Production technology optimization of biscuit baked by electric-contact way

G A Sidorenko, V P Popov, T V Khanina, E Sh Maneeva, M S Krasnova

Federal State Budgetary Educational Institution of Higher Professional Education «Orenburg State University", Orenburg, Pobedy Av., 13, 460018, Russia

E-mail: Sidorenko_GA@mail.ru

Abstract.
Electric-contact way of baking allows one to maintain more nutrients used in biscuit making. As a result of the biscuit production technology optimization, it is established that 30-62,5% is an optimal amount of starch brought instead of flour; 184-200% is optimal amount of egg melange; at this a complex indicator of organoleptic properties will be more than 340 degrees, a complex indicator of physical and chemical properties will be more than 3,3 degrees, and specific costs of energy spent on the biscuit electric-contact baking process will be less than 100 W/kg.

1. Introduction

Nowadays the development of intensive, resource and power saving production technologies of food, especially, biscuit is relevant.

Application of the electric-contact way of baking in biscuit production is high potential.

At the electric-contact power supply, not only baking process is accelerated, but also micronutrients of raw materials are less destructed, the formation of undesirable substances and indigestible compounds in the baked products is prevented [1-7].

In this regard the optimization of the production technology of the biscuit baked by the electric-contact (EC) way is presently topical.

2. Materials and methods

For EC-baking of biscuit, specially developed laboratory installation was used.

Dough for a biscuit semi-finished product was received by continuous beating up of egg melange and granulated sugar (the increase in mass volume from 2,5 to 3 times is observed) and subsequent fast mixing with flour. Ready dough was immediately poured in the installation between two electrodes and then it was baked in the EC way.

The quality of the ready biscuit was estimated by organoleptic (image, taste, flavour) and physical and chemical indicators of quality: weight yield, volume yield, specific volume, acidity. Specific costs of energy on the biscuit electric-contact baking process were controlled.

Calculating a complex indicator of biscuit physical and chemical properties, the authors developed five-grade scale transferring the values of separate indicators to grades of the complex indicator of semi-finished product quality.

The complex indicator of physical and chemical properties was calculated as total score of each separate indicator, multiplied by the corresponding coefficients of significance (table 1).

For the assessment of the biscuit organoleptic properties, the authors chose the group of experts. By results of the expert assessment (carried out by a ranging method), the authors counted a complex indicator of the biscuit organoleptic properties as the sum of the ranks for a separate indicator multiplied by the corresponding coefficients of significance.

Table 1. Ten point scale transfer of individual indicators scores of the comprehensive indicator of physical and chemical properties of biscuit

Comprehensive indicator, grad	Volume output, %	Weight output, %	Specific volume, %	Acidity, grad
5	>650	>125	>546	<6.5
4	501-650	111-123	430-545	6.6-8.9
3	351-500	98-110	315-429	7.8-8.9
2	201-350	85-97	200-314	9,0-10.1
1	<200	<84	<199	>10.2
Significance coefficient	0.42	0.13	0.42	0.03

Specific costs of energy (SE) were defined dividing the energy costs into the mass of a biscuit sample baked by the electric-contact way. Energy costs on electric-contact baking of biscuit samples were defined by integration of the surface area, limited by the power curve, spent for the baking process.

3. Optimization of production technologies of biscuit

For definition of the optimum technological modes of the biscuit production baked by the electric-contact way according to well-known techniques [8], the plan of a two-factor experiment was made and realized. As an influence factor at the biscuit production optimization, the amount of the starch (from 0 to 100%) brought instead of flour and the amount of the added egg melange (from 160 to 240% to amount of starch-flour mix) were used. As output parameters, the complex indicators of organoleptic, physical and chemical properties and specific costs of energy on the biscuit electric-contact baking process were chosen.

By results of the experiment, using the software developed at the Faculty of Applied Biotechnology and Engineering at Orenburg State University [9], the regression equations of the second order are received and the optimization of EC-baking of biscuit is performed.

Regression equations:

for a complex indicator of biscuit organoleptic properties

$$EA = 380,1 + 27,0X_1 + 43,0X_2 - 32,75X_1X_2 - 28,4X_1^2 + 21,9X_2^2;$$

for a complex indicator of biscuit physical and chemical properties

$$CI_{hc} = 3,33 - 0,15X_1 + 0,03X_2 + 0,05X_1X_2 - 0,48X_1^2 + 0,09X_2^2;$$

for specific costs of energy on biscuit electric-contact baking

$$SCE = 92,36 + 1,69X_1 + 5,07X_2 - 6,25X_1X_2 + 35,13X_1^2 + 35,81X_2^2,$$

where: X_1- amount of the starch brought instead of flour, e.u.;

X_2- amount of the added egg melange, e.u.

For the conversion of the equivalent units into natural ones, it is necessary to use the following equations:

$$D_M = 50 \cdot X_1 + 50;$$
$$C_i = 40 \cdot X_2 + 200$$

where Dm – amount of the starch brought instead of flour, a dosage, %;

Ci – amount of the added egg melange, %.

Verification of the received mathematical model was made by means of the pointed software with the use of Fisher's variance ratio. It was established that at the set hit probability of the received single value in a confidential interval is equal to 0,95, the deviation of calculated values from experimental data makes no more than 3 %. It testifies a possibility of the mathematical model application both for results forecasting, and for optimization of the technological process.

The response plane, reflecting the dependence of a complex indicator of organoleptic properties on the amount of the starch brought instead of flour and the amount of the added egg mélange, is presented in Figure 1.
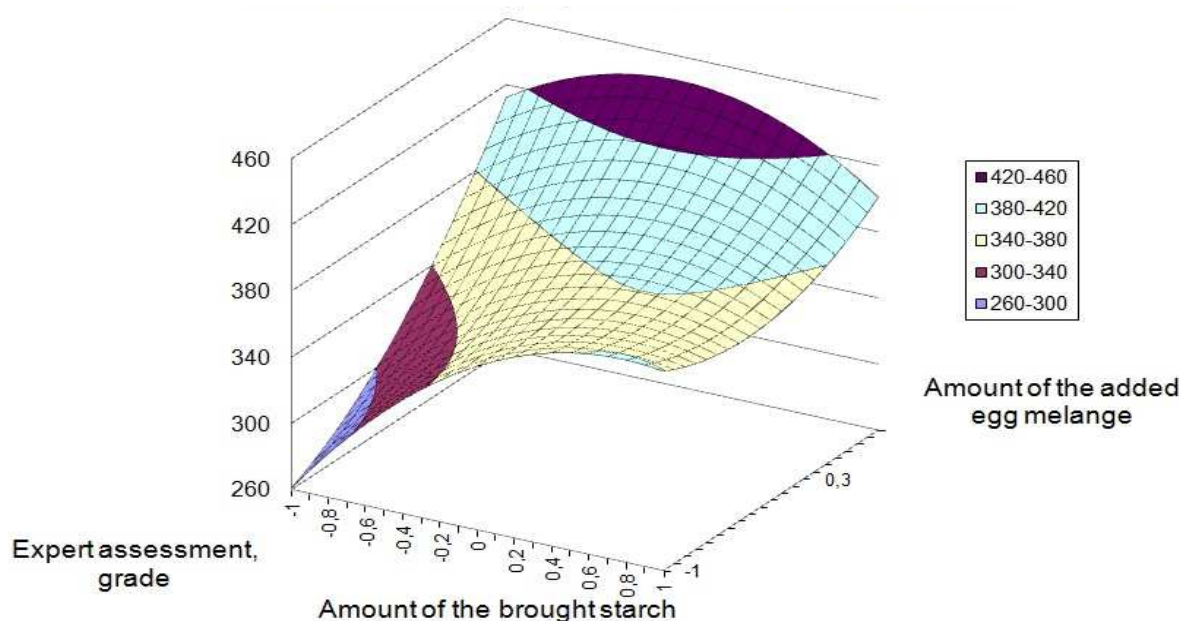

Figure 1. The response plane, reflecting the dependence of a complex indicator of organoleptic properties on the amount of the starch brought instead of flour and the amount of the added egg mélange

The analysis of Figure 1 established that the maximum values of a complex indicator of organoleptic properties (more than 340 grades) are reached at the amount of the starch brought instead of flour from 25 to 100% (from -0.5 to 1 e.u.), and the amount of the added egg melange is in the range from 176 up to 196% (from -0.6 to -0.1).

The response plane, reflecting the dependence of a complex indicator of physical and chemical properties on amount of the starch brought instead of flour and the amount of the added egg mélange, is presented in Figure 2.

The analysis of Figure 2 established that the maximum values of a complex indicator of physical and chemical properties (more than 3.3) are reached at the amount of the starch brought instead of flour from 30 to 60% (from -0.4 to 0.2 e.u.) and the amount of the added egg mélange - in the range from 160 up to 240% (from -1 to 1 e.u.).

The response plane, reflecting the dependence of the specific costs of energy on the electric-contact baking process on the amount of the starch brought instead of flour and the amount of the added egg mélange, is presented in Figure 3.
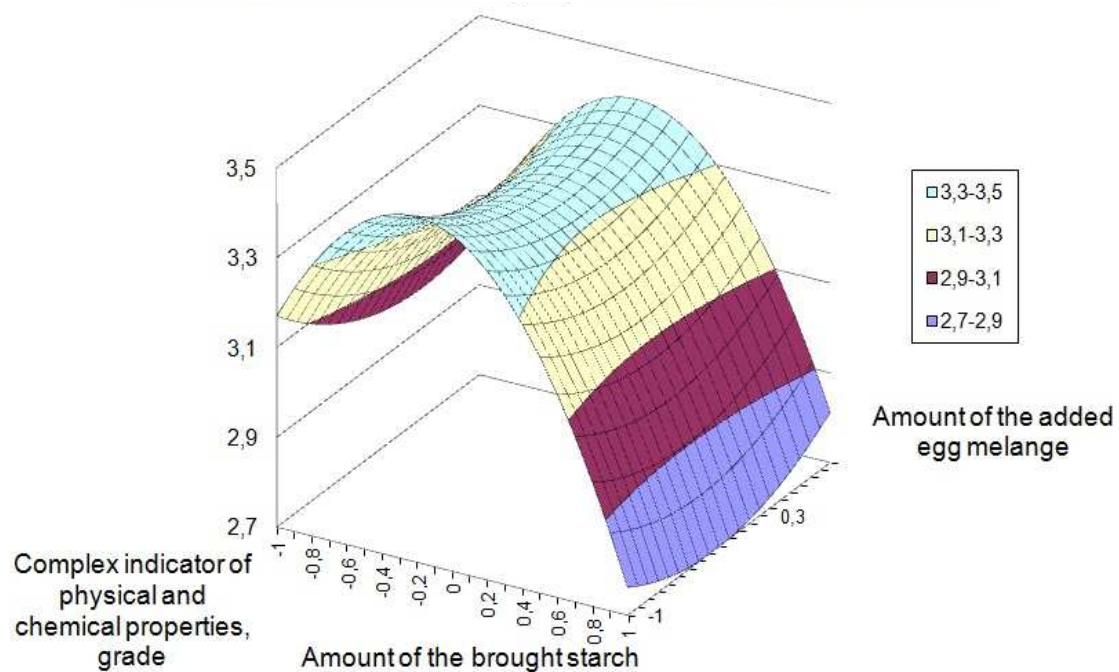
Figure 2. The response plane, reflecting the dependence of a complex indicator of physical and chemical properties on the amount of the starch brought instead of flour and the amount of the added egg melange
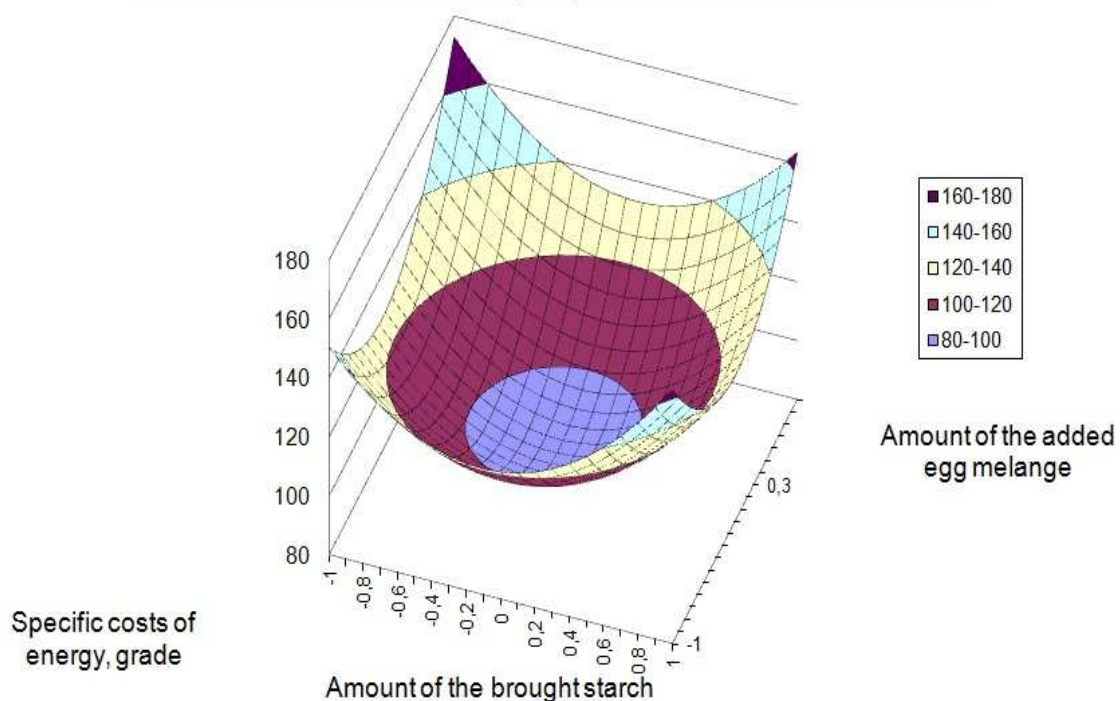

Figure 3. The response plane, reflecting the dependence of specific costs of energy on the electric-contact baking process on the amount of the starch brought instead of flour and the amount of the added egg melange

The analysis of Figure 3 established that the minimum values of specific costs of energy on the electric-contact baking process (less than 100 W/kg) are reached at the amount of the starch brought instead of flour from 30 to 60 % (from -0.4 to 0.4 e.u.), and the amount of the added egg mélange - in the range from 184 up to 208 % (from -0.4 to 0.2 e.u.).

During the research, an installation for baking was designed (figure 4). The installation represents a special form with variable volume, made of non-conductive heat-resistant material. On the inner surfaces 2x of the opposite walls of the mold set stainless steel plates which are electrodes included on the baking time in the network of alternating current with regulation of the applied voltage. The unit has instruments for measuring amperage and the temperature of the dough pieces in the baking process. Baking is considered to be completed when the current drops to zero.

Superposing the horizontal projections of the response planes, reflecting the dependences of the complex indicators of organoleptic, physical and chemical properties, and also specific costs of energy on the electric-contact baking process on the amount of the starch brought instead of flour and the amount of the added egg mélange, the area of the optimum modes of biscuit making, baked by the electric-contact way, was allocated.
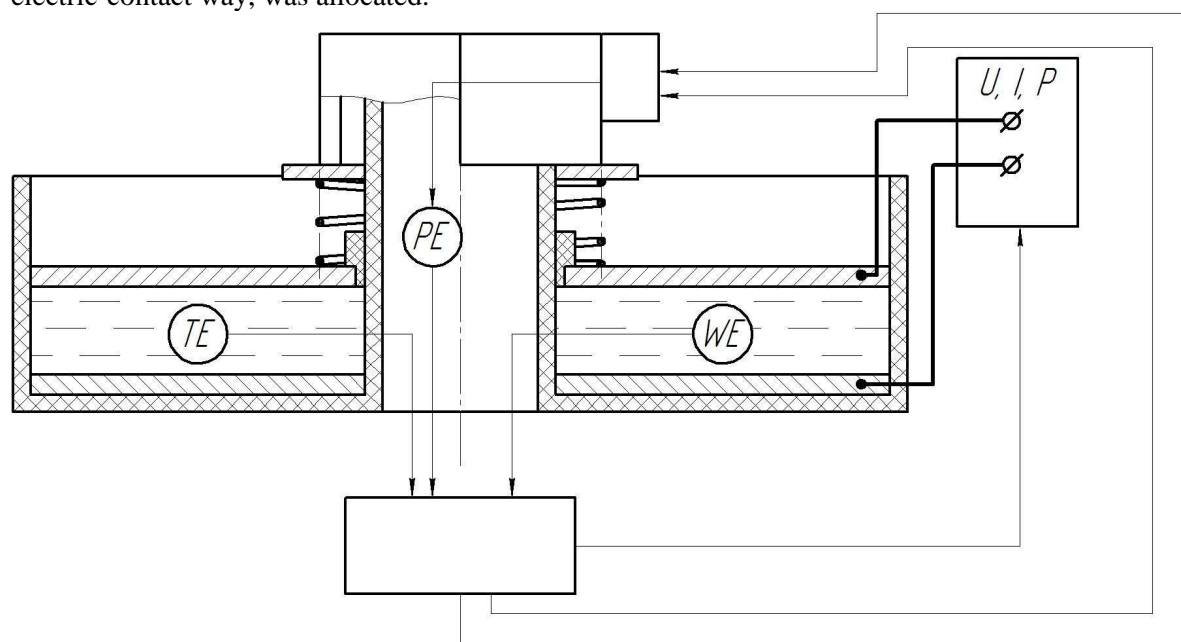

Figure 4. Installation for EK baking

4. Conclusion

As a result of the experiment, it is established that the added egg amount of the starch brought instead of flour equal to 30-62.5% (from -0.4 to 0.25 e.u.) is optimal; and the amount of the added egg melange equal to 184-200% (from -0.4 up to 0 e.u.) is optimal. At the same time, a complex indicator of organoleptic properties will be more than 340, a complex indicator of physical and chemical properties will be more than 3.3, and specific costs of energy on the biscuit electric-contact baking process will be less than 100 W/kg.

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