09; 0.29; 0.49; 0.69 N.

Results and discussion

Uniaxial tensile test more fully reflect the plastic characteristics of the dough. For all of the samples during immersion, after reaching value of the relative deformation, was observed plastic elongation with decreasing cross-sectional area, formation neck and rupture.

Since the beginning of formation neck sample loses its shape, strain and deformation is not distributed more or less uniformly over the length of the sample yet, and is concentrated in the section where the cross-sectional area is smallest.

The test material is cannot be of uniform quality throughout the length; in some sections quality of the material should be the lowest. At the same time, the sample cannot be completely cylindrical, but should have the smallest cross-section. Therefore, when immersed in one of these sections will be greatest elongation. In the same section will be the largest reduction in cross-sectional area. This, in turn, increase the tension and reach a maximum at the smallest cross section. In this section of the yield strength increases. In accordance with Figure 2 shows that all this leads to rupture of the sample.



σ_d - elastic deformation, σ_l - elastic limit, σ_h - hardening of the sample, σ_s - yield strength.

Figure 2. The curve of the dependence tension from deformation.

The deformable sample at different stages of tests have different resistance, depending on the properties of dough. The process of extension of the sample (Figure 2) occurred at four sites:

- σ_d elastic deformation, where tension is proportional to the load and the initial part of the diagram can be viewed as a straight line, it is characterized by a corresponding portion of the diagram;

-σ_l the elastic properties of the material are retained to tension, called the elastic limit, i.e. it is the greatest tension, to which the material does not get permanent deformations;

- σ_h hardening of the sample, where the load increases again, but stretching is much slower;

- σ_s yield strength of dough without increasing the load, where the deformation of the sample is increasing rapidly without any appreciable increase in tensile strength. This stage is characterized by a horizontal section the diagram.

At the end portion of the diagram in the result of stretching dough formation of neck and rupture. In the formed neck, occurs destructive deformation and in a result of rupture of the sample occurs minimal elastic recovery of dough.

From Figure 2 shows that the region σ_d, σ_l, σ_h characterizes the elastic properties of dough, and the region σ_h, σ_s - plastic properties. For the forming process unleavened dough the most interesting is the region σ_h, σ_s at uniaxial tension, because here occurs the greatest deformation of dough.

Results of researches extensibility of all samples are shown in Table 2 and Figure 3.

Table 2. Results of the experiment on the extensibility of the dough

Sample of the dough	Humidity, %	Time aging, min		
		15	30	40
		Extensibility, cm		
Premium flour, 0,1kg	45	20	27	36
	40	19	25	32
Flour of the first grade, 0,1kg	45	17	23	29
	40	15	21	27

Results of researches showed that the grade of flour, humidity dough, the duration of the pre-aging effect on the structural and mechanical properties of dough. With increasing humidity dough, duration aging and mechanical processing, plastic characteristics of dough is increase. For example, at a temperature of 35 ^{0}C, duration aging 30 min and humidity 40%, the maximum linear deformation increased on average 1.7 times, and at the duration aging 90 min and humidity 45% maximum linear deformation increases in average 2.6 times. The dough is made from premium flour more extensible than the dough made from the flour of the first grade.

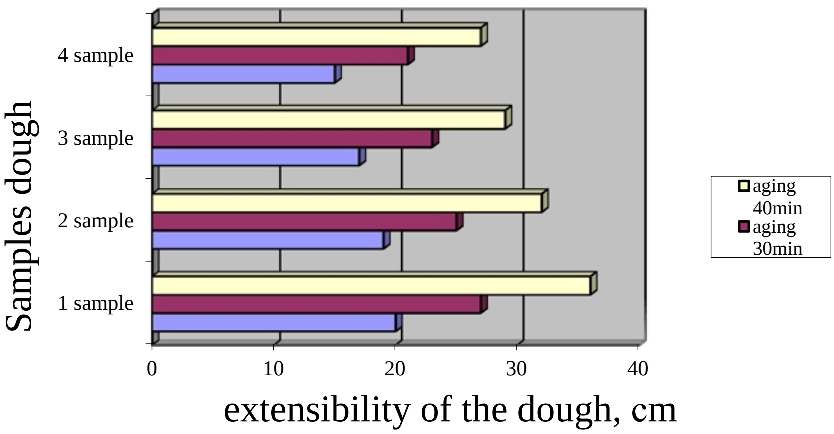


Figure 3. Diagram of the results extensibility of the dough.

Processing of experimental data showed that the tension diagram dough are well described by the equation:

$$\sigma = \frac{F}{A}, \qquad (1)$$

where: σ - normal strain, Pa; F – load at the moment of deformation, N; A – cross sectional area, m^2.

If we denote A_0 initial cross-sectional area of the sample, then

$$A = A_0(1-\gamma\varepsilon)^2 \qquad (2)$$

where: γ - Poisson coefficient; ε - deformation at tensile, m.
Deformation at tensile is equal to

$$\varepsilon = \frac{l_f - l_i}{l_i} \cdot 100 \qquad (3)$$

where: l_i, l_f – initial and final length of sample, m.

Conclusion

Tests uniaxial tensile most fully reflected the plastic characteristics of the dough. In the study of the influence of the quality flour, humidity, duration of aging, mechanical processing revealed that during long time of aging and machining temporary resistance at strength is reduced and relative extension increased, that is, the dough becomes more plastic.

On tensile deformation, we defined the conditions under which dough begins destruction. In order to prevent rupture of dough, operating load must not exceed the following values, respectively: the dough of premium flour humidity of 40% - 550 Pa, and a humidity of 45% - 650 Pa; the dough from the flour of the first grade humidity of 40% - 450 Pa and a humidity of 45% - 600 Pa.

Processes that contribute adsorption and especially osmotic binding of water and swelling of colloids dough, and therefore increase the amount and volume of the solid phase improve the rheological properties of the dough, making it dense in consistency, elasticity, extensibility. One of the most important indicators, responsible for the quality and rheological properties of dough is the sugar content and protein in the dough, which increases during aging.

References:

Kosoi V.D., Vinogradov A.D., Malyshev A.D. Engineering rheology of biotech environments - M., 2005. – 648p.

Schramm G. Bases practical rheology and rheometry – M., 2003. – 312 p.

Hardt N.A., Boom R.M. et al. Wheat dough rheology at low water contents and the influence of xylanases. J. Food Research International. Volume 66. 2014. P.478-484

Simon A.D., Yevtushenko A.M. Rheology of raw materials, semi-finished and half-finished products of bakery and confectionery products. M.– 2004.

Ryszard Myhan, Ireneusz Bialobrewski, Marek Markowski. An approach to modeling the rheological properties of food materials. J. Food Engineering. Volume 111. 2012. P.351-359

Gipsy Tabilo-Munizaga, Gustavo V.Barbosa-Canovas. Rheology for the food industry. J. Food Engineering Volume 67. 2005. P.147-156

A.K.S. Chesterton, B.E. Meza et al. Rheological characterisation of cake batters generated by planetary mixing: Elastic versus viscous effects. J. Food Engineering Volume 105. 2011. P.332-342

Hayat Benkhelifa, Graciela Alvarez, Denis Flick. Development of a scraper-rheometer for food applications: Rheological calibration. J. Food Engineering, Volume 85, Issue 3, April 2008, P. 426-434

Patent RK №13939. Yerkebayev M.J., Kulazhanov T.K., Shambulova G.D. 05.11.03. Almaty.

Maksimov A.S., Black V.J. Rheology foods. Laboratory practice - M., 2006. – 176 p.