

# EFFECT OF RECIPE AND PRODUCTION TECHNOLOGY OF CHOCOLATE PRODUCTS ON THEIR QUALITY DURING STORAGE

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## Abstract

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The effect of four storage temperature modes (6, 12, 20 and 30 °C) on sensory properties of chocolate products and their colour changes in the experiment over a period of 6 months. The results were evaluated with regard to the production technology and composition of chocolate products. The experiment was performed on filled milk chocolate product called Orion Pistachio made in four versions such as a standard containing cocoa mass of 35 % referred to retempered variant (RS) and not treated by retempering (NS variant) and with higher proportion of cocoa mass (45 %) stated as retempered variant (R45) and not treated by retempering (N45 variant). Retempering means the exposure of products for 24 hours at 24 °C immediately after the production and packaging. The results show that the technology of retempering can effectively increase the resistance of chocolate products to the fat bloom as reflected in the improved colour stability. Sensory most acceptable products were stored at 6 and 12 °C throughout the experiment.

Keywords: chocolate, retempering, storage temperature, sensory analysis, colour

## INTRODUCTION

Failure to follow the production practices, improper storage or transporting chocolate products can cause defects of chocolate. Typically, the chocolate shows two basic types of defects such as fat and sugar bloom losing its gloss and covered with a fine layer of whitish (Afoakwa, 2010). Fat bloom can cause not only serious defects in the appearance significantly affecting the acceptability of the product but can also affect the taste and texture of chocolate. Grayish coating is often formed on the surface of the chocolate but may have other forms passing from the surface into the internal structures (Bui, Coad, 2014; Hartel, 1999). The causes may be different either

technological such as bad tempering of chocolate, improper cooling methods, the presence of soft fat fillings, chocolate products, the addition of fats incompatible with cocoa butter or may arise from improper storage in bad conditions at high or fluctuating temperatures (Minifie, 1982; Nöbel *et al.*, 2009). When processing of chocolate, an important role plays the composition of matter and especially the crystallization of cocoa butter for obtaining high quality of products (Fernandes *et al.*, 2013). Cocoa butter shows polymorphism, which is able to crystallize in six crystal forms under the certain conditions. A crystalline form of V is desirable for chocolate production and dominates in a well tempered chocolate (Quast *et al.*, 2013; Fernandes *et al.*, 2013). The form of V converted

naturally in stable form of VI during the durability leading to the formation of fat bloom and aging. This process is highly influenced by storage temperature (Afoakwa *et al.*, 2009; Beckett, 2008). Sensory analysis is an objective analytical method using training evaluators instead of machine equipment. The important role of sensory analysis proves the fact affecting quantitative indicators that can not be characterized by the instrumental method and provides a set of factors determining the ultimate consumer impression (Neumann *et al.*, 1990). Instrumental analysis can serve as a complement of sensory evaluation showing statistically significant correlations (Afoakwa *et al.*, 2008). Spectrophotometric measurement of colour is a useful complement to sensory analysis in the visible range. Software of CM-S100w enables the expression of the colour in space CIELAB (ball). The values of L\* (lightness) represent the range from 0 (black) to 100 (white) by the International Commission on Illumination (CIE). The colour coordinates of +a\* to -a\* (the axis running from red to green) and +b\* to -b\* (axis from yellow to blue) show positive or negative values depending on the location in three-dimensional system (Třešňák, 1999).

It can be assumed chocolate will be seeded with large amount of stable crystals in form V if its temperature is prolongedly maintained below the melting point of the stable cocoa butter crystals (retempering). So the retempering of chocolate can be a method that prevents fat bloom to occur. The aim of the study was to observe the influence of recipes and retempering of chocolate products within 6 months of storage and evaluate the effect of different storage temperatures on qualitative changes and sensory acceptability accompanied by instrumental measurements of colour changes.

## MATERIALS AND METHODS

The effect of storage temperature, composition of chocolate mass, production technology on colour change connected to the creation and development of fat bloom was tested on a chocolate product called Orion Pistachio (28 % of milk chocolate with pistachio and 36 % of hazelnut filling with 1.5 % pieces of pistachios; Nestle Zora Olomouc). Orion Pistachio chocolate was made with a standard cocoa mass content (35 %) and higher proportion of cocoa mass (45 %). Both variants were prepared as retempered (RS – 35 % of cocoa mass and R45 – 45 % of cocoa mass) and not treated by retempering method (NS – 35 % of cocoa mass and N45 – 45 % of cocoa mass). Retempering was performed on the finished products by keeping them in a controlled environment for 24 h at 24 °C. The samples were stored at four temperature modes (6 °C, 12 °C, 20 °C and 30 °C) for 6 months. Refrigerated warehouses were chosen to simulate cold temperatures at 6 °C and 12 °C used in commercial stores. Laboratory air-conditioned room

provided a temperature of 20 °C corresponding to standard room temperature and thermostat set at 30 °C simulated the improper storage conditions, which may occur during the transportation in the summer months or unsuitable storing of chocolate products (eg. the exhibition of products under illumination). Standard samples were deep-frozen (-18 °C). Six samples were carried out and evaluated within 6 months i.e. the entrance assessment was proved immediately after the production and subsequently after 2, 6, 10, 18 and 26 weeks from the production. Sensory assessment and colour changes were performed in a spectrophotometer in the visible spectrum at each sampling. Before the analysis, 24 hour equilibration of all samples including the standards were always kept in a room temperature (20 °C) to compensate particular textural and sensory properties of the samples from the various temperature modes.

### Sensory assessment

The sensory profile method was used to determine the sensory attributes of chocolate products. To measure the perceptions, unstructured graphical scales were used with the verbal description of the endpoints, the scale length being 10 cm. The samples of various products from all storage temperatures including standards were administered at once to enable their comparison in descriptors. All of the sensory assessments were underway in a specialized laboratory under standard conditions (ISO 8586-1 of assessment specialist and ISO 8589 of the spaces, assessment at 20 °C). The results of the graphical scales were obtained by measuring the distance of the mark from the right scale end (in cm) and are graphically rendered in the form of radar charts as an average rating of all assessment specialists (n = 8). "10" refers to the highest/best quality at the scale left end, while "0" is the least favourable / lowest quality at the right end. The radar charts thus graphically express the sensory profiles of the products during storage, clearly illustrating the differences between each of the production variants as well as between the temperature modes.

### Measuring colour

Konica Minolta Spectrophotometer CM 3500d was used for determining the colour and its changes during the storage period of each sample. For chocolate products, the regime of the elimination of gloss (SCE – specular component excluded), D 65 (illumination regime – 6,500 Kelvin) and a slot of 8 mm were chosen for colorimetric colour determination using reflectance (d/8). The measurements were done each time for three times on the cavity and three times on the coating in two samples per group.

### Statistical Analysis

The acquired data were analysed using MS Excel. The statistical analysis of all the sourced data was carried out using STATISTICA version 12 – analysis of variance (ANOVA) at a significance level of  $P = 0.05$ .

## RESULTS AND DISCUSSION

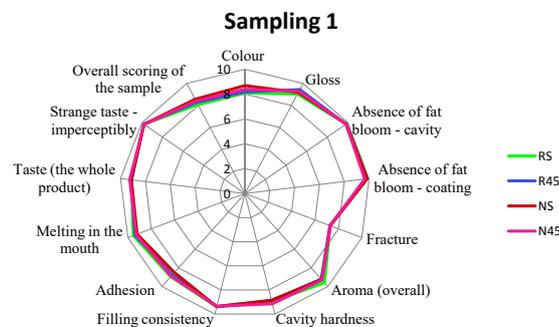
### Sensory assessment

The sensory profile method was used to determine the sensory attributes of chocolate products. The samples were administered at once to enable their mutual comparison in descriptor. Similarly, Silva *et al.* (2013) discloses a method for the optimized descriptive profile (ODP) trying to meet the requirements of speed and descriptive methods and also provides quantitative information about the sensory properties of food. In this method, the assessment specialist uses the sensory protocol with descriptors characterizing the individual attributes of the products. The unstructured scales are recommended with fixed end points indicated by the terms “weak” and “strong”. In this type of evaluation, the assessment specialists receive all the samples at once, and are instructed to compare samples of each attribute, and to mark in the unstructured scale corresponding effort. During the assessment, the samples can be tested again and reassess the quality grades. The initial analysis

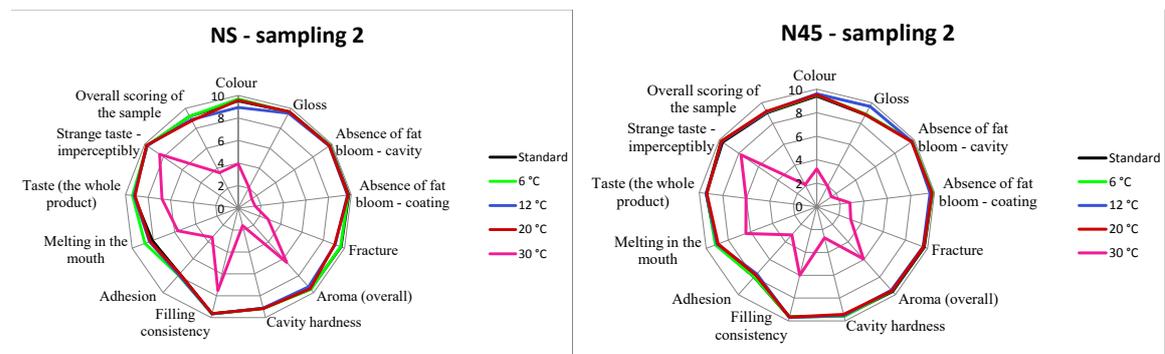
performed two days from production no significant differences (Fig. 1) between the variations of four products were found.

Fig. 2 and 3 present the results of the sensory assessment in the second sampling in which particularly storage mode at 30 °C affected negatively all variants over two weeks of sample storage at given temperature regimes in all variants. The changes occurred mainly in descriptors such as colour and gloss caused by developing of fat bloom. The exposure of the samples to high temperatures also decreased their hardness, fracture deterioration and of course the decline in the overall sample assessment. The differences between technologies were not significant. The results showed only a slight difference on the basis of the hardness based on content of the chocolate mass in which the samples containing 45 % of cocoa mass prove a slightly higher hardness in a comparison with samples of a standard contains. In chocolate samples stored in the temperature modes at 6, 12 and 20 °C, the values of determined descriptors correspond to the standard properties. In the following weeks of storage, the results of assessment were similar.

The analysis of samples showed a difference in the resistance to the fat bloom due to the manufacturing technology (Fig. 4 and 5) in the fifth sampling (after 18 weeks of storage). The samples, stored in the temperature modes at 20 °C, in which retempering (RS and R45) was performed, showed higher resistance to

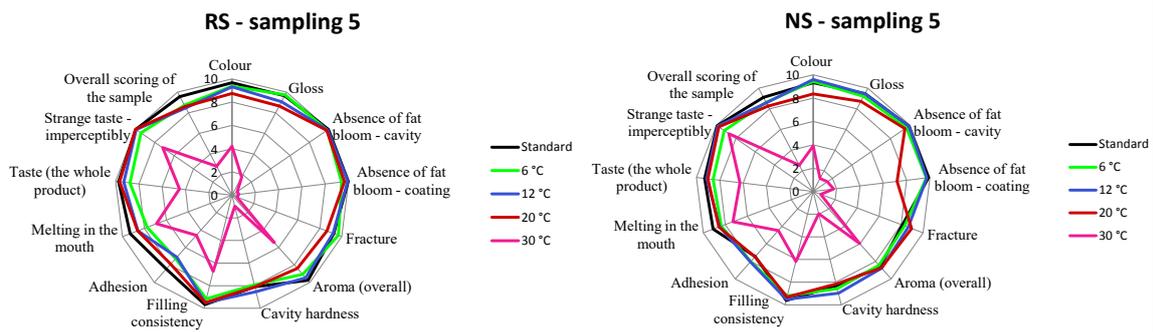


1: Sensory profile – sampling 1



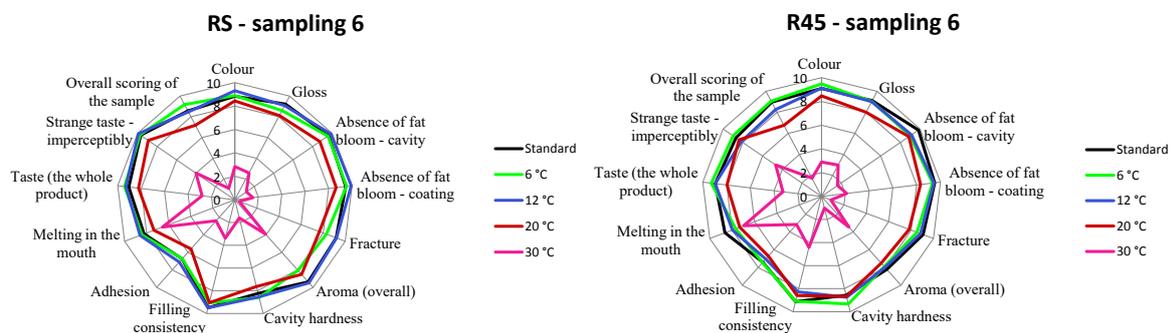
2: Sensory profile – NS sampling 2

3: Sensory profile – N45 sampling 2



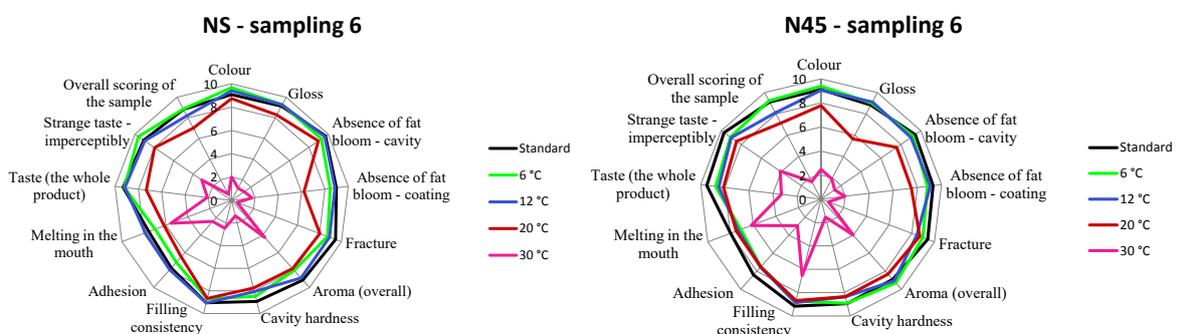
4: Sensory profile – RS sampling 5

5: Sensory profile – NS sampling 5



6: Sensory profile – RS sampling 6

7: Sensory profile – R45 sampling 6



8: Sensory profile – NS sampling 6

9: Sensory profile – N45 sampling 6

the occurrence of fat bloom in a comparison with no retempered samples (NS and N45). For no retempered samples, the development of fat bloom began to be noticeable on the chocolate coating. Storage temperature of 20 °C was already proven to be inadequate. The improved stability of retempered products can be explained by the presence of a larger amount of cocoa butter in stable form V created during retempering. Stable form of cocoa butter associated with a higher melting temperature, improved resistance of products to the fat bloom creation (Afoakwa, 2014) and increased sensorial scores of retempered products.

Fig. 6–9 show the descriptor change of each of the samples after 6 months of storage at these temperature modes. The results describe that the storage temperature of 6 and 12 °C was the most appropriate for all variants. In these samples, significant changes were not found out even after six months of storage and their properties correspond to sensory properties of standard. In the samples stored at 20 °C, a slight deterioration compared to the standards of some descriptors such as gloss and adhesion to the mouth floor and the overall assessment was determined. In the last sampling, a slight occurrence of fat bloom was determined in non-retempered samples, however, no occur

was observed in retempered samples. The results thus demonstrate that the technology of chocolate production produced by retempering proved to be the most resistant against fat bloom in the samples stored at 20 °C.

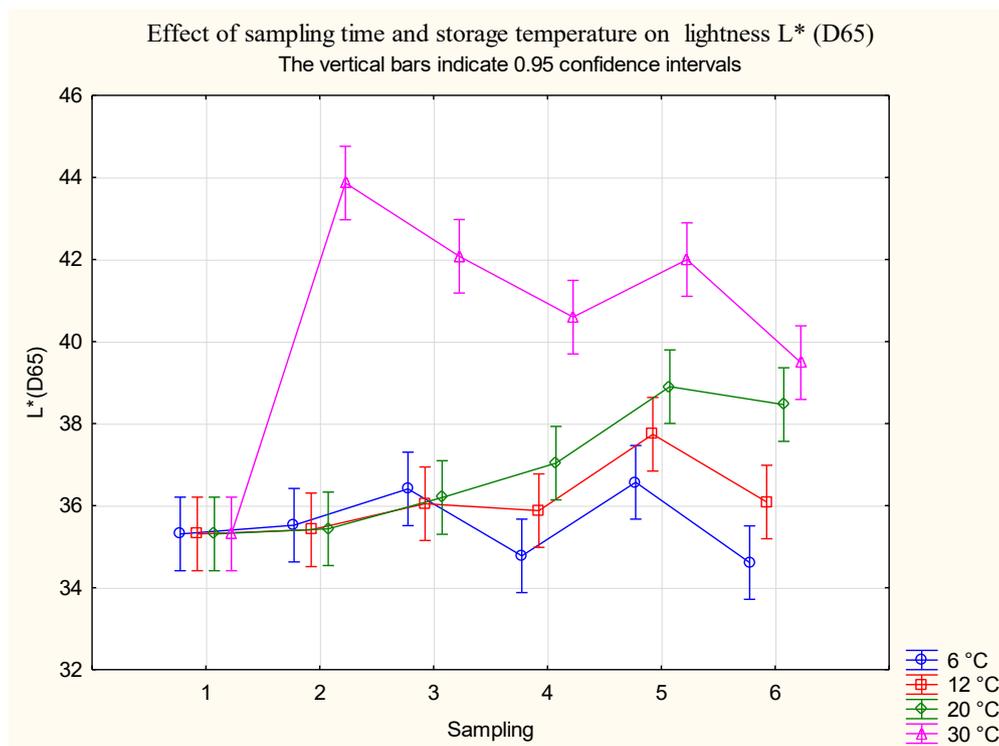
During the storage, temperature of 30 °C proved to be the least suitable for sensory attributes of chocolate. These samples showed the deterioration of almost all descriptors mainly caused by the formation of fat bloom. The same results were achieved by Ali *et al.* (2001) who stated that the migration of fat under these temperatures adversely affects the product integrity and appearance. In chocolate products, the typical deterioration associated with fat migration is manifest in softening. All of this reduces the product acceptability for the consumer. The results were also confirmed in their study by Bui and Coad (2014) when storing temperature at 35 °C caused the chocolates to significantly decrease their sensory quality after seven days of storage. The largest losses in terms of quality occurred with increased percentage share of fat bloom. The appearance and the overall acceptance of the products are the most sensitive descriptors. The deterioration of quality occurs exponentially with time. Jinap *et al.* (2000) confirmed that fat bloom appearing in chocolate stored at 18, 30 and 35 °C for 8 weeks, was not detected during storage at 18 °C while in the storage at 30 °C and 35 °C, the development of fat bloom was observed after week 4 and week 1, respectively. Temperature of 30 °C also caused a change in the consistency of the filling changed in solid and

dry during storage. The products of standard content of cocoa mass (35 %) were detected in less suitable situation. This phenomenon was probably caused by the migration of fat from the filling and its drying. Nöbel *et al.* (2009) stated that the migration rate of fat from the filling may be affected by the storage temperature and the structure of the chocolate cavity. In their study, they tested the stuffed products including a barrier layer between the filling and the chocolate cavity. They report that the use of this layer resulted in a significant reduction in the migration rate of oil from the filling and reduced the formation of fat bloom.

### Colour of chocolate products

For statistical evaluation, the value of L\* (lightness) representing the appropriate colour change of samples during measurement was applied. The results show that different temperature modes may have a different effect on the colour change of the stored chocolate products. The highest colour change occurred in the storage system at 30 °C, when samples achieved significantly lighter colour after two weeks of storage (Fig. 10). For the other temperature regimes 6, 12 and 20 °C, more pronounced colour changes began to show up at the fourth sampling.

Fig. 11 shows colour changes in the technologies of the storage time at temperature mode of 6 °C in which colour changes were not detected in any variant contrary to the entrance analysis. A slight lightness was observed in the products stored at 12 °C after 6 months. A lightness was also found

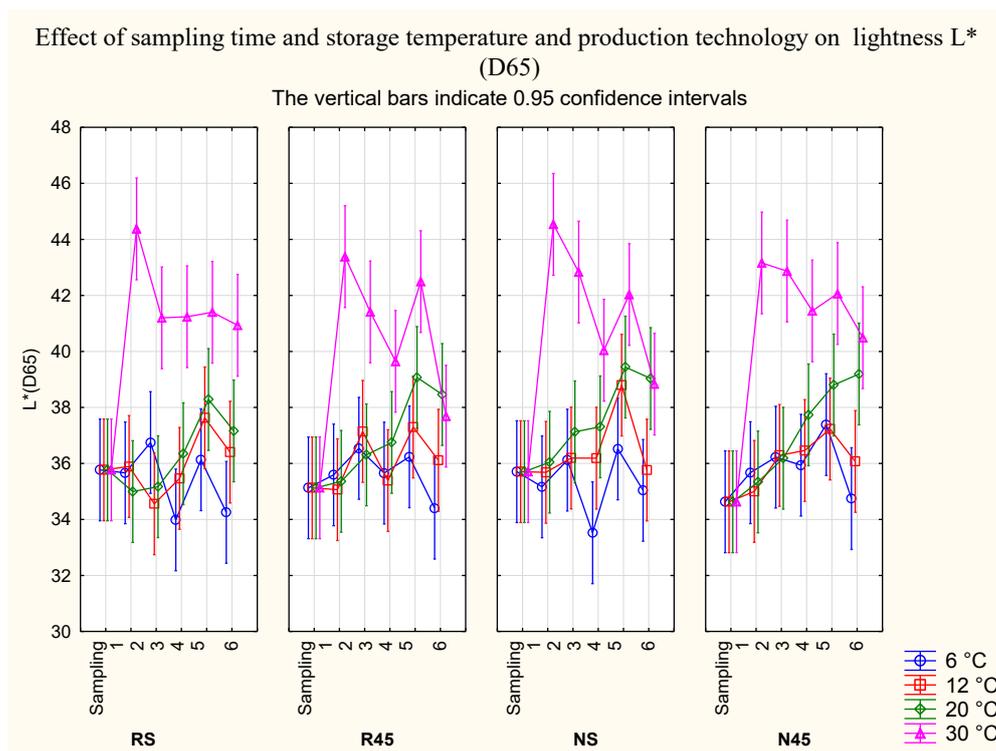


10: Effect of sampling time and storage temperature on lightness L\* (D65)

out in the products with temperature mode of 20 °C especially in the last two samplings. This colour change confirmed the results of sensory assessment in which the occurrence of fat bloom was also monitored in the samples of this regime. Mexis *et al.* (2010) detected that the consequence of fat bloom was also observed in colour change. According to Afoakwa *et al.* (2008), chocolate products with fat bloom distract more light and the product seems to be lighter and less rich in colour. Lighter colour contrary to other temperature mode was reached in the products stored at 30 °C after two weeks of storage. This fact was probably caused with the development of fat bloom. Briones and Aguilera (2005) mentioned that fat bloom, developed by the effect of surrounding temperatures, caused gradual colour change, loss of gloss and grey appearance of the chocolate surface.

In the entrance measuring, the products with higher share of cocoa mass show darker colour in the variant of R45 and N45. The effect of the individual production technologies on colour

change was not significant. The values of lightness of the last two samplings showed slight higher values of no retempered samples contrary to retempered samples in the temperature mode of 20 °C caused by developing of fat bloom. The effect of retempering was not detected in other temperature modes. This fact is confirmed in the figure of 11 where the differences between retempered and no retempered technologies in tenths of L\* are demonstrated. It can be assumed the prolonged maintenance of the chocolate temperature below the melting point of meta-stable forms during retempering probably increased their melting speed and the conversion of liquid butter into a stable form V, which stabilized the characteristics of the end product and improved the chocolate resistance to fat bloom creation. Hence the improved resistance to fat bloom creation was manifested as the decrease of color changes in retempered chocolate products.



11: Effect of sampling time and storage temperature and production technology on lightness L\* (D65)

## CONCLUSION

According to the results of sensory assessment and colour changes of chocolate products, the temperature of 30 °C was not suitable for storage time not even for a short period. The chocolate changes such as sensory properties, detected after two weeks of storage, were degraded in the connection with the occurrence of fat bloom accompanied with significant whitening of colour. Lower quality was detected in all four chocolate variants without significant differences. The samples, stored at 20 °C, proved a suitable quality to fifth sampling, in which no retempered samples showed the apparent development of fat bloom. In the last sampling, it was also monitored in retempered chocolates. This fact was detected by the colour change. The modes of 6 and 12 °C were confirmed to be the most suitable temperature conditions of storage for all chocolate variants from all evaluated parameters. From the point of sensory assessment, the samples reached the standard properties with which were compared and kept their sensory and tasty properties for six months of storage. The technology of retempering showed to be effective in the increased resistant to fat bloom contrary to no retempered samples. The content of cocoa mass was neither detected significantly changed for sensory assessment nor for colour change. From the experimental results, it can be concluded that suitable storage temperature of chocolate products should be lower than 20 °C in order not to occur the fat bloom.

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