Optical properties of sea buckthorn drinks as the main physical characteristic of their quality

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Abstract. The hue and color intensity are referred to optical properties of soft drinks made from fruit and berry raw materials that are crucial for control of their quality and identification. In addition, a natural color of raw materials is attractive for consumers since it provides a more appealing natural appearance to the drink. Sea buckthorn drinks are prone to browning during storage due to the specific chemical composition of berries, which necessitates the control of their optical properties. The study aimed to investigate optical properties of different groups of sea buckthorn drinks during storage, namely clarified juice and dry wine material made from sea buckthorn of the Chuiskaya variety, and to establish the possibility of using some calculated parameters that characterize the drink color in techno-chemical control practices. Optical properties of drink samples were determined with a UV-1800 spectrophotometer, and the values obtained were used to calculate the parameters of intensity, hue, and yellowness. It is shown that physical methods can be used to control optical properties of sea buckthorn drinks in order to objectively assess the color as one of the basic organoleptic parameters of drink quality. It is established that the results of optical analysis are consistent with visual assessment of the sea buckthorn drink samples during storage, which opens up prospects for implementation of this research method in the laboratories of enterprises involved in processing of sea buckthorn to produce various groups of drinks.

1. Introduction

Optical properties of drinks, namely the intensity, hue, and yellowness, are the main objective physical characteristics of drinks, and should be basic to control their quality and identification. For the consumer, these parameters contribute to formation of consumer preferences due to ‘recognition’ of the drink. In addition to a psycho-emotional and physiological effect of color properties of drinks on the consumer
[1], there is some evidence that the drink color significantly affects the consumer’s ability to correctly identify taste and form clear taste profiles and preferences, and also dominates over other sources of information on taste, including product description [2, 3]. The main trend in the Russian beverage industry, including non-alcoholic drinks, is the use of fruit and berry raw materials and semi-finished products, which impart additional functional properties to drinks that, according to market experts, should be in harmony with color and taste sensations excited by the drink. A natural color of raw materials additionally attracts consumer’s attention due to natural appearance formed.

An objective way to assess the appearance of drinks is to study optical, or so-called, chromatic parameters, such as color intensity and hue, as well as color coordinates in the CIELAB system [4–9]. The data of measurement of the chromatic parameters of drinks can be used to calculate such parameter as yellowness of color, which has recently been widely introduced into the practice of quality control of numerous food products and characterizes the degree of color change of white (transparent) sample to yellow one [10–12].

The need to control optical properties of sea buckthorn drinks is largely due to chemical composition of berries. First, sea buckthorn berries are rich in phenolic compounds of various classes, many of which are quite reactive to participate in polymerization and condensation reactions with subsequent formation of dark-colored products; second, sea buckthorn berries are rich in ascorbic acid, which binds oxygen and prevents a deep course of oxidative processes associated with the change in the drink color. However, the presence of a large number of metal ions, acids and other compounds in the products, and the impact of thermal energy, significantly increases the rate of ascorbic acid degradation. Spontaneous dehydration and decarboxylation may form furfural, a compound that is an intermediate of melanoidinogenesis reaction that causes food darkening.

The technology developed should meet expectations of consumers of food products and provide rational use of agricultural raw materials [13, 14].

The aim of the study was to investigate optical properties of different groups of sea buckthorn drinks during storage to establish the possibility of using some calculated drink color parameters in technological control practices.

2. Materials and methods

The objects of the study were clarified sea buckthorn juice (titratable acidity 4.5±0.1 g/dm$^3$, sugar content 90.0±2.5 g/dm$^3$), dry sea buckthorn wine material (strength 11.7±0.5 % vol., sugar content 1.5±0.3 g/dm$^3$), and liquor wine (strength 21% vol., sugar content 210 g/dm$^3$) produced from sea buckthorn of the Chuiskaya variety (harvest of 2018, place of raw material harvesting – the city of Barnaul, M.A. Lisavenko Scientific-Research Institute of Horticulture of Siberia). Juice was clarified with bentonite at a dosage of 3.5 g/dm$^3$ followed by filtration through a filter paper retaining particles of 1 μm. The wine material was prepared by fermentation with Oenoferm yeast (LW 317-28 race by Erbslöh Geisenheim AG, Germany) followed by clarification with bentonite at a dosage of 2.5 g/dm$^3$ and filtration. Liqueur wine was made by blending wine material with sugar syrup (67.5% solids) and rectified ethyl alcohol.

The optical properties of the studied samples of sea buckthorn drinks were determined in accordance with the current OIV recommendations [15, 16] using a UV-1800 spectrophotometer (Japan, Shimadzu). The optical properties obtained for the drinks were used to calculate the following values:

- the value of the parameter of color intensity defined as the sum of values of the drink absorption at wavelengths of 420, 520 and 620 nm ($I$):

$$I = A_{420} + A_{520} + A_{620},$$

(1)

- the value of the hue parameter of the drink color determined as the ratio of the drink absorption measured at wavelengths of 420 and 520 nm (N):

$$N = A_{420} / A_{520},$$

(2)
the value of the parameter of yellowness of color (G, %) determined by equation [49]:

$$G = \frac{1.28X - 1.06Z}{Y} \times 100$$  \hspace{1cm} (3)

where $X$, $Y$ and $Z$ are the color coordinates in the CIELAB coordinate system:

$$X = 0.42 \cdot T_{625} + 0.35 \cdot T_{550} + 0.21 \cdot T_{445}$$  \hspace{1cm} (4)

$$Y = 0.20 \cdot T_{625} + 0.63 \cdot T_{550} + 0.17 \cdot T_{495}$$  \hspace{1cm} (5)

$$Z = 0.24 \cdot T_{495} + 0.94 \cdot T_{445}$$  \hspace{1cm} (6)

where $T_{625}$, $T_{550}$, $T_{445}$, $T_{495}$ are transmittance determined relative to distilled water at appropriate wavelengths, %.

3. Results and discussion

Figure 1 shows the dynamics of color intensity during storage of test samples in the dark for 52 weeks at a temperature of 22±2 °C and relative humidity of 60±5%.

![Figure 1. Dynamics of color intensity of sea buckthorn drink samples during storage.](image)

During storage, the color intensity increases, but the drink color visually changes compared to the color observed at the initial period of storage, which becomes apparent only after 20–30 weeks of storage (1.12–1.18-fold increase in the color intensity). It can be noted that color intensity in sea buckthorn drinks containing sugar increases slower, which is probably due to the preservative activity of sugars reported in [17].

The changed color hue of drinks during storage is primarily associated with a decrease in its absolute value (figure 2).

Similar to the color intensity, a sharper change in the color hue was found for dry wine material made from sea buckthorn when determining this parameter for the drink samples. In the absence of high concentration of sugars in the drinks, which is sufficient to affect oxidative processes, the degradation of ascorbic acid and condensation of polyphenolic substances are likely to dominate.

Another optical parameter that shows the drink color is yellowness; however, generally accepted norms for this parameter are set for grape wines only, and the yellowness parameter therefore cannot be
used to assess the condition of drinks made from fruit and berry raw materials, including sea buckthorn. However, the yellowness parameter was calculated for the drink samples (figure 3).

Figure 2. Dynamics of color hue of drink samples during storage.

Figure 3. Dynamics of yellowness of color of sea buckthorn drinks during storage.

The obtained results of visual assessment of the drink samples during storage showed a higher intensity of brown hue in the sample of dry sea buckthorn wine material, which is completely consistent with the data on the increase in yellowness presented in figure 3.

Calculation of the trichromatic parameters of wine (XYZ color coordinates) and the $X$ and $Y$ coordinates (the CIELAB coordinate system) showed a more intense shift of the $X$ coordinate (chromatic green-red axis), while the $Y$ coordinate (chromatic yellow-blue axis) practically does not shift (figure 4, a, b).
4. Conclusion

Thus, the results of our studies showed that physical methods can be used to evaluate the optical properties of sea buckthorn drinks for an objective assessment of color, one of the basic organoleptic parameters of the drink quality. The results of optical analysis are consistent with the visual assessment of the sea buckthorn drink samples during storage, which opens up potential for implementation of this method in the laboratories of enterprises involved in processing of sea buckthorn to produce various groups of beverages.

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