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Effect of fat content on the mechanical properties of texture of gingerbread pastry

Elżbieta Kusińska, Agnieszka Starek

Department of Food Engineering and Machinery, University of Life Sciences in Lublin, Poland,
e-mail: elzbieta.kusinska@up.lublin.pl

Summary. The paper presents the results of a study on the mechanical properties of gingerbread pastry texture with the use of the dual compression test TPA. The variable parameters in the experiment were the amount of fat added and the time of storage. The experiment was conducted for three consecutive days. Additionally, sensory assessment was performed for the purpose of selection of the optimum amount of fat addition on the basis of the textural properties.

Key words: gingerbread pastry, fat, texture, sensory assessment.

INTRODUCTION

Gingerbread occupies an equivalent position in the classification of confectionery products next to yeast pastry, puff pastry, shortcrust pastry, sponge-cake and others [7]. Gingerbread has a porous structure, is characterised by a spicy taste and flavour, and has brown colouring [4, 3, 18, 9]. It has health-prompting properties due to the spices added in its preparation (ginger, cloves, cinnamon, nutmeg, and allspice) [15, 2, 3]. The large content of spices puts the product in the category of bakery products with extended shelf-life [13].

Another component of gingerbread is fat, which - like carbohydrates - is primarily a source of energy [23]. Fats play also an important role in the process of regeneration and development of an organism [1, 8, 6, 24]. The content of fat in confectionery products has an effect on their properties, among other things it raises their nutritive value, ensures their crunchiness, and first of all it determines their consistency and taste [22]. Fats used in pastry-baking should have excellent sensory features, resistance to oxidation, and their consistency should comply with their intended use [10, 21].

In spite of its numerous taste values, gingerbread has certain shortcomings related with, among others, incorrect amounts of added components [12]. In the confectionery industry, textural parameters play an important role in the overall sensory and instrumental assessment of food. They depend on a number of raw material and production process features [11, 5]. To create new products and to improve those already produced, it is necessary to acquire knowledge on changes in the theological properties of semi-finished products and to relate those with the results of the sensory assessment [19, 20, 17]. Also, the analysis is necessary of correlation between the measured physical properties of the product and their sensory equivalents in each product under study [14].

OBJECTIVE AND SCOPE OF RESEARCH

The objective of the study was to determine and select the optimum values of the mechanical properties of the texture of gingerbread pastry during storage and in relation to the amount of fat added.

The scope of the study comprised the development of the recipe and the baking of pastries, instrumental measurement of the mechanical properties of their texture and sensory assessment of the products.

METHODS

The experimental material was four kinds of gingerbread with varied fat content (100g, 150g, 200g and 250g). Each of the gingerbreads studied was prepared using the following components: 5 eggs, 150g of sugar, 500g of wheat flour, 350g of liquid honey, 250g of 12% sour cream, margarine Kasia (in amounts varying for the various gingerbread kinds), 5g of soda, 30g of gingerbread spice mix. The prepared dough was placed in baking pans with dimensions of 10×38 cm and baked at temperature of 160°C for 60 min. When the pastries cooled down, they were covered with aluminium foil and kept in a refrigerator at temperature of 6°C.

The experimental material prepared as above was subjected to instrumental testing with the use of the texturemeter TA.XT.plus, linked with a computer. The dual compression test TPA (Texture Profile Analysis) was performed, using 10 samples of crumb from each of the kings of gingerbread in the form of cubes with 2 cm side. The samples were compressed at tester head travel velocity of 50 mm·min^{-1} to 50% of their height. The basic texture parameters were read directly and calculated from the measurement curve:

- hardness, i.e. the maximum force during the first cycle of compression,
- elasticity, that characterises the degree of recovery of the initial form; it is the quotient of sample deformations during the first and second compression (E=L2/L1),
- cohesiveness characterising the forces of internal bonds that hold the product in one piece; it is the quotient of the areas beneath the graphs of forces of the first and second compression of the sample (Coh=W2/W1),
- chewability which is a measure of force required to chew a bite of food to make it ready for swallowing; it is defined as the product of hardness, cohesiveness and elasticity.

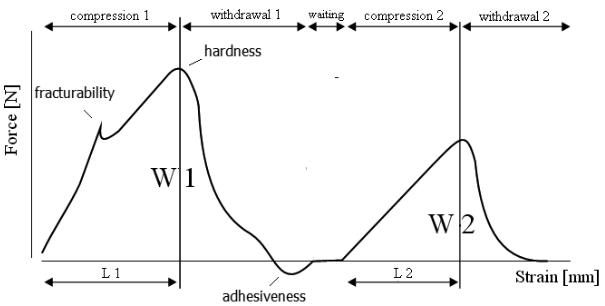

Fig. 1. Example of a graph obtained in the double compression test (TPA)

To observe changes taking place in the pastries during storage, the tests were conducted over three consecutive days.

Determination of the moisture content of the products and the sensory assessment were conducted in accordance with the Polish Standard PN-A-74252-1998. [16] The jury evaluated the uniformity of the batch, the external appearance, structure and texture, and the taste and flavour. They also estimated the quality of the gingerbreads.

RESULTS

The results of the study are presented in Figs. 2-5. Extension of the time of storage caused an increase of the hardness of the pastries. The highest hardness was achieved by the pastries after three days of storage (Fig. 2). Hardness decreased with increase in the amount of margarine added to the dough. The lowest effect on hardness during storage was noted when the margarine was added in the amount of 200g. The hardness of the pastry after 3 days of storage was higher by 0.51 N compared with the pastry after one day of storage.

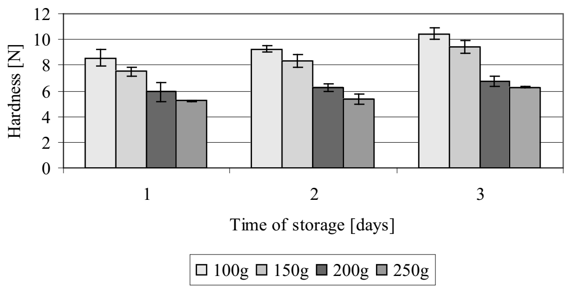

Fig. 2. Effect of fat addition on hardness of gingerbread in relation to time of storage

The effect of fat addition *m* [g] and time of storage *t* [days] on the hardness *H* [N] of gingerbread pastry was described by means of the equation:

$$H = 10.773 - 0.0271m + 0.707t, \quad (1)$$

R^2=0.94, α≤0.05.

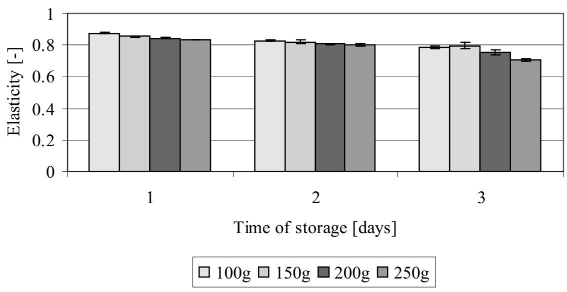

Fig. 3. Effect of fat addition on elasticity of gingerbread in relation to time of storage

The highest value of elasticity (Fig. 3) was noted on the first day for gingerbread with fat content of 100g, at 0.875, and the lowest on the third day for gingerbread with fat content of 250g – 0.707. Increase in the fat addition caused insignificant decreases in gingerbread elasticity during the first and second days of storage. Whereas on the third day a significant decrease of elasticity was observed between gingerbreads with fat content of 150g and 200g and those with 200g and 250g.

The changes in elasticity *E* [-] are described by the equation:

$$E = 0.958 - 0.000343m - 0.0448t, \quad (2)$$

R^2=0.884, α≤0.05.

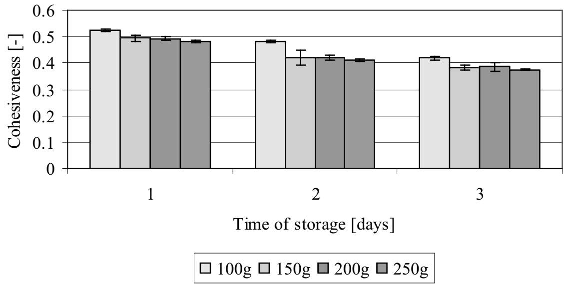

Fig. 4. Effect of fat addition of cohesiveness of gingerbread with relation to time of storage

For all the tested kinds of gingerbread, the cohesiveness decreased with the passage of time (Fig. 4). The highest value of that trait was noted after one day of storage for gingerbread with fat content of 100g (0.524), and the lowest for that in which the fat content was 250g, after three days of storage (0.374). For gingerbreads tested on the first day there were no significant differences in the values of cohesiveness. On successive days there appeared a significant decrease of cohesiveness between gingerbreads with margarine content of 100g and 150g. The decrease was at the level of ca. 12-13%.

The relations presented in Fig. 4 are described by the equation:

$$COH = 0.6047 - 0.00032m - 0.05405t, \quad (3)$$

R^2=0.914, $\alpha \leq 0.05$.

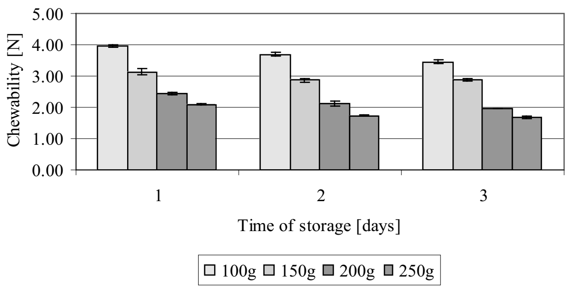

Fig. 5. Effect of fat addition on chewability of gingerbread in relation to time of storage

For each tested kind of gingerbread the value of chewability decreased with the passage of time of storage. As it can be seen in Fig. 4, on the first day of storage the value of that trait decreased by as much as 47% with increasing fat content. The value of chewability was the highest on the first day for the gingerbread with fat content of 100g, at 3.96 N, and the lowest for the gingerbread with fat content of 250g, on the third day since baking, at 1.68 N.

The changes in chewability *CH* [N] are described by the equation:

$$CH = 5.325 - 0.128m - 0.21t, \quad (4)$$

R^2=0.961, $\alpha \leq 0.05$.

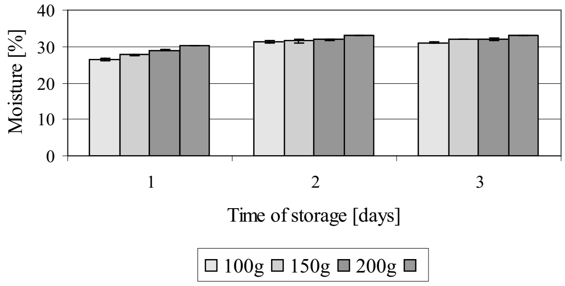

Fig. 6. Effect of fat addition on moisture of gingerbread in relation to time of storage

The lowest moisture (Fig. 6) was recorded for the crumb of gingerbread with 100g addition, on the first day of the study (26.43%), and the highest for that with fat content of 250 g, after two days of storage (33.13%). On the second and third days of storage the moisture changes did not differ statistically significantly.

The effect of fat addition *m* [g] and time of storage *t* [days] on the moisture content *M* [%] of gingerbread is described by the equation:

$$M = 11.57 + 14.541t + 0.0237m - 3.035t^2, \quad (5)$$

R^2=0.857, $\alpha \leq 0.05$.

The results of sensory assessment (Tab. 1) of the gingerbread pastries indicate that the gingerbread with fat content of 200g was classified in the first level of quality of confectionery products. The jury members declared that that batch of products was of good uniformity and homogeneity and no greater differences were noted among the individual items. The external appearance was characteristic for gingerbread pastry. The particular kinds of gingerbread differed slightly in crumb colour (the darkest was that with the lowest fat content). All of them had highly desirable taste, typical of that type of pastries, aromatic with well balanced intensity, ensuring consumption value. Gingerbread with traits desired by the consumer, one day after baking, should be characterised by the following mechanical properties of texture: hardness of 5.107–6.931N, elasticity of 0.837-0.847, cohesiveness of 0.482-0.503, chewability of 2.383-2.491N, and moisture of 28.113-29.152%. Studying the properties of texture one can largely eliminate the costly sensory evaluation, determined by personal references and sensitivity of sensory assessment, in favour of objective instrumental analysis, permitting rapid acquisition of a large number of repeatable results.

Table 1. Effect of fat content on sensory features of gingerbrea

Fat content	Quality factors pastry				Total points	Level of quality
	Batch uniformity	Appearance	Structure and texture	Taste and flavour		
100g	4	4	3	4	15	II
150g	4	5	4	4	17	II
200g	5	5	5	5	20	I
250g	4	4	4	3	15	II

CONCLUSIONS

1. The properties of the texture of gingerbread pastry are significantly affected by the amount of fat added and by the time of storage.
2. Extension of the time of storage caused a significant increase of gingerbread crumb hardness and moisture, and a decrease of elasticity, cohesiveness and chewability.
3. Hardness, elasticity and cohesiveness decreased with increasing level of margarine addition, while moisture increased.
4. The highest consumer rating was awarded to the gingerbread with fat content of 200g. It was qualified to the first level of quality of confectionery products.

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WPŁYW ZAWARTOŚCI TŁUSZCZU NA WŁAŚCIWOŚCI MECHANICZNE TEKSTURY CIASTA PIERNIKOWEGO

Streszczenie. W pracy przedstawiono wyniki badań pomiaru mechanicznych właściwości tekstury ciasta piernikowego z użyciem testu podwójnego ściskania TPA. Parametrami zmiennymi w doświadczeniu były: ilość dodanego tłuszczu oraz czas przechowywania. Badania prowadzono przez trzy kolejne dni. Dodatkowo wykonano ocenę sensoryczną, która pozwoliła na dobór optymalnej ilości tłuszczu na podstawie właściwości teksturalnych.

Słowa kluczowe: ciasto piernikowe, tłuszcz, tekstura, ocena sensoryczna.