EFFECT OF STORAGE REGIME ON TEXTURE AND OTHER SENSORY PROPERTIES OF CHOCOLATE

ARTSIOM RUBAN, LUDEK HRIVNA, LENKA MACHALKOVA, SARKA NEDOMOVA, VIERA SOTTNIKOVA
Department of Food Technology
Mendel University in Brno
Zemedelska 1, 613 00 Brno
CZECH REPUBLIC
artsiom.ruban@mendelu.cz

Abstract: As part of the experiment, we have studied the effect of different storage conditions chocolate in a normal household. Freshly produced chocolate was stored in five temperature regimes, namely frozen -18 °C, 6 °C, 12 °C, 20 °C, and 30 °C. After one month of storage, the samples were removed from individual regimes and immediately subjected to sensory analysis supplemented by the evaluation of textural properties on the TIRA test device. The significantly lowest values (p > 0.95) of hardness were determined for samples stored at 30 °C (2.5–5.5 N). The greatest hardness of the chocolate had frozen samples (52.2–75.9 N). When stored at temperatures 6 °C or 12 °C, the products did not significantly differ in terms of hardness. At the room temperature of 20 °C, conclusive softening already took place (19.3–29.6 N). Higher storage temperature (30 °C) significantly (p > 0.95) reduced the colour evaluation, while glossiness was the significantly better (p > 0.95) than samples at 30 °C, 6 °C and frozen, but did not differ compared to 12 °C. Higher temperatures (30 °C) deteriorated breakage and aroma. Temperature of 30 °C significantly (p > 0.95) decreased the hardness at the time of consumption and increased the stickiness of chocolate.

Key Words: chocolate, storage, changes in texture, sensory properties

INTRODUCTION
Quality chocolate has a completely homogeneous structure, fine melting flavour, hard consistency, shell-like fracture, and shiny surface. Quality of chocolate products is affected by the entire manufacturing process, recipe, raw materials used, and storage conditions. All these aspects act on the rheological, physical, and sensory properties, and thus determine the final quality of the products (Afoakwa 2010).

In chocolate processing, for obtaining high quality products an important role is played by the composition of matter and especially the crystallization of cocoa butter. For chocolate production, the desired crystalline form is the V (β) which dominates in a well-tempered chocolate (Quast et al. 2013, Fernandes et al. 2013). The crystallization conditions determine not only the crystal form of cocoa butter and arrangement of the crystalline lattice, but are the main factors that determine the rheological and textural properties of chocolate (Afoakwa et al. 2008).

Quality ingredients and properly implemented tempering do indeed significantly affect the sensory and textural properties of chocolate. However, also crucial are the conditions in which we store it, particularly the temperature regime, and also the conditions during consumption.

One of the important sensory characteristics is the hardness of chocolate. This is influenced not only by the recipe composition and tempering technology (Afoakwa 2010), but also by the temperature conditions during storage. And these conditions can significantly influence the overall perception during its consumption. Unsuitability of storage temperature, especially high temperature is reflected in soft texture and the appearance of fat blooms (Debaste et al. 2008, Afoakwa et al. 2007).

High temperatures during storage of chocolate products promote migration of fat through the matrix of chocolate particles and consequently lead to its recrystallization on the surface. Dull surface appearance due to blooming occurs due to diffusion of light by agglomerates of fat crystals that protrude from the surface of chocolate (Aguilera et al. 2004, Lohman and Hartel 1994). Other defects associated...
with fat migration include softening of chocolate layers, hardening of fillings in filled chocolates and desserts, as well as an overall sensory deterioration of products (Svanberg et al. 2011).

In our experiment, we have focused on monitoring the impact of temperature of storage and temperature during consumption of chocolate on texture and other sensory properties.

MATERIALS AND METHODS

Materials

We have analysed the chocolate product Boci - milk chocolate (cocoa solids 35%) with pieces of biscuit (10%) and apricots (3.5%).

Samples were stored for one month in five temperature regimes, namely frozen (-18 °C), 6 °C, 12 °C, 20 °C, and 30 °C. Storage temperatures were selected so as to mimic normal procedures of storing in homes. Here the consumer has the option to keep the chocolate in a freezer, in a refrigerator at t = 6 °C to 12 °C, at room temperature of 20 °C, or nonstandard elevated temperature such as in overheated room, or contact with a source heat, such as sunlight. For the experiment, we have used refrigerators with freezers with temperature control, air-conditioned warehouses, and a thermostat. At the beginning of the experiment after 30 days storage, we have carried out physical analysis of the product texture by a texturometer, and a sensory analysis.

Texture analysis

For texture measurements, we have used universal instrument intended for measurement of physical characteristics, namely the TIRA test (type 27025) from Germany. To test chocolate products we have used a penetration test with a probe in the shape of a knife. The selected criteria for penetration tests of chocolate products via a pressure test included the length of knife blade 10 mm, v₁ = 40 mm/min (test speed).

Sensory analysis

Immediately after the removal from the respective storage regime, we have carried out sensory analysis using experienced sensory evaluators (n = 10). The parameters evaluated in chocolate included colour, odour, glossiness, fat bloom on the top and bottom sides of the product, fracture, hardness on bite, consistency, homogeneity, adhesion - stickiness in mouth, melting in mouth, flavour, and finally the overall impression. For graphic representation of results, we have used unstructured scales, 100 mm long, where 1 mm scale corresponded to 1 point.

Statistical data processing

The collected data were processed using MS EXCEL. Statistical analysis of data obtained was performed via statistical program STATISTICA Version 12–ANOVA, namely analysis of variance with interactions, tested at a significance level of P = 0.05.

RESULTS AND DISCUSSION

Texture analysis

Textural characteristics of the stored products are evaluated as a force in Newtons that must be applied to get the penetration body through the chocolate sample. The measured quantity then characterizes the strength or hardness of the product. The results in Figure 1 clearly show the influence of the temperature regime used in storage on the hardness of analysed chocolate samples. Significantly lowest values (p = 0.95) of hardness were determined for samples stored at 30 °C. The frozen samples had the greatest hardness. When stored at temperatures of 6 °C to 12 °C, the samples were not significantly different. The room temperature of 20 °C has already caused a significant softening. Except for the highest storage temperature, at all other storage temperature regimes, the storage time positively and significantly affected their hardness. We can evaluate the long-term storage of chocolate at temperatures above 20 °C as critical. Similar experiences were presented by Ali et al. (2001).
Figure 1 Effect of temperature on the hardness of stored products

Vertical columns indicate the confidence interval 0.95

<table>
<thead>
<tr>
<th>Storage scheme</th>
<th>Hardness (N)</th>
<th>Consistency of fracture</th>
<th>Stickiness on palate</th>
<th>Melting in mouth</th>
<th>Taste</th>
<th>Overall impression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frozen</td>
<td>60.0±2.5</td>
<td>6.2±a</td>
<td>6.2±a</td>
<td>7.1±2.5</td>
<td>6.3±a</td>
<td>6.1±a</td>
</tr>
<tr>
<td>6 °C</td>
<td>58.6±2.5</td>
<td>6.7±a</td>
<td>6.7±a</td>
<td>7.2±2.5</td>
<td>6.7±a</td>
<td>6.3±a</td>
</tr>
<tr>
<td>12 °C</td>
<td>46.8±5.5</td>
<td>6.9±b</td>
<td>6.9±b</td>
<td>7.0±2.5</td>
<td>6.5±a</td>
<td>6.0±a</td>
</tr>
<tr>
<td>20 °C</td>
<td>29.6±19.3</td>
<td>7.0±b</td>
<td>7.0±b</td>
<td>6.9±2.5</td>
<td>6.5±a</td>
<td>6.1±a</td>
</tr>
<tr>
<td>30 °C</td>
<td>2.5±5.5</td>
<td>6.2±a</td>
<td>5.1±a</td>
<td>5.7±2.5</td>
<td>5.9±a</td>
<td>4.8±a</td>
</tr>
</tbody>
</table>

Note: Averages of the individual variants are not significantly different (p > 0.95), if they have an identical superscript.

Similarly Briones and Aguilera (2005) indicate that chocolate products that are stored at higher temperatures experience yellowing, which is associated with the development of fat bloom. We can therefore assume that there was influence of fat bloom. Aguilera et al. (2004) stated that the bloom on
chocolate is produced by action of high temperatures and includes a gradual discoloration, loss of glossiness, and causes grey surface appearance of chocolate. In their study Bui and Coad (2014) also recorded colour changes among the experimental and control samples during storage at 30 °C. They found out that during storage at higher temperatures, there was a lighting of products increasing with the storage time.

More results support it as well. Higher temperature deviations from the room temperature of 20 °C also adversely affect (p > 0.95) the product glossiness. In chocolate stored at 30 °C, the glossiness was limited due to colour change, and its lightening, which as mentioned above, was probably due to fat bloom. As reported by Ali et al. (2001), migration of fats with lower melting point towards the surface of chocolate may at higher temperatures, such as 30 °C, occur prominently. Conversely, temperatures around 18 °C can be considered non-problematic from the point of view of fat bloom and not threatening for glossiness. The glossiness of chocolate at 20°C was the best from all temperatures, but it was not significantly different from the temperature of 6 °C and 12 °C. Freezing of the product or storing it at 6 °C or 12 °C ensures the preservation of its quality and freshness, as stated by Machálková et al. (2015).

The problem occurs when the product is consumed immediately upon removal from storage and is not subjected to stabilization at 20 °C ± 2 °C, as stated by Afoakwa (2010). Due to micro condensation, the product loses its glossiness. This result was statistically significant (p > 0.95) in both storage regimes (frozen, 6 °C). Colder products were better evaluated in assessing of fat bloom lower side. Samples at -18 °C had significantly better evaluation of fat bloom of lower side, but not statistically different from samples at 6°C. The dull fat bloom after one month storage was probably helped by the fact that the chocolate was without filling. There could thus not be a significant migration of fat from the filling to the surface of the product. Differences in the triacylglycerol composition between the soft fillings, such as nut paste or peanut butter, and the chocolate, lead to the migration of fat towards the product surface. This manifests itself in an undesirable softening of the chocolate layer by diluting the solid fat content (cocoa butter), hardening of the filling, and recrystallization of the cocoa butter on the chocolate surface, which is reflected by visible fat bloom (Nöbel et al. 2009).

Although the fat bloom was not observed on the upper side of the products, the lower side had noticeable statistically differences (p > 0.95). The worst state was determined in the warmest storage regime. The dull surface appearance caused by fat bloom occurs due to diffusion of light by agglomerates of fat crystals that protrude from the surface of chocolate (Lohman and Hartel, 1994).

Higher storage temperature (30 °C) than at lower temperatures (12 °C, 6 °C, -18 °C) significantly affected (p > 0.95) the fracture of products. Warmer products were soft and this negatively reflected on their textural characteristics. Products stored at 12 °C and below, were better ranked than chocolate stored at 30 °C (Table 1). They had even better texture properties that were also visible on a shell-like fracture which is typical for high-quality chocolate. Likewise, the smell of these products was more intense, which was reflected on the favourable outcome of sensory evaluation.

The results by Mexis et al. (2010) suggest that changes in texture, accompanied by a change in colour due to fat bloom, indicate that there was also softening of the chocolate product.

This was also reflected in our experiments not only in assessing fracture, but also in evaluating hardness of the product that is best evaluated “on bite”. The storage temperature of 30 °C had a statistically significant (p > 0.95) negative impact on this parameter. Chocolate was characterized by minimal resistance to pressure exerted upon its chewing in the mouth. This condition very closely corresponded with the results assessed by texturometer (TIRA test). Consistency on fracture was not significantly affected. Products stored at high temperatures have been rated lower than those stored at lower temperatures.

Storage temperature 30 °C has a statistically significant (p > 0.95) effect on stickiness of products, worsened their melting in mouth, and negatively affected the taste as well. These factors were negatively reflected in the overall evaluation of products, which was unfavourable for storage regime with the highest temperature (30 °C). We can consider as positive that the other temperature regimes did not manifest themselves significantly (p > 0.95) when assessing the overall impression.

CONCLUSIONS
Storage conditions for chocolate can be very diverse. Chocolate is not always stored in satisfactory conditions. Due to its composition, what can most affect its quality are temperature and humidity of the environment. In our observation, we have focused on the influence of storage temperature on its textural and sensory characteristics after being removed from various types of storage regimes with the immediate assessment of the sensory quality. The produced results have shown that the storage temperature is very important for the sensory quality of chocolate. The most suitable temperature for the subsequent immediate consumption seems to be 12 °C, or the room temperature of 20 °C. Higher temperatures adversely affect both the texture and other sensory properties of chocolate. Higher temperature promotes change in the colour of chocolate and deteriorates its glossiness. This largely corresponds with the formation of fat bloom, and the chocolate becomes soft and sticky. For chocolate that is frozen or stored in the temperature regime of 6 °C, which corresponds with conventional refrigerators, it is necessary to wait prior to consumption until temperatures equalize and if possible not to allow occurrence of condensation of the product. Especially glossiness of chocolate in immediate consumption is negatively affected.

ACKNOWLEDGMENTS
We would like to thank to the Zora Olomouc Company (Nestlé Česko Ltd.) for cooperation and supplying samples for the research. This paper was funded with the financial support of the IGA Mendel University in Brno IP_ 27/2016.

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