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Effect of non-ideal storage conditions on candy gum quality

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Abstract

Candy gums are very popular confectionery products with a semisolid complex gel texture. The quality of the product is determined mainly by the textural and rheological characterizes. The texture can be influenced in wide range by the storage conditions, namely time, temperature and humidity of air. Cool, and dry place for store is suggested by the producer, like 'ideal storage conditions', but exact temperature and air-humidity values are not given or mentioned. Although in practice in the commerce and by the consumers the non-ideal storage (at room temperature, on shelf) is more frequent, than the ideal one.
So the aim of our work was to determine the rheological parameters of candy gum during the non-ideal storage. Samples for long-time storage were purchased from local market. The samples were from the same producer's same type product, from the same production unit. Modeling the non-ideal storage the unopened packages were stored for 12 month in four thermo boxes of 10 liter volume at controlled temperature: 15℃, 20℃, 25℃, and 30℃ respectively, and the air humidity was not controlled. The temperature, the air humidity and the dew point was registered with a data logger.
Texture Profile Analysis (TPA) curves and Creep-Recovery Test (CRT) curves were recorded monthly by a SMS TA.XT-2 precision texture analyzer, 30-30 samples from each storage temperature group. By the TPA curves 0.5 relative deformation with 0.2 mm/s deformation speed was set. By the CRT curves 0.2 mm/s deformation speed, 5 N loading force and 60 s creeping- and recovering time was set. The measured curves were recorded with an aluminum cylinder probe of 75 mm diameter to avoid the measuring errors caused by the rugged surface of the sample. Several parameters were evaluated from the curves, for example firmness, ratio of force to deformation, degree of elasticity, ratio of elastic deformation to total one, ratio of decompression work to compression one, etc.
During the storage the candy gum became harder and its elastic behavior decreased in a high range. The decrease of degree of elasticity and the ratio of elastic deformation to total one can be observed. The tendency of the changes is obvious, but the analysis of variances did not give significant differences in short time period (1-2 month), just in long time period (5-6 month). These changes were caused by mainly the storage temperature and secondly by the storage time. The explanation of the observed phenomenon is probably the decrease of the hydration of the dissolved gelatin, which give softness to the hard sugar based texture. The exact description of the macromolecular processes needs further researches.

Keywords: candy, texture, long time storage, rheology

1 Introduction

The candy gums are one of popular confectionery products. Generally, the candy gum is flavored and colored and formed by moulding. It is soft and elastic, made of sugar, glucose syrup, invert sugar syrup, gelatin and different additives (gum Arabic, fruit origin aroma and odor additives, etc.). Similarly to other confectionery products they are shelf-stable for approximately 12-15 months.

The quality of the candy depends on mostly the quality of applied gelatin. The origin, the quality and the quantity of applied gelatin determines the main quality and sensory properties of candy (Mohos, 2010). Örsi et al. (2000) investigated the uncomfortable changes of texture of candy gums with a half-automatic LABOR MIM penetrometer under different storage conditions. The authors determined that the increase of the moisture content caused a decrease in the gel hardness and in the intensity of the bitter flavor. DeMars et al (2001) used a texture analyzer to measure the texture of gelatin/pectin-based confectionary gums. This method was successful to measure the tension stress and tension strain of different gel textures. The measured stress and strain values showed good correlation with sensory firmness and elasticity. Segtnan and Isaksson (2002) tested the spectral changes in gelatin gels under decreasing temperature with near infrared spectroscopy in the 2160-2210 nm range. The results showed that with decreasing temperature both the Bloom strength and the maturation time increased. The storage conditions, especially the temperature, have a great influence on the quality properties of candy gum (Csima et al., 2010). Describing quality properties during storage between different conditions has primary importance from aspect of producer. If the storage conditions are not appropriate, the quality of candy gums will change in a wide range.

The textural properties (hardness, chewability, elasticity, etc.) of candy-like confectionery product can be used in organoleptic sensory characterizing too. The texture is "a multi-parameter attribute, not just tenderness or chewiness, but a gamut of characteristics … It is detected by several senses, but the most important ones being the senses of touch and pressure" (Szczesniak, 2002). The description of the changes in textural properties is easy with rheological methods and models. Lambert-Meretei et al (2010) elaborated a rheological method for characterizing the effect of bread improver dosage on bread crumb texture. They used Creep-Recovery Test (CRT) and its result parameter to describe the rheological characteristics of bread crumb. Kaszab and co-workers (2008, 2011) investigated with different measuring methods (cutting tests and CRT tests) the changes in carrot xylem and phloem texture caused by non-ideal storage conditions. They found that, after 3-4 week non-ideal storage the carrot became more gummy, lost its hardness and the sensory quality decreased. Similarly to the candy gum, other confectionery products also can have complex structure, which could change under storage (e.g. chocolate, marsh mallows, etc.). The effects of storage parameters (temperature, time, and humidity) on chocolate were investigated by Biczó et al (2013). They proved the strong influence of temperature on texture properties of chocolate (hardening, change in fracturability).

The used measuring methods in our research were different type compression tests. From the several available test methods (Sitkei, 1986) many would be appropriate for one purpose, but there were no one which is generally appropriate for every purpose. According to the present scientific literature the rotation and oscillation viscometry is generally used to describe rheological properties, but mentioned measuring methods are not able to give information about texture, structure and product behavior in mouth. On one hand the candy gum like samples are heavy to measure with rotation or oscillation viscometry, because the candy is not so liquid, it is too hard and has a too high value of elasticity and viscosity. On the other hand the compression tests modeling the consume process, the chewing. The consumer's primary impressions about the product are based on mouth feel, which is function of textural and rheological properties. So in our experiments two compression test method, Texture profile Analysis (TPA) and Creep –Recovery Test (CRT) was featured with a TA.XT-2 texture analyzer.

The aim of the work reported here was to observe and give a description of the changes in candy texture during various non-ideal storage conditions via rheological test. The texture is very important from quality point of view, so further goal was to estimate the effect of temperature and humidity (as storage conditions) separately on candy gum quality. It was also purpose to estimate the shelf-stable time of candy based on TPA and CRT tests.

2 Materials and methods

2.1 Materials

The candies which were used for the experiments purchased from the local market. The samples were packed in semi permeable plastic package in an amount of a100 g per package (that mean about 40 candies pro package). The samples were from the same type, they were produced by the same producer in the same time. The unopened packages were stored in temperature controlled thermo boxes, which were modified freezer bags with volume of 10 liters. The samples were stored on different storage temperatures (15°C, 20°C, 25°C and 30°C) for 12 month. The temperature and air humidity data was gathered by a data logger in every minutes. The data logger was placed between the stored packages.

The 15°C and 20°C storage temperature in the thermo boxes was controlled with a thermostat, which switched on and off the built-in cooling system (a Peltier-cell with ventilator) via a relay. In case of 25°C the direct current power supply of the Peltier-cell was switched by the relay with appropriate polarity according to the temperature control. In case of 30°C the power supply of the Peltier-cell were switched with reverse polarity constantly. The dead band of the temperature control was 0.3°C, the controlled temperature alternated with 0.5°C amplitude and about period time of 10 minutes.

To avoid the high humidity values, a wire gauze holder filled with drop-size silica gel balls was placed in the thermo boxes above the samples. The ventilator pushed the air through the silica gel layer. The silica gel was regularly changed and reused after a drying out and cooling down. With this method the fluctuation of air humidity was inside a range about 5%. The air humidity values were depended on the room temperature of the building, but they were quasi constant during the storage period.

For the experiments in every month two packages was taken out and opened from every storage temperature. One package (with about 40 candies) was used for the Texture Profile Analysis (TPA) and one package for the Creep Recovery Test (CRT) experiments. The opened packages were stored during the measurements in a thermos to preserve the storage temperature of the samples.

2.2 Methods

2.2.1 TA.XT-2 precision penetrometer

The experiments were featured on a Stable Micro Systems® produced TA.XT-2 precision penetrometer. For the experiments a metal cylinder probe with smooth surface was used with diameter of 75 mm in mode 'measure force in compression'. The deformation speed was 0.2 mm/s in both of applied tests. The data acquisition rate was 25 PPS (measured point pro seconds), the trigger force was 0.05 N. The precision of the measured data was 0.001 mm, 0.001 N and 0.001 s respectively.
In the Texture Profile Analysis (TPA) the definite deformation was 5 mm (about 0.5 relative deformation) to simulate the mastication process.
In the Creep-Recovery Test (CRT) the definite loading force was 5.0 N, the creeping and recovering time was the same, 60 s.

2.2.2 Texture Profile Analysis (TPA)

It is a well-known, quasi as standard used rheological test method (Bourne, 2002) for describing the textural properties of investigated sample. In case of foods it simulates the chewing process with two compression-decompression cycle with constant deformation speed, like two bites after each other. This method offer several mechanical (e.g. firmness, ratio of force to deformation at force peaks) and rheological parameter (cohesion, elasticity, chewability, etc.). The typical measuring curves of TPA test are shown in the Figure 1.

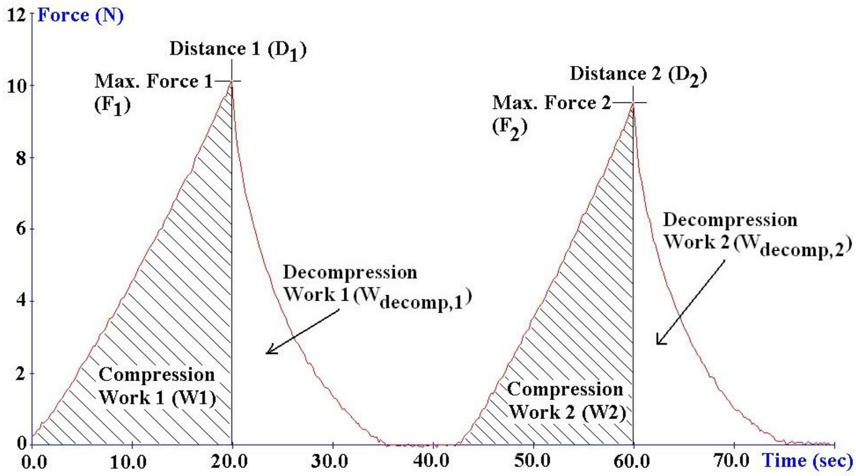

Figure 1: Typical deformation-time curve of TPA test featured on candy gum

2.2.3 Creep-Recovery Test (CRT)

The CRT test is also a well-known compression test method (Rao et al, 2005). This test is a combination of creeping test and a relaxation test. It contains three steps. In the first step the sample is loaded with a definite deformation speed (it was 0.2 mm/s) until reach a definite force value (it was 5.0 N). Than starts the second step, the creeping, when the sample is loaded with the constant definite force for definite time (60 seconds). In the third step the loading force is decreased to zero and the recovery of the sample deformation is measured for the same time than the creeping was hold (60 seconds in our tests). Unfortunately, the loading and the unloading is not instantly, which occurred theoretically and practice measuring problems. The typical CRT measuring curve of candy gums are shown in Figure 2 and 3.

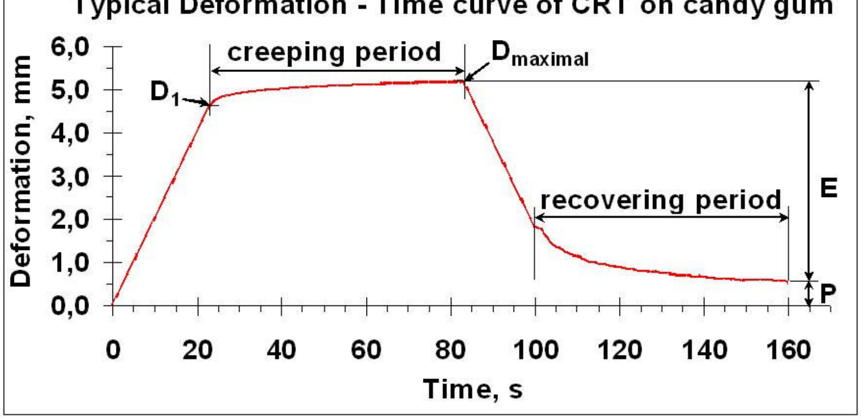

Figure 2: Typical deformation-time curve of CRT featured on candy gum

The Creep Recovery Test (CRT) can give a good describe about elastic properties of candies. Dolz et al (2008) characterized the rheological behavior of food emulsions like gels with creep test and give a good model description for these materials. Vozáry et al (2011) investigated the rheological behavior of candy material by different stress strain and deformation speed values, simulating biting. They found, that at higher stress strain and by higher deformation speed the range of elastic parameter of candy gum changes significantly because of cracking of gel structure (Foegeding, 2007).

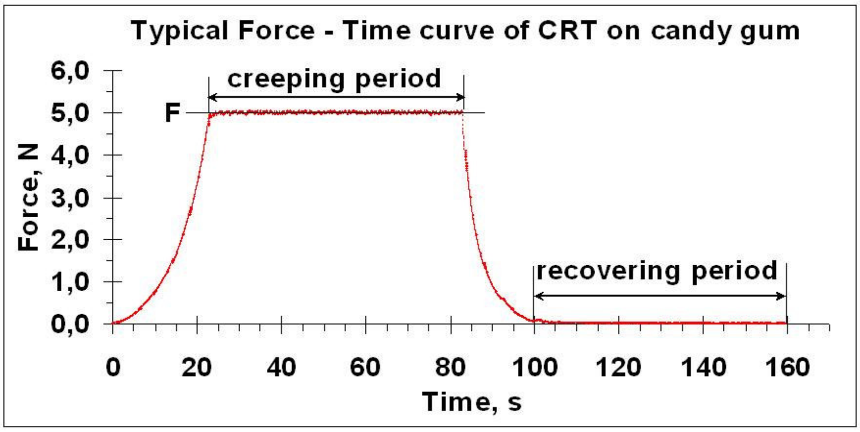

Figure 3: Typical force-time curve of CRT featured on candy gum

3 Results and Discussions

The results of the featured test are shown on Figure 4-7. From the TPA test the hardness (the first force peak value), the ratio of the two force peak values and the degree of elasticity (ratio of work under decompression and compression curve in the first cycle) values are figured in function of storage time. On each figure, all the results of four storage temperatures are shown, one point represent the average of 30 experiments.

The Figure 4 shows, that on all storage temperature the candy became more hardener, at the more higher temperature the range of hardening is the more stronger. This fact accorded to the producers suggest: store the samples at low temperature. After 6 month storage the hardening of candy is obvious.

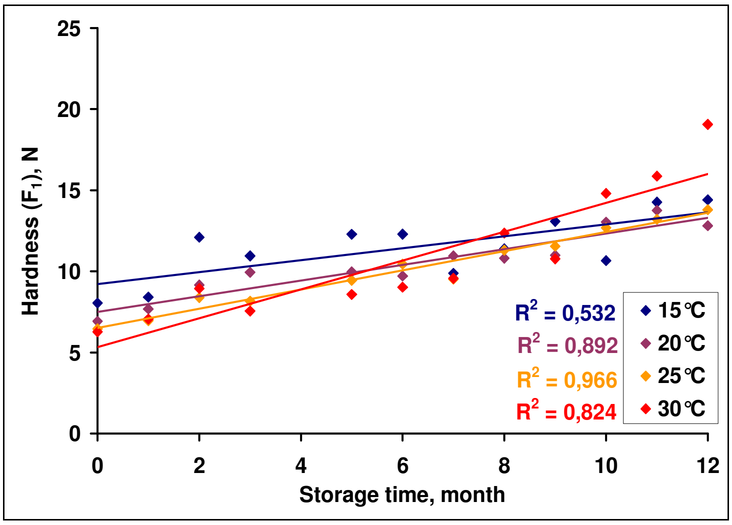

Figure 4: Change hardness (F_1) during 12 month long storage in case of candy gum

Because of the relatively high relative deformation (~0.5) the structure of candy damaged, the chains and the polymer mash can be crashed. Because of this in the second compression-decompression cycle the measured force peak value was smaller, than in the first one.

This change results a kind of elasticity. On higher temperature the candy was softer, than on lower temperature, and it was independent from the storage time (Figure 5).

The storage temperature had significant effect on the degree of elasticity: While on low temperature the value is constant, on the higher temperatures the degree of elasticity decreased in higher range. The change of elasticity during storage is shown on Figure 5 and 6.

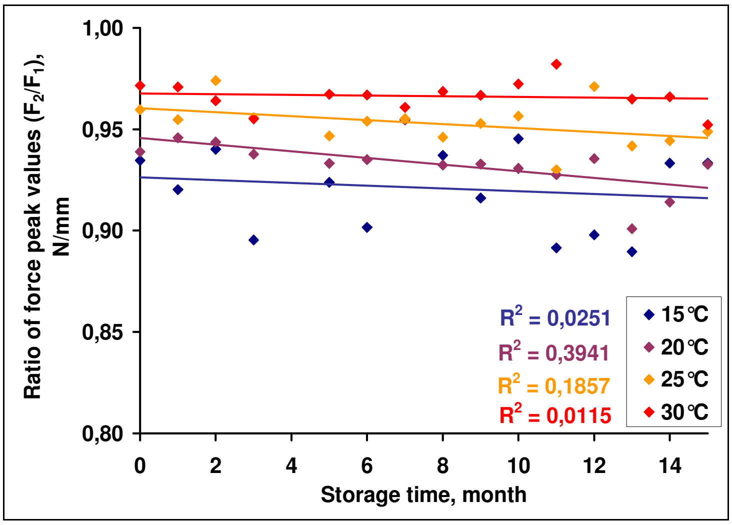

Figure 5: Change of ratio of force peak values (F_2/F_1) during 12 month long storage in case of candy gum

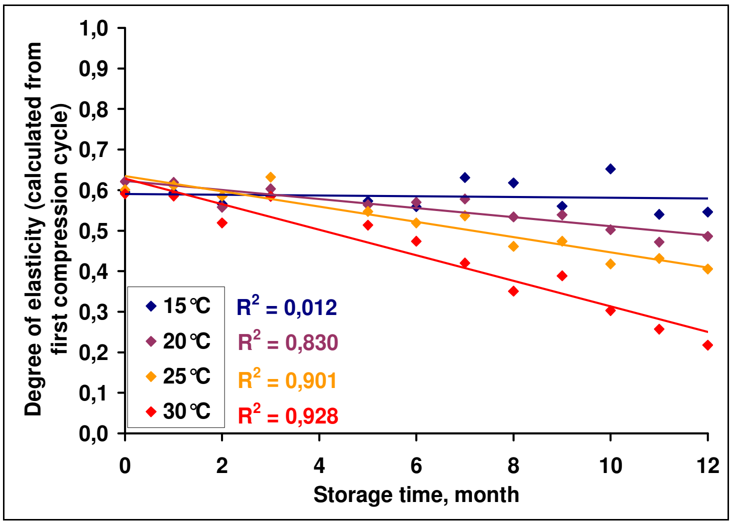

Figure 6: Change of degree of elasticity during 12 month long storage in case of candy gum

From the CRT test the ratio of elastic deformation to total one (E/D_{max}) and the ratio of plastic deformation to total one (P/D_{max}) was calculated. Between the two parameters there is a mathematic connection: $E+ P = D_{max}$. Because of this connection, only the change of E/D_{max} ratio was figured in the function of the storage time (Figure 7). On Figure 7 all the results of four storage temperatures are shown, one point represent the average of 30 experiments.

The effect of storage temperature on the ratio E/D_{max} and P/D_{max} was significant on higher temperature. Because of drying the structure damaged, so the candy lost its elasticity, became harder and plastic. On the higher temperatures this process is faster, on lower temperatures there was no significant changes.

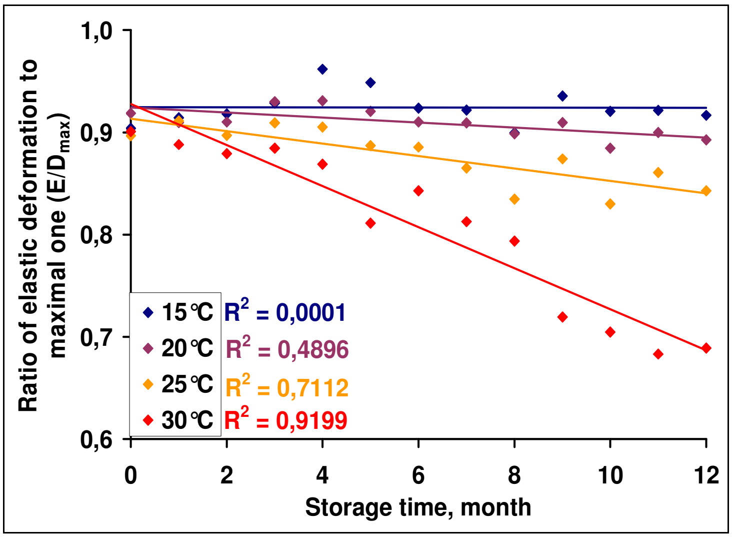

Figure 7: Change of ratio of elastic deformation to maximal one (E/D_{max}) during 12 month long storage in case of candy gum

The observed changes in rheological properties of candy gum are very similar to the results of Csima et al (2010). We investigated the effect of temperature on candy gum quality under short time storage. The changes in texture results changes in organoleptic properties, which was proved by Csima et al (2011). The sensory panelist prove the quality change after 6 month long storage.

4 Conclusions

Both the TPA and the CRT test proved that the candy gum lost its elasticity and became harder during the storage and the temperature has a big influence on this process of hardening The candy lost its water content, and this drying occurred structural and textural changes. The structure (polymer mesh from polysaccharides and gelatin) contracted, the inner bonds damaged because of compression loading. According to hardening the degree of elasticity also decreased.

The results proved that the storage temperature has the primary and the storage time has only a secondary effect on textural and rheological properties of candy gum. As it was shown on the figures, on cooler temperatures the rheological properties were quasi constant, only the hardening was obvious. On higher temperatures the rheological properties changed in a wide range, after 6 month long storage the changes were significant. The product is shelf-stable, but after one year the quality changed in very high range.

5 Acknowledgements

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