MASO INTERNATIONAL 1.2022: 000–000; https://doi.10.2478/mjfst-2022-0013

Effect of storage on sensory quality of chocolate

Alexandra Tauferová, Tereza Tkadlecová

Department of Plant Origin Food Sciences, Faculty of Veterinary Hygiene and Ecology, University of Veterinary Sciences Brno, Palackého tř. 1946/1, 612 42 Brno

Abstract

The consumers are increasingly interested in high-quality chocolate products. This study focuses on the evaluation of the sensory quality of chocolate and changes it undergoes during storage. For the analysis, three types of dark chocolate were selected from the market network in the Czech Republic. For the evaluation, both quantitative descriptive analysis and hedonic evaluation were used. After the two-month period, the evaluators were able to detect differences in the sensory quality of chocolate stored in various ways. To preserve the organoleptic properties of chocolate, the most suitable storage appeared to be storage at the temperature of 16°C with a relative humidity of 60%. Our results did not find significant deterioration in quality during storage at the temperature of 8°C with a relative humidity of 70%, since during the two-month storage period, the chocolate samples showed neither sugar bloom nor odour absorption, nor any other statistically significant sensory quality deterioration ($p < 0.05$), even at a higher relative humidity. Storage at room temperature with a relative humidity of 55% proved to be the least suitable storage method for chocolate, as it resulted in statistically significant deterioration ($p < 0.05$) in sensory descriptors.

Keywords: temperature, humidity, refrigerator, bloom, smell

Introduction

Chocolate is indisputably one of the most popular food in the whole world. To a large extent, its popularity relates to the ability of chocolate to trigger pleasant feelings in the brain and stimulate positive emotions (Gunaratne et al., 2019). Chocolate is a suspension of cocoa mass and sugar in cocoa butter (Islam et al., 2022). Globally, the demand for dark chocolate is increasing. It is projected that the global chocolate market will continue to grow at a compound annual growth rate of 4.5%. The major market share is held by European consumers, who prefer high-quality chocolate products, e.g. chocolate made from selected cocoa beans of single origin, organic chocolate, hand-made and hand-crafted chocolate. At the same time, the demand for dark chocolate, characterized by a lower content of sugar and a rich bitter taste of concentrated chocolate, is increasing. This increased demand is in part due to the increasing awareness of its positive effect on a consumer's organism (Chocolate market – growth, trends, COVID-19 impact, and forecasts, 2022). In fact, chocolate products belong to the most significant sources of polyphenols in our diet and are a potential benefit for our cardiovascular health, show antioxidation activity, help to maintain a balanced cholesterol level and have anti-allergic, antiviral, anti-inflammatory and anti-carcinogenic properties (Rocha Santos et al., 2017). Dark chocolate with a higher percentage of cocoa contains more flavonoids than milk chocolate (Beckett, 2008).

According to legislation, chocolate is classified as a non-perishable food, i.e. food with a minimum shelf life. Chocolate is a stable product, and if hygiene requirements for raw materials, production and storage conditions are met, there is a very low risk of harmfulness. The reasons for this are a higher content of sugar, high cocoa butter stability and also low water activity (Subramaniam, 2009). Dark chocolate has a standard minimum shelf life of 24 months. However, another issue is the sensory quality of chocolate during the minimum shelf life. Quality chocolate is characterized by a pleasant aroma, even brown

Address for correspondence:

Phone:
Fax:
E-mail:
www.maso-international.cz

colour without bloom and a glossy appearance (Afoakwa, 2016). These organoleptic properties, especially aroma, taste, gloss and the absence of bloom are largely affected by storage conditions; improper storage can result in substantial deterioration of these properties long before the minimum shelf life expires.

The recommended conditions for storing chocolate usually include a dry environment with no exposure to light and a constant temperature in the range of 12–18°C. However, consumers frequently ignore these recommendations; some commonly store chocolate in a refrigerator, where higher humidity represents a risk factor and others store it at high and fluctuating temperatures.

The main objective of this study was to chart the extent to which sensory changes appear for the selected dark chocolate samples during a two-month storage period. One sub-objective was to verify if various storage methods common among consumers differ significantly with respect to their influence on the sensory quality of chocolate. Another was to determine if consumers are able to sensorially notice these changes and differences during the two-month storage period, and if so, in which descriptors the significant changes occur.

Material and methodology

For the analysis, three types of dark chocolate from various price levels and various producers were selected from the market network in the Czech Republic. Their ingredients are stated in Table 1.

Table 1: Chocolate sample ingredients

Samples	Cocoa solids content [%]	Ingredients
CH1	70	sugar, cocoa mass, cocoa butter, reduced-fat cocoa powder, emulsifiers (soy lecithin, polyglycerol polyricinoleate), flavouring, peanut and nut flour
CH2	70	cocoa mass, sugar, reduced-fat cocoa powder, cocoa butter, emulsifiers (soy lecithin, polyglycerol polyricinoleate), Bourbon Madagascar vanilla extract, may contain milk and dried nuts
CH3	50	cocoa mass, sugar, cocoa butter, vanilla, may contain traces of nuts, milk, soy, sesame seeds and wheat (gluten)

The sensory analysis of the chocolate samples was performed after purchase, i.e. at the beginning of storage (control sample) and then after completion of the two-month storage period. The chocolate samples were stored under different conditions representing common storage methods used by consumers (refrigerator, pantry, room temperature; see Table 2 for exact conditions).

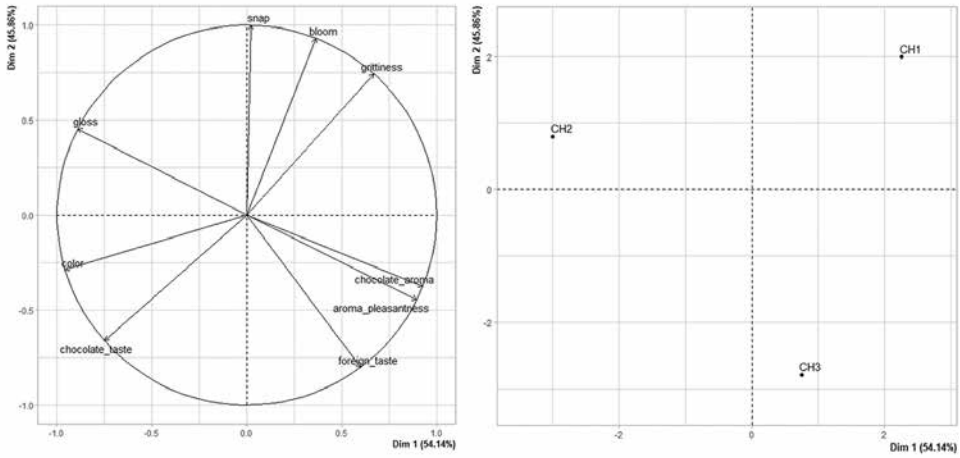
Table 2: Storage conditions for storing chocolate samples

Storage method	Temperature [°C]	Humidity [%]	Exposure to light
S1	8	70	NO
S2	16	60	NO
S3	23	55	YES

After the storage time elapsed, all samples were sensorially evaluated by a panel of 14 trained evaluators from the employees and students of the Faculty of Veterinary Hygiene and Ecology, University of Veterinary Sciences Brno. The average age of the panel members was 27 years. Sensory analysis was used to evaluate 13 descriptors using seven-digit categorical ordinal scales with described extreme values where number 7 corresponded to the highest intensity/pleasantness. Within the quantitative descriptive analysis, the following descriptors were evaluated: chocolate aroma, foreign odour, gloss, bloom, colour, snap, chocolate taste, foreign taste and grittiness. Within the hedonic analysis, the following descriptors were evaluated: aroma pleasantness, taste pleasantness, texture pleasantness and overall acceptability. The samples were served randomly, identified by three-digit numerical codes; still water was available as a neutralizer. The data from the sensory analysis were processed by the statistic software R version 3.3.3 (The R Foundation for Statistical Computing, Austria) using principle component analysis.

Results and discussion

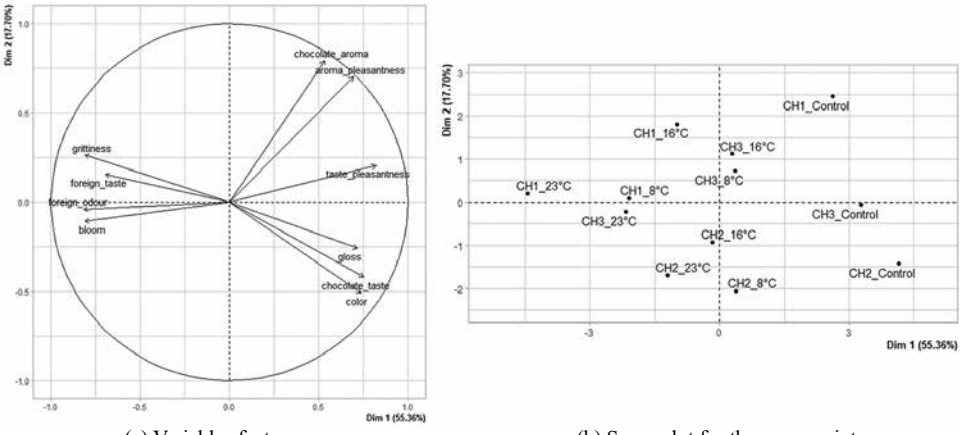
The samples of respective chocolate types from various producers differed substantially in terms of quantitative descriptive analysis within individual descriptors ($p < 0.05$) (Figure 1); nevertheless, in terms of hedonic analysis, no statisticall0y significant differences were found.



(a) Variables factor map. (b) Score plot for the mean points.

Figure 1. The results of PCA of sensory analysis of chocolate samples from selected producers: (a) Variables factor map. (b) Score plot for the mean points.

The graph with results of the principle component analysis focused on respective samples during storage explains 73.06% of the variability, where the first component explains 55.36% and the second 17.70% of variability. Based on the factor map of variables (Figure 2), it can be concluded that snap, texture pleasantness and overall pleasantness descriptors had no significant impact on the total variability of chocolate samples.



(a) Variables factor map. (b) Score plot for the mean points.

Figure 2. The results of PCA of sensory analysis of individual chocolate samples at the beginning of the storage (CH1-CH3_Control) and after the experimental storage period: (a) Variables factor map. (b) Score plot for the mean points.

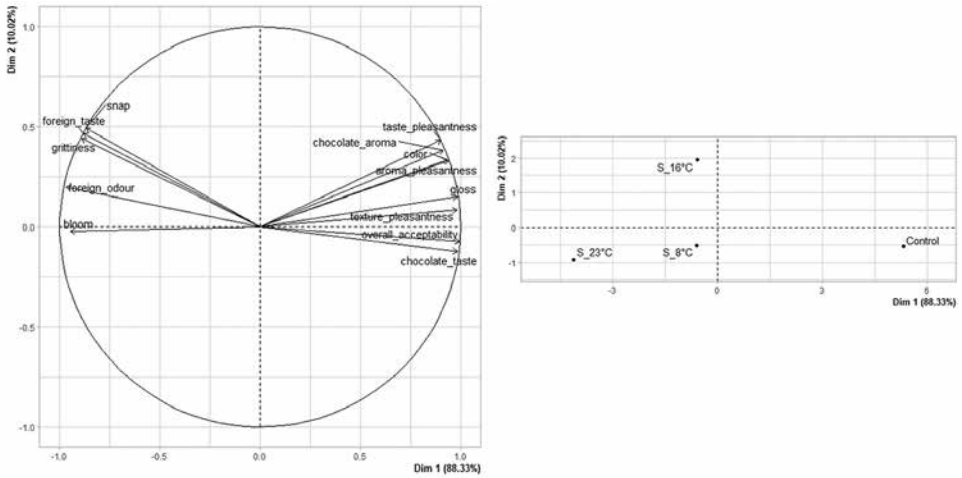
A number of statistically significant differences ($p < 0.05$) was found between respective control samples and the samples after the experimental storage. In terms of quantitative descriptive analysis, the most significant differences were found in the following descriptors: colour, chocolate aroma, bloom and grittiness. Although the changes in bloom and grittiness descriptors were statistically significant, the values were very low, which was confirmed by the results of A1i et al. (2001), who investigated the effect of storage temperature on texture and bloom formation in filled dark chocolates. According to their results, the bloom in chocolates wasn't formed until the third week of storage at 30°C. Texture deterioration was also noted at this temperature. In the case of storage at 18°C, the bloom was not formed during the whole two-month experimental storage.

The results of our hedonic analysis of respective samples are contained in Table 3, where the statistically significant differences are emphasized with colours. The pink colour represents statistically significant lower values; the blue colour represents statistically significant higher values of the descriptor.

Table 3. Adjusted mean of hedonic evaluation of chocolate samples at the beginning of the storage (CH1-CH3_Control) and after the experimental storage period.

	aroma_pleasantness	overall_acceptability	texture_pleasantness	taste_pleasantness
CH3_23°C	4.357	4.5	4.714	4.071
CH1_23°C	4	4.571	4.714	4.286
CH2_23°C	4.071	4.786	4.786	4.5
CH1_8°C	4.429	4.643	4.929	4.571
CH3_16°C	4.929	4.571	5	4.929
CH2_8°C	4.143	5	5.214	4.643
CH3_8°C	4.857	4.786	5.071	4.643
CH2_16°C	4.429	4.857	5.286	4.786
CH1_16°C	4.857	4.929	4.857	5
CH3_Control	4.857	5.214	5.286	5
CH1_Control	5.429	4.929	5.286	5
CH2_Control	4.857	5.357	5.571	5.286

The graph with results of the principle component analysis focused on respective storage methods explains 98.35% of the variability, where the first component explains 55.36% and the second 10.02% of variability. Based on the factor map of variables (Figure 3), it can be concluded that all evaluated descriptors formed the total variability of stored chocolate samples.



(**a**) Variables factor map. (**b**) Score plot for the mean points.

Figure 3. The results of PCA of sensory analysis of chocolate samples stored at individual experimental conditions: (**a**) Variables factor map. (**b**) Score plot for the mean points. Control = chocolate samples at the beginning of the experimental storage period.

The overall acceptability descriptor was most correlated with chocolate taste, texture pleasantness and gloss descriptors. Although in terms of mean values of point evaluation in respective descriptors, no significant change between the samples stored using different methods and control samples before the experimental storage was described, statistically significant differences ($p < 0.05$) were found between the control samples and the samples stored at room temperature with exposure to light (Table 4 and Table 5). At the same time, the samples stored at 23°C showed statistically significant lower values ($p < 0.05$) in the following descriptors: colour, gloss and chocolate aroma. Aroma or flavour, are one the key characteristics of quality chocolate. They are formed by the presence of volatile compounds and their profile are shaped from the beginning by the genotype of the cocoa beans, soil, sunshine and subsequently is affected by the fermentation and roasting processes. Perfect chocolate should be characterized by high intensity of chocolate, fruit and woody aroma (Cemin et al., 2022; da Veiga Moreira et al., 2018). The samples stored at 23°C also showed statistically significant higher values in the foreign odour descriptor. This can result from absorption of foreign odours from the environment during storage. Nevertheless, despite various temperature and humidity conditions during storage, bloom formation was not recognised in any case, which is apparently the result of correctly performed tempering of the chocolate masses.

The chocolate samples stored at 16°C and 8°C and simultaneously protected against light were evaluated rather positively by the evaluators. In the Islam et al. (2022) study, a sub-objective was to monitor the influence of the storage temperature at 4°C on organoleptic properties of milk chocolates. It showed that the colour and the appearance of chocolate did

not change for up to 90 days. Flavour was maintained without any statistically significant changes during the period of one month; then it slightly worsened. Already during the first month, the sample texture statistically significantly worsened ($p \leq 0.05$), and this trend continued, although all evaluated sensory parameters maintained the acceptable values.

In the case of our dark chocolate samples stored at 16 °C without exposure to light simulating pantry storage conditions, statistically significant higher values ($p < 0.05$) in foreign taste and grittiness descriptors were confirmed. In terms of quantitative descriptive analysis, the control samples were classified as the most pleasant by the evaluators. In all evaluated parameters, it showed statistically significant better values ($p < 0.05$), with the exception of the chocolate taste descriptor, where no statistically significant changes appeared during storage.

Table 4. Adjusted mean of hedonic evaluation of storage methods.

	overall_acceptability	taste_pleasantness	texture_pleasantness	aroma_pleasantness
S_23°C	4.619	4.286	4.738	4.143
S_8°C	4.81	4.619	5.071	4.476
S_16°C	4.786	4.905	5.048	4.738
Control	5.167	5.095	5.381	5.048

* Control = samples at the beginning of the experimental storage period

Table 5. Results of the Hotelling's T2 test for chocolate storage methods (quantitative descriptive analysis).

	Control	S_16°C	S_23°C	S_8°C
Control	1	0.0005416	0.00007534	0.006218
S_16°C	0.0005416	1	0.0008733	0.003432
S_23°C	0.00007534	0.0008733	1	0.05211
S_8°C	0.006218	0.003432	0.05211	1

* Statistically significant differences between the groups are emphasized with pink colour. Control = chocolate samples at the beginning of the experimental storage period.

Conclusions

Based on the statistic evaluation of the sensory analysis results, it was confirmed that after passing the two-month storage period, the evaluators were able to perceive differences in the sensory quality of differently stored chocolate samples.

Although storing chocolate in a refrigerator is not recommended due to higher humidity and the risk of odour absorption, it remains a common practice for many consumers. Our results did not confirm any significant deterioration in the quality during storage at the temperature of 8°C with a relative humidity of 70%, since during the storage period of two months, even with a higher relative humidity, the chocolate samples showed neither sugar bloom nor odour absorption, nor any other statistically significant sensory quality deterioration. In terms of hedonic analysis, the most suitable method from all tested experimental storage methods simulating the storage methods common for consumers is storage at 16°C with a relative humidity of 60% without exposure to light.

However, the most common method of chocolate storage for consumers obviously remains storage at room temperatures. Our study confirmed that this storage method is the least suitable in terms of the sensory quality of chocolate.

Although chocolate in households is often stored in various ways and consumers commonly do not perceive or do not think about the possible impact on the changes in its sensory quality, these changes occurs quite rapidly. Changes occur in increased intensity of foreign odours, foreign taste and texture roughness with simultaneously impaired chocolate aroma, gloss and colour, which affects the perception of the pleasantness of the chocolate. During the two-month experimental storage, no fat or sugar bloom (indicative of serious defects in sensory quality) occurred in any storage method.

References

Afoakwa E 2016: Chocolate Science and Technology. 2nd ed. John Wiley, ISBN 1118913779, 536 p.

Ali A, Selamat J, Man YC and Suria AM 2001: Effect of storage temperature on texture, polymorphic structure, bloom formation and sensory attributes of filled dark chocolate. Food Chemistry **72:** 491-497

Beckett ST 2008: The Science of chocolate. 2nd ed. Cambridge: Royal Society of Chemistry, ISBN 9781847558053, 240 p.

Cemin P, Ribeiro SR, de Oliveira FDC, Leães FL, dos Santos Nunes MR, Wagner R and Sant'Anna V 2022: Chocolates with Brazilian cocoa: Tracking volatile compounds according to consumers' preference. Food Research International **159**: 111618

Gunaratne TM, Fuentes S, Gunaratne NM, Torrico DD, Gonzalez Viejo C and Dunshea FR 2019: Physiological responses to basic tastes for sensory evaluation of chocolate using biometric techniques. Foods **8**: 243

Chocolate market – growth, trends, COVID-19 impact, and forecasts (2022 – 2027). Industry report. Mordor Intelligence Web site. Available at: https://www.mordorintelligence.com/industry-reports/chocolate-market. Last modified 2022. Accessed October 11, 2022

Islam MZ, Masum AKM and Harun-ur-Rashid M 2022: Milk chocolate matrix as a carrier of novel Lactobacillus acidophilus LDMB-01: Physicochemical analysis, probiotic storage stability and in vitro gastrointestinal digestion. Journal of Agriculture and Food Research **7**: 100263

Rocha IS, Santana LRRD, Soares SE and Bispo EDS 2017: Effect of the roasting temperature and time of cocoa beans on the sensory characteristics and acceptability of chocolate. Food Science and Technology **37**: 522-530

Subramaniam PJ 2009: Shelf-life prediction and testing. In Science and technology of enrobed and filled chocolate, confectionery and bakery products. Woodhead Publishing, pp. 233-254

da Veiga Moreira IM, de Figueiredo Vilela L, Santos C, Lima N and Schwan RF 2018: Volatile compounds and protein profiles analyses of fermented cocoa beans and chocolates from different hybrids cultivated in Brazil. Food Research International **109**: 196-203