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THE IMPORTANCE OF VARIETY CHARACTERISTICS IN OBTAINING FOOD COLORANTS FROM THE POMACE SKINS OF WINE GRAPE VARIETIES

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Abstract:
This article examines the methods for extracting natural food colorants from grape skin and their potential applications. Grape skin is rich in anthocyanins, flavonoids, and other bioactive compounds, making it a sustainable alternative to synthetic dyes in the food industry. Various extraction methods, including solvent-based and enzymatic techniques, are compared in the article. Factors affecting the stability of the extracted colorants and their storage conditions are also analyzed. These natural colorants not only impart color to food products but also enhance their functional properties. The study’s findings contribute to the promotion of eco-friendly technologies through the widespread use of colorants derived from grape skin.

Keywords: Grape skin, Anthocyanin, Natural colorants, Extraction, Flavonoids, Food colorants, Stability, Enzymatic methods, Eco-friendly technologies, Food industry.

INTRODUCTION. The color and visual attractiveness of food products are among the most important factors in product evaluation; therefore, modern food technologies involve the use of food colorants for coloring or restoring color in the production of various food products [1–3]. Food colorants are classified into natural and synthetic colors [2].

Most synthetic colorants produced industrially possess molecular structures that differ from those of natural compounds and are characterized by higher color stability, a wider range of shades, lower cost, and an extensive raw material base compared to natural dyes. However, the human body is not sufficiently adapted to their metabolism, and the effects of degradation products of these coloring compounds on the biochemical processes of the human body remain insufficiently studied [2].

It should be noted that many synthetic dyes currently used in the food industry were originally synthesized not for food purposes but for dyeing fabrics and other products, as well as for chemical analysis of certain metal cations. For example, the azo dye “tartrazine” (E102), widely used for

imparting yellow color to food products, was initially developed for the analysis of silver cations in aqueous solutions; therefore, it contains “pyridine nitrogen”, which possesses complex-forming properties [4].

The presence of a nitrogen atom with electron-donating properties in the tartrazine molecule enables the formation of complexes with trace element metal cations (cobalt, copper, zinc, magnesium, etc.) in neutral or slightly alkaline environments. This, in turn, may disrupt biochemical processes in the human body, especially in children and elderly individuals.

In this regard, the demand for natural food colorants has been increasing significantly in recent years. To impart red color to food products, natural colorants such as cochineal (E120), anthocyanins (E163), and betanin (E162) are commonly used. Among them, anthocyanins are considered the most widely distributed.

Anthocyanins are natural pigments found in the flowers, fruits, and leaves of plants, giving them red, blue, purple, and black colors. Anthocyanins belong to the polyphenol group and possess strong antioxidant properties. These compounds serve not only as important protective agents for plants but are also beneficial for the human body due to their anti-inflammatory effects, prevention of cardiovascular diseases, and immune-enhancing properties.

Materials and Methods. In this study, the grape varieties “Magarachskiy,” “Muskat Rozoviy,” “Tashkentskiy,” “Saperavi,” “Khindogni,” “Qora Mayskiy,” “Qora Kishmish,” and “Rkatsiteli”, cultivated in the Qibray district of Tashkent region, were selected. These grape varieties were extracted using a rotary evaporation unit (model: RE100-Pro). Water was used as the extraction solvent during the extraction process. In this study, grape density, anthocyanin and flavonoid content (polyphenolic compounds), and sugar content were evaluated. The hard or soft texture of grapes also affects the extraction process. Harder grapes may contain higher amounts of coloring compounds. Therefore, grape density was determined using a penetrometer. Anthocyanin and flavonoid contents were analyzed by HPLC (High-Performance Liquid Chromatography). Sugar content was determined by the refractometric method using a field refractometer.

The main objective of this study was to determine the efficiency of the varieties “Magarachskiy,” “Muskat Rozoviy,” “Tashkentskiy,” “Saperavi,” “Khindogni,” “Qora Mayskiy,” “Qora Kishmish,” and “Rkatsiteli” for obtaining red food colorants. For this purpose, grape berries of each variety were separated from their stems and 1.5 kg of each variety was collected in equal amounts. The grape fruits were initially crushed using a “Vestel 8500” hand blender.

Water was selected as the extraction agent in the study. The reason for selecting water was that, firstly, it is non-toxic and therefore considered safe for food industry applications. Secondly, compared with other solvents, such as ethanol, water is a more economical solvent.

Temperature and extraction time are among the most important factors affecting the extraction of anthocyanins from grapes using water. To ensure maximum transfer of anthocyanins into water, the process should be carefully controlled because prolonged extraction time and high temperatures may lead to pigment degradation. An extraction period of 4–12 hours is generally considered optimal. Longer extraction times (for example, 24–48 hours) may enhance complete pigment release; however, they can also result in pigment degradation, especially at elevated temperatures.

A temperature range of 50–70°C was found to be effective. At temperatures of 80°C and above, anthocyanins are at risk of chemical degradation. At lower temperatures (20–30°C), the process becomes slower and pigment extraction efficiency may decrease.

The addition of small amounts of citric acid or acetic acid to maintain the pH within the range of 3–4 increases anthocyanin stability. Neutral pH conditions (pH 7) may reduce extraction efficiency.

Based on the above considerations, the crushed grape mass was kept in water for 10 hours. The pH of the extraction mixture was maintained between 3 and 4. Initially, the extraction mixture was heated to 70°C. To maintain the extraction temperature within the range of 50–70°C, the mixture was reheated to 70°C every 2.5 hours, or approximately every 150–160 minutes.

Results and Discussion. The main objective of this study was to determine the efficiency of the varieties "Magarachskiy," "Muskat Rozoviy," "Tashkentskiy," "Saperavi," "Khindogni," "Qora Mayskiy," "Qora Kishmish," and "Rkatsiteli" for obtaining red food colorants. Based on this objective, the morphobiological and physicochemical characteristics of the selected varieties were investigated during the study. Within the framework of morphobiological characteristics, the fruit color, skin thickness, and surface texture (smooth or rough structure) of the grape berries were examined. The physicochemical properties studied included sugar content (measured in °Brix), acidity, mineral composition, vitamins, polyphenolic compounds, and fruit density.

The purpose of considering these indicators in the study was to evaluate their influence on the color extraction process. The morphobiological characteristics of grape varieties are considered important factors in obtaining food colorants. For example, grape color is one of the main determining factors in the production of food dyes. Red grape varieties are of particular importance compared to other varieties because their skin and pulp contain various anthocyanins, which serve as red pigments [7].

Table 1. Morphobiological characteristics of the varieties selected for the study

Varieties	Color	Skin thickness	Skin texture
Magarachskiy	Black	Thick	Smooth
Muskat Rozoviy	Dark red	Thin	Smooth
Tashkentskiy	Black	Thick	Smooth
Saperavi	Dark blue	Very thick	Rough
Khindogni	Dark blue	Medium thick	Rough
Qora Mayskiy	Dark blue	Thick	Coarse
Qora Kishmish	Black	Thin	Smooth
Rkatsiteli	Golden yellow	Thin	Smooth

Color pigments in grape skins (anthocyanins and flavonoids) are considered the main sources of food colorants. Red and dark-colored grape varieties are preferable for obtaining high-quality dyes because they contain higher amounts of anthocyanins.

Thick skins may complicate pigment extraction because they contain more cell wall material. These cell walls can slow down the extraction of pigments. At the same time, thick-skinned grape varieties may contain higher pigment concentrations, which provides the possibility of obtaining larger amounts of colorants.

Smooth skins facilitate pigment extraction because the cell walls create less mechanical resistance during the extraction process. In contrast, pigments from rough or coarse-textured skins may require stronger physical or chemical treatments for efficient extraction.

The physicochemical properties of grape fruits, including sugar content, acidity, minerals, vitamins, polyphenolic compounds, and fruit density, are considered major factors in the production of food colorants.

Table 2. Biochemical characteristics of the varieties selected for the study

Variety	Sugar content (°Brix)	Titratable acidity (g/L)	Vitamins* (g/kg, based on dry matter)	Fruit density (g/cm³)	Polyphenolic compounds* (g/kg, based on dry matter)
Magarachskiy	18.5	4.6	2.9	0.9	75.3
Muskat Rozoviy	17	5.5	3.0	0.8	65.5
Tashkentskiy	17	5.1	2.9	0.8	61.3
Saperavi	19	5.5	3.1	1.1	89.9
Khindogni	18	4.9	2.8	0.9	64.1
Qora Mayskiy	17	4.6	2.5	0.8	64.5
Qora Kishmish	15	4.3	2.9	0.7	59.3
Rkatsiteli	14	6.7	3.0	0.6	60.0

* **Polyphenolic compounds** (anthocyanins, flavones, and flavonols) were determined relative to the **total mass of the grape fruit** (pulp, seeds, and skin).

* **Vitamins** were determined relative to their **total content**.

Sugar content (mainly glucose and fructose) affects the extraction process in two ways. First, sugars may slow down the oxidation of anthocyanins and contribute to their stable preservation. Second, fruits with high sugar content have increased liquid viscosity, which may somewhat hinder the complete release of anthocyanins. Therefore, for optimal extraction, dilution of the juice or enzymatic degradation of sugars is recommended.

Titratable acidity affects color stability and the extraction of grape pigments (such as anthocyanins). Acidity ensures the chemical stability and microbiological safety of fruit colorants. Low acidity may lead to rapid color loss, whereas high acidity helps maintain color stability.

Vitamins are among the important factors in obtaining food colorants from grapes. In particular, vitamin C (ascorbic acid) protects pigments from oxidation and extends the storage life of the colorant. Vitamins increase the functional value of the coloring product because of their health benefits. Vitamins B and A are also important in increasing the functional value of the product, although their direct effect on color stability is lower.

Density reflects the degree of grape maturity and dry matter content. Riper and denser grapes may contain higher concentrations of anthocyanins. Grape density provides information about the ratio between water and dry matter (sugars, acids, and polyphenols). High density indicates the presence of greater amounts of pigments and compounds necessary for colorant production. Low density indicates that grapes contain more water, which may reduce pigment concentration.

Polyphenolic compounds (anthocyanins and flavonoids) are the natural coloring pigments of grapes and constitute the main source for colorant production. Polyphenols are used as pigments and also possess antioxidant properties, which further enhance the medical and functional value of the coloring product.

According to the results of the conducted study, the “Saperavi” and “Magarachskiy” grape varieties produced food colorants of higher quality and greater quantity. The food colorants obtained from “Muskat Rozoviy,” “Tashkentskiy,” “Khindogni,” and “Qora Mayskiy” varieties showed relatively similar yields. The lowest food colorant yield was obtained from the “Qora Kishmish” and “Rkatsiteli” varieties.

The following table presents the amount of powdered food colorant obtained from the selected varieties used in the study.

Table 3. Quantitative indicators of food colorants obtained from different grape varieties

Variety	Amount of fruit used for extraction (kg)	Volume of solvent (L)	Obtained food colorant (powder form, mg)
Magarachskiy	1.5	2	5120
Muskat Rozoviy	1.5	2	4750
Tashkentskiy	1.5	2	4700
Saperavi	1.5	2	5200
Khindogni	1.5	2	4800
Qora Mayskiy	1.5	2	4445
Qora Kishmish	1.5	2	4151
Rkatsiteli	1.5	2	3970

From the above results, it can be concluded that among the morphobiological characteristics of the varieties, color and skin thickness are factors influencing the extraction of food colorants. A larger amount of food colorant was extracted from varieties with dark black and dark blue (nearly black) colors and thick skins. The study found that the skin structure was not of significant importance. In particular, although the “Magarachskiy” variety had a smooth skin structure, it showed much higher efficiency compared with other smooth-skinned varieties. In contrast, although the “Qora Mayskiy” variety had a rough skin structure, a lower-than-average amount of food colorant (4445 mg) was extracted from it.

During the study, it was confirmed that among the physicochemical characteristics of the varieties, sugar content, polyphenolic compounds, and fruit density are the main factors in obtaining food colorants.

From the two varieties with the highest sugar content, “Saperavi” (19) and “Magarachskiy” (18.5), 5200 mg and 5120 mg of powdered food colorant were extracted, respectively. In general, based on the colorant yield, the varieties can be divided into three groups: varieties with high colorant yield — “Saperavi” and “Magarachskiy”; varieties with medium colorant yield — “Muskat Rozoviy,” “Tashkentskiy,” “Khindogni,” and “Qora Mayskiy”; and varieties with low colorant yield — “Qora Kishmish” and “Rkatsiteli.” Sugar content indicators were also recorded in accordance with these results.

It was found that polyphenolic compounds are the factor that has the greatest influence on the yield of food colorant. For example, the varieties with the highest content of polyphenolic compounds, “Saperavi” (89.9 g/kg, based on dry matter) and “Magarachskiy” (75.3 g/kg, based on dry matter), also showed the best results in terms of food colorant yield (Table 3).

Although fruit density, vitamin content, and titratable acidity are considered important factors in extracting food colorants from grape fruits, evaluating their influence on colorant production requires further in-depth research. For example, some researchers have noted that density has a positive effect on food colorant production. However, in our study, varieties with the same or similar density, vitamin content, and titratable acidity showed different food colorant yields (Table 3).

Conclusion. In general, it can be concluded that although fruit density, anthocyanin and flavonoid content (polyphenolic compounds), and sugar content are important factors in extracting food colorants from grape fruits, variety-specific characteristics also have particular importance. Determining exactly which variety-related factors affect the quality and quantity of colorant production requires further in-depth research. To provide a more accurate explanation of these results, all variety-specific factors should be considered in future studies.

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