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Effect of storing conditions on the color of distillate Tuzemák

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Abstract

Changes in the color of a Tuzemák distillate were monitored over a period of 24 months. The experiment was designed in cooperation with the manufacturer. The manufacturer was looking for a suitable type of bottle to sale the product. Dark and clear glass bottles with Tuzemák were stored in two temperature regimes (6 °C, 20 °C). The bottles were placed i) in a dark room, ii) in a room with daylight and iii) under LED fluorescent lighting. Color changes were monitored during the storage period using a Konica Minolta CM 3500d spectrophotometer. The results confirmed that storage conditions have a significant effect on color stability. The most stable color was observed in Tuzemák's samples stored in a dark bottle in a dark room at low temperatures (± 6 °C). The effect of light and temperature on storage in dark bottles was weaker than in clear bottles. The color of the samples stored in clear bottles at higher temperatures was paler than that of the samples stored in dark bottles at low temperatures.

Keywords: Tuzemák; distillate; color; spectrophotometry

1 Introduction

The production of distilled beverages has a long tradition in the Czech Republic. Estimated production (according to data available from producers) is about 70 million liters per year (Vaňatová, 2023). Tuzemák is a traditional alcoholic beverage that accounts for up to 20% of consumption of distillates in Czech Republic Tuzemák is also a component of many cold and hot drinks and is used to improve the flavor of bakery and confectionery products. Its production was primarily driven by the effort to replace expensive imported rums from overseas. Tuzemák is made by mixing fine alcohol, softened water, flavorings (rum, vanilla) and sugar. The alcohol content of the product is 37.5% by volume (Decree No. 248/2018). The characteristics of Tuzemák are similar to those of Cachaça, a Brazilian rum which containing 38–48% alcohol. Cachaça is produced by fermenting sugarcane juice, aged in wooden barrels, and is considered to be a 'mother' of rum (Ratkovich et al., 2023). It can be either clear or naturally colored by wood pigments, whereas Tuzemák is colored with caramel.

Caramel E150a is used to obtain desired color of Tuzemák. This coloring agent is produced by caramelization of a sugar (sucrose, glucose). According to Al-Abid et al. (2007), caramel colorant is produced by the degradation of carbohydrates in acidic and alkaline environments in the presence of catalysts. Food grade acids, bases, and salts can be used to support the caramelization process in amounts that comply with good manufacturing practice (GMP) (Sengar and Sharma, 2014). The caramel production process is influenced by several factors such as the type of carbohydrate, temperature, pH, and catalyst properties. Caramelization requires temperatures higher than 120 °C and pH 3 < pH < 9 (Kroh, 1994). Caramels are generally reported to be stable to light and temperature

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changes (Emerton, 2008). However, for manufacturing practice, it is necessary to determine the effect of a glass bottle type on product quality in a real environment. The applicability of modern methods of color changes determination can now bring knowledge applicable in Tuzemák production. Color stability during storage is the most important quality factor for both colorants and foods (Espejo and Armanda, 2014). The electrical charge is a very important characteristic of caramel as it influences the suitability of the caramel for use in various products (food, beverage). Each molecule of caramel carries an electrical charge generated during the production process. The charge is strongly influenced by the pH (Kamuf et al., 2003). Sengar and Sharma (2014) reported that the European Technical Caramels Association (EUTECA) has standardized the properties of 4 classes and 10 types of caramels. Based on the isoelectric point (pI), caramels can be classified as positive (pI 5.0–7.0), negative (pI 4.0–6.0), and alcoholic (pI<3.0). The pI determines the possibility of application of caramels. Class I caramel is used in the production of Tuzemák. This type of caramel has a slightly negative electrical charge. It is stable in solutions containing up to 70% ethanol and is widely used as a coloring agent in the production of alcoholic beverages (Wrolstad and Culver, 2012). The stability of colorants is generally affected by its production process as well as food characteristics such as oxidation, hydration, heat treatment, and exposure to daylight (Ghidouche et al., 2013). The stability of caramel depends on the charge carried by the reactants in the caramel. If they are negatively charged, the color is stable. If the reactants consist of negatively and positively charged molecules, the caramel color will precipitate, resulting in an unstable caramel color. The absence of flocculation, precipitation and haze formation is expected (Kasim, 2010). According to Bordiga (2017), the product stability to light is another important characteristic of the colorant.

The aim of this study was to investigate the effect of storage conditions on the color changes and organoleptic properties of Tuzemák, which are influenced by the stability of E150a caramel. Although E150a is considered as color-stable, factors such as the type of spirit, length of storage and storage conditions can negatively affect the color of the product. The findings of this study provide valuable practical insights for Tuzemák producers. They highlight how to maintain color stability throughout the shelf life of Tuzemák and what happens to the product under typical, less-than-ideal retail storage conditions.

2 Materials and methods

Tuzemák (AROMKA BRNO, s.r.o., Czech Republic) was prepared in accordance with a standard production process (Hauser et al., 1985). Fine alcohol, softened water, rum and vanilla flavoring agents and coloring agents caramel E150a were coldly mixed. The dose of caramel was 0.5 g per 100 ml of product. The alcohol content of the finished product was adjusted to 37.5% vol. (Decree No. 248/2018). Immediately after production, Tuzemák was filled into 200 ml clear and dark (brown) glass bottles. After sealing, the bottles were placed in the observed storing regimes. The regimes were selected to simulate the different storage methods commonly used today. Samples were stored for 24 months. The design of the experiment is shown in Table 1.

Table 1 *The design of the experiment*

variant	bottle	Storage temperature (°C)	Light mode
1	clear	20	daylight
2	dark	20	daylight
3	clear	20	dark
4	dark	20	dark
5	clear	20	LED fluorescent lamp
6	dark	20	LED fluorescent lamp
7	clear	6	dark
8	dark	6	dark

A Konica Minolta CM – 3500d spectrophotometer (KONICA, Japan) with a d/8 geometry was used to determine color of samples. The measurement was conducted immediately following the bottling process and then at three-month intervals for a total of 24 months. A sample was transferred into a glass cuvette (CM-A98, glass, 10 mm) and the transmittance was determined at wavelengths of 380–780 nm. The spectrophotometer was connected to a computer with the CMs-100w Spectramagic NX program. The L* (lightness) values, which range from 0 (black) to 100 (white), were measured together with the color coordinates a* and b*. The value of a* defines the color green (-a*) to red (+a*), while the value of b* defines the color blue (-b*) to yellow (+b*). The shift on the a* axis from left to right represents the transition from red to green, and the b* axis from yellow to blue (Vik, 1995). The objective deviations (ΔE*ab, ΔL*, Δa*, and Δb*) were calculated according to the following formulas:

$$\Delta L^* = L^*_{sample} - L^*_{blank}$$

$$\Delta a^* = a^*_{sample} - a^*_{blank}$$

$$\Delta b^* = b^*_{sample} - b^*_{blank}$$

A scale for quantifying the extent of discordance between two colors was employed to facilitate the interpretation of the obtained values (Table 2). Light in (D65) mode was used, which is the standard for these methods with a color temperature of 6500K (Zmeškal et al., 2002).

Table 2 *Color difference scale (Třešňák, 1999; Zmeškal et al., 2002)*

ΔE*ab	Difference
0.0 – 0.2	Imperceptible
0.2 – 0.5	Very weak
0.2 – 1.0	Perceptible
0.5 – 1.5	Weak
1.0 – 2.0	Discernible
1.5 – 3.0	Clearly perceptible
2.0 – 4.0	Not yet disturbing
3.0 – 6.0	Medium
4.0 – 8.0	Slightly disturbing
6.0 – 12.0	Distinct
12.0 – 16.0	Very noticeable
> 16.0	Disturbing

ΔE*ab is characterized by the formula $\Delta E^*ab = [(L^*)^2 + (a^*)^2 + (b^*)^2]^{1/2}$, where L* is brightness and coefficients a* and b* characterizing color shade. For better understanding and illustration in Figure 1.

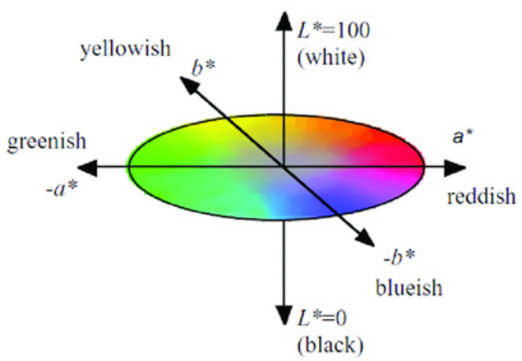


Figure 1 *Color levels (KONICA materials)*

The data were subjected to statistical analysis using Statistica 12 (StatSoft, USA). The significance of the difference between samples was determined by analysis of variance (ANOVA) using multifactorial analysis of variance, followed by Tukey's post-hoc test at the 95% significance level ($p<0.05$).

3 Results and discussion

The shelf life of light-sensitive beverages is influenced by a number of factors, such as packaging materials, storage temperatures, type of lighting or exposure time (Espejo and Armanda, 2014).

3.1 Effect of lighting mode

The lighting conditions had a considerable impact on the color changes observed in the tested spirit (Figures 2–4). The most notable changes were evident during the initial three-month period of storage. When storing samples in the dark, the light level (L*(D65)) was significantly ($p<0.05$) lower than for samples stored in the light (Figure 2). The products stored in a daylight environment and under fluorescent lighting exhibited the most pronounced lightening of color. The lightening of the product is evident from the green to red transition (a* (D65)) and the blue to yellow transition (b* (D65)). These changes in coloration are illustrated in Figures 3 and 4. The beneficial impact of storage without exposure to daylight on the color of the alcoholic beverage has been previously described by Castaneda-Olivares et al. (2010). The susceptibility of caramel-colored spirits to light conditions was also confirmed by Refsgaard et al. (1993). They concluded that the caramel is degraded in ethanol solutions due to light absorption. Our findings may be explained by similar factors. The accelerated degradation of anthocyanins contributes to the color change observed in products stored under daylight access as well (Laleh et al., 2006). The rate of degradation depends on the composition of the beverage and has been observed to reach up to 26%.

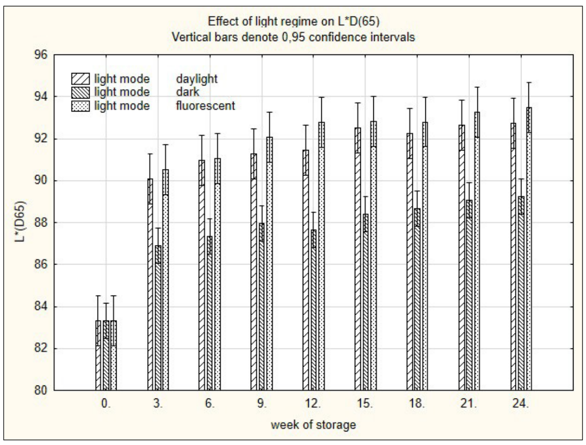
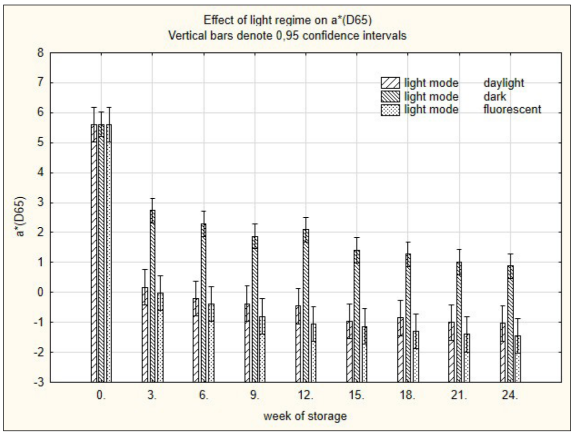


Figure 2 *Effect of light regime on L*(D65)*

3.2 Effect of temperature regime

The findings substantiated that storage at lower temperatures, in conjunction with the absence of light, is an effective strategy for maintaining optimal color stability, as compared to storage at room temperature with access to light. As reported by Espejo and Armanda (2014), elevated temperatures (25–45 °C) have a detrimental impact on color. This is demonstrated by the results, which indicate that the degree of change at lower storage temperatures was significantly lower ($p<0.05$) than at higher temperatures (Figures 5–7). These findings were confirmed in the determination of L*(D65) and a*(D65) as well as b*(D65). The green color exhibited degradation and transitioned to red, while the blue color shifted towards yellow. In our study, a significant change was observed, particularly in the degradation of the blue color and a notable influence of the light regime on the parameter b*(D65). Similarly, the authors Cristea et al. (2015) previously described that higher temperature and longer storage lead to a significant degradation of the blue color towards yellow, which is in agreement with our findings. Similar conclusions regarding the impact of temperature on color alteration were also reached by Hellström et al. (2013), who investigated the stability of anthocyanins in fruit beverages and demonstrated that elevated temperatures (21 °C) accelerate their degradation. Narkprasom et al. (2012) evaluated the influence of graded temperatures (20, 30, 40, 50 °C) and observed that color deterioration accelerated with increasing storage temperature.



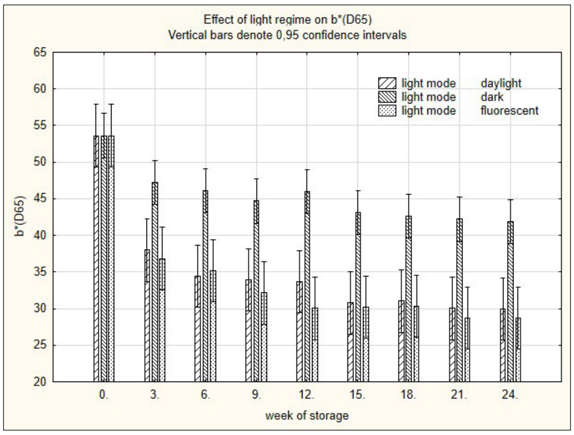
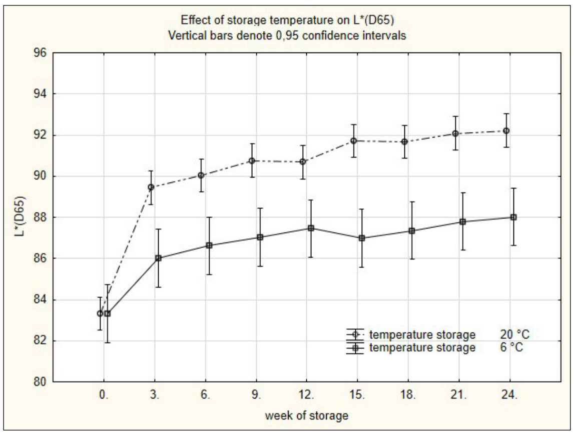
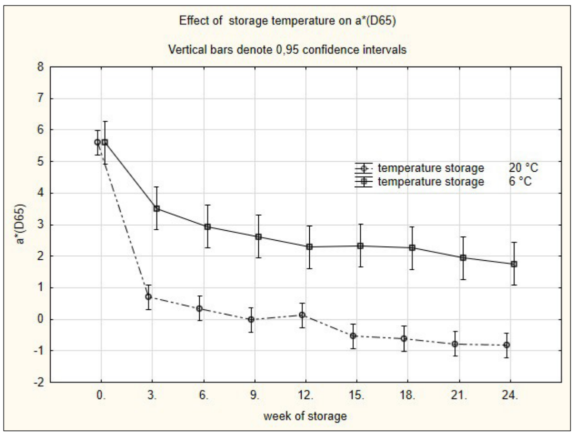


Figure 3 *Effect of light regime on a*(D65)*

Figure 4 *Effect of light regime on b*(D65)*





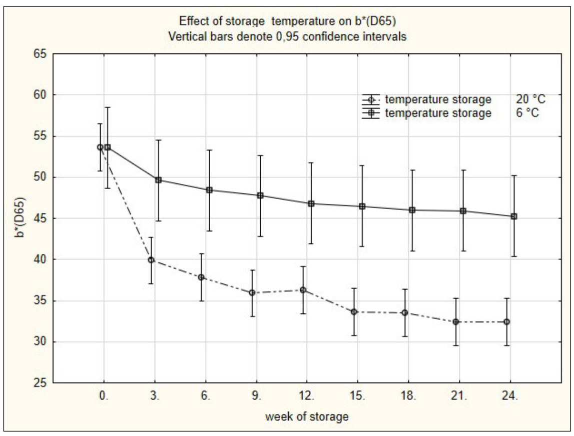


Figure 5 *Effect of storage temperature on L*(D65)*

Figure 6 *Effect of storage temperature on a*(D65)*

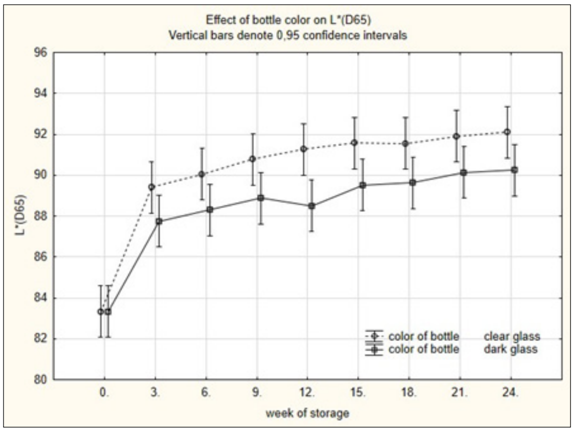
Figure 7 *Effect of storage temperature on b*(D65)*

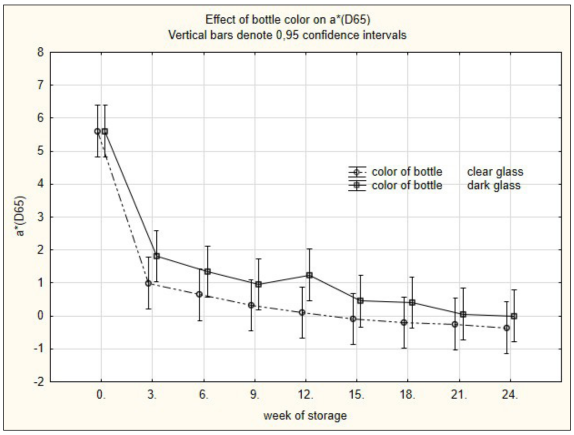
3.3 *Effect of bottle color*

From Figures 8–10 can be observed better color stability for samples stored in brown bottles, however, there is no obvious statistically significant difference compared to clear bottles ($p<0.05$). As previously concluded by Maury et al. (2010), glass color is a significant factor influencing the color stability of spirits. This finding was supported by the results of Tamuno and Onyedikachi (2015), who observed that samples stored in green or brown bottles exhibited greater color stability than samples stored in clear glass bottles. Similarly, Kralj Cigić and Zupančič-Kralj (1999) found that storage in green bottles has a more positive effect on storage compared to storage in colorless bottles, in which degradation is enhanced by access to sunlight. This finding is supported by the research of Selli et al. (2002), who found that the short-term storage of orange wine in brown bottles reduced discoloration. Additionally, the research of Tamuno and Onyedikachi (2015) showed that the storage of wine in brown and green bottles is more suitable for maintaining sensory properties (color, aroma, flavor) than storage in clear bottles, particularly for longer-term storage. Not only the color, but also the composition of the glass is important, as Abramova et al. (2020) states that glass containers can be a potential source of some cations, due to the fact, that the storage process of alcoholic beverages can disturb the surface of the glass and thus enrich the spirit with sodium and calcium cations.

3.4 *Color difference ∆E*ab*

In order to ascertain the optimal storage method for the elimination of color changes, we may utilize the parameter ΔE*ab for evaluation. Table 3 illustrates the dynamics of color change during storage. Storage variant 5 exhibited the most significant color change. The combination of LED fluorescent lighting at 20 °C and the use of a clear bottle was identified as the least suitable for storing Tuzemák. Conversely, storage in the dark at 6 °C and in a dark bottle was found to be crucial for maintaining higher color stability.





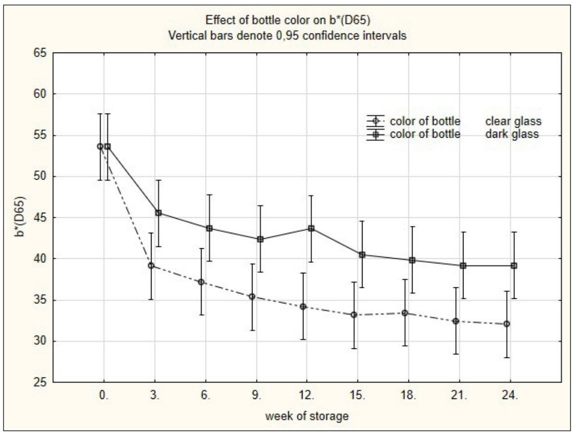


Figure 8 *Effect of bottle color on L*(D65)*
Figure 9 *Effect of bottle color on a*(D65)*
Figure 10 *Effect of bottle color on b*(D65)*

Table 3 *Color difference expressed as ΔE*ab*

Variant*	Months of storage								
	0	3	6	9	12	15	18	21	24
1	0.00	23.86	28.65	28.61	28.45	32.23	31.61	33.11	32.66
2	0.00	11.99	14.39	15.60	16.40	18.87	18.75	19.41	20.01
3	0.00	10.80	11.52	14.16	15.32	16.30	17.15	17.86	18.19
4	0.00	10.18	11.66	13.67	5.34	15.82	16.28	17.27	17.01
5	0.00	25.78	27.02	31.77	34.56	33.59	31.83	34.07	34.99
6	0.00	12.55	14.79	16.51	18.15	18.82	20.38	21.47	20.82
7	0.00	5.29	6.80	7.37	8.79	9.32	9.93	9.70	10.63
8	0.00	5.21	6.65	7.79	8.45	8.05	8.60	9.57	10.05

*Note: Color change related to initial state ; * The explanation of variants is provided in Table 1.*

4 Conclusion

The conditions under which food is stored have a significant impact on its physical and chemical properties. The results demonstrate that the most significant alterations in the color of Tuzemák occur when stored in a transparent glass bottle under LED fluorescent lighting and at room temperature. In contrast, the changes are more gradual when stored without light in a dark bottle and at low temperature.

As the majority of producers package spirits in clear bottles to enhance their products' visual appeal and storage is often at room temperature, it is crucial to indicate at least the basic storage conditions on the labels or to utilize additional, i.e., secondary, packaging to prevent light penetration into the product. This ensures that Tuzemák maintains its desired sensory properties.

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