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NUTRIENTS CONTENT IN FRUITS OF VARIETIES AND HYBRIDS OF GUELDER ROSE (VIBURNUM OPULUS L.) IN CONDITIONS OF THE WESTERN SIBERIAN SOUTH

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Guelder rose (V. opulus L., 1753) is a rare garden crop widespread throughout Russia. It is a valuable food and medicinal raw material due to its rich chemical composition. It contains biologically active phenolic compounds, pectin substances, triterpenoids, polysaccharides, carbohydrates, organic acids, and macro- and micro-elements.

The study aimed to investigate the content and variability of soluble solids (SS) and sugars in fruits of V. opulus L. in the conditions of the South of Western Siberia. The research objects are fruits of V. opulus L. of 2 varieties (Taezhnye Rubiny and Avrora) and 15 hybrids. The authors employ the Taezhnye Rubiny variety as a control.

The SS content has been determined by the refractometric method and the mass content of sugars – by direct titration of an aqueous extract. The authors calculate Selyaninov's hydrothermal coefficient (HTC) to characterize the growing season. The limits are determined for the accumulation of SS (from 10.2% to 18.2%) and sugars (from 7.3% to 10.0%) and the variability of these features (14% and 10%, respectively).

The number of genotypes with a stable accumulation of SS identified over the years is 82%, and that with high sugar content (8.6%–10.0%) is 35%. The analysis reveals an average adverse correlation between HTC and the accumulation of SS (r=-0.62) and sugars (r=-0.34) in fruits and a strong dependence of these biochemical features on HTC in control (r=0.93, r=0.95).

Keywords: *fruits; guelder rose; soluble solids; sugars; variability of features*

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СОДЕРЖАНИЕ ПИТАТЕЛЬНЫХ ЭЛЕМЕНТОВ В ПЛОДАХ СОРТОВ И ГИБРИДОВ КАЛИНЫ ОБЫКНОВЕННОЙ (VIBURNUM OPULUS L.) В УСЛОВИЯХ ЮГА ЗАПАДНОЙ СИБИРИ

И.Д. Бородулина, И.В. Ершова

Калина обыкновенная (V. opulus L., 1753) – это редкая садовая культура, широко распространенная на всей территории России. Калина является ценным пищевым и лекарственным сырьем благодаря богатому химическому составу. Она содержит биологически активные фенольные соединения, пектиновые вещества, тритерпеноиды, полисахариды, углеводы, органические кислоты, макро- и микроэлементы. Целью настоящих исследований стала оценка содержания и изменчивости растворимых сухих веществ и сахаров в плодах калины обыкновенной в условиях Юга Западной Сибири. Объекты исследования – плоды V. opulus L. 2 сортов (Таежные Рубины и Аврора) и 15 гибридов. В качестве контроля авторы используют сорт Таежные Рубины. Содержание СВ определяли рефрактометрическим методом, а массовую долю сахаров – прямым титрованием водной вытяжки. Авторы рассчитали гидротермический коэффициент Селянинова (ГТК) для характеристики вегетационного периода. Определены пределы накопления СВ (от 10.2% до 18.2%), сахаров (от 7.3% до 10.0%), и изменчивость этих признаков (14% и 10% соответственно). Количество выявленных генотипов со стабильным накоплением СВ по годам составляет 82%, с высоким содержанием сахаров (8.6%–10.0%) – 35%. Анализ выявил среднюю неблагоприятную корреляцию ГТК с накоплением СВ (r=-0.62) и сахаров (r=-0.34) в плодах и сильную зависимость этих биохимических показателей от ГТК в контроле (r=0.93, r=0.95).

Ключевые слова: *плоды; калина; растворимые сухие вещества; сахара; изменчивость признаков*

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Introduction

One introduces the *Viburnum opulus* L. due to several factors, which attribute significant status to the plant among unusual fruits and berry species. Its extensive habitat includes the entire European part of Russia, the Caucasus, the Urals, and Western and Eastern Siberia [10]. *Viburnum opulus* L. is frost-hardy and low-maintenance in terms of soil fertility. It exhibits high productivity potential and excellent decorative qualities, which makes it widely utilized in landscaping. For a long time, it has been used as a food and medicinal plant. Diversified application of *V. opulus* L. in orthodox and traditional medicine is due to the rich biochemical composition of its fruits and other parts of the plant and a complex of biologically active substances (BAS), including antioxidants [20]. In addition to sugars (primarily glucose and fructose) and organic acids (malic, formic, acetic, valerian, etc.), guelder rose fruits are a rich source of carotenoids, pectin and tannins, bioflavonoids, vitamins (C, E, P, B2), and macro- and micro-elements (phosphorus, iron, manganese, zinc, copper, etc.). The fruits of *V. opulus* L. exhibit anti-inflammatory, antibacterial, antiradical, antispasmodic, hypotensive, diuretic, and other types of pharmacological effects. Many papers focus on the composition, possible use, and effects for human health of viburnum fruits. The results of such studies were presented by different authors, such us L.N. Skrypnik et al. [21], G.N. Dubtsova et al. [18], O. Demchenko [17], D. Kajszczak, M. Zakłos-Szyda and A. Podsędek [19], M. Zakłos-Szyda et al. [22]. The current paper focuses on studying the biochemical composition of unique hybrids of guelder rose, which is significant for breeding work when creating varieties of this crop. Such studies can be found in the scholarly literature, but to a greater extent, they relate to the research of wild species rather than breeding material.

V. opulus L. introduction in Russia started at the Lisavenko Research Institute of Horticulture for Siberia (RIHS), Altai Federal Scientific Center for Agrobiotechnology, in 1970. The fruits of the initial seven varieties used for technical purposes were slightly bitter and exhibited a high content of biologically active substances, which determined the further selection of *V. opulus* L. [2]. The selection obtained the varieties among open-pollinated seedlings of local (Altai) wild *V. opulus* L. species. They were included in the State Register and approved for use throughout Russia. Later, along with analytical selection, the varieties and the selected forms were hybridized. The current selection of *V. opulus* L. at RIHS aims at obtaining high-yield, frost-hardy, disease- and pest-resistant varieties with ample fruits and improved taste. Promising forms are selected through a comprehensive assessment of the priority economic and biological features and the nutritional and vitamin value of fruits.

As mentioned above, guelder rose fruits have increased their nutritional value. They are traditionally consumed in fresh and processed products (compotes, marmalade, marshmallow, jelly, liqueurs, and sauces) as raw materials for dietary supplements, herbal teas, etc. The rational use of guelder fruit rose for food purposes (food manufacturing or expanding food range) implies a detailed study of the chemical composition and consumer properties of the variety from a particular region. These depend on the genotype, soil, climatic conditions of the region where it grows, pattern of its growing season, etc. Therefore, the study and identification of the features of nutrient component accumulation are highly relevant.

The quantitative content of SS and sugars is one of the significant features of the biochemical composition of fruits, which demonstrates the advantages of the variety, which are often associated with the yield and quality of finished products during the processing.

Materials and methods

The research goal is to analyze the content and variability of SS and sugars in the fruits of *V. opulus* L. under the conditions of the South of Western Siberia. The paper aims at determining the content of soluble solids and sugars, their variation, conducting a correlation analysis of the dependence of nutrients on weather conditions, and identifying genotypes with a stable nutrient content in fruits.

The study has been conducted at the Laboratory of Industrial Technologies, M.A. Lisavenko Research Institute of Horticulture for Siberia, Altai Federal Scientific Center for Agrobiotechnology, in the 2014–2019 period. The research objects are the fruits of *V. opulus* L. of 2 varieties (Taezhnye Rubiny, the control, and Avrora) and 15 hybrids. The authors analyze the fruits at the commercial (physiological) maturity stage in the 1^{st}–3^{rd} thirds of September, taking them from 3–5 trees of each variety and hybrid from different sides and levels of a crown.

The biochemical composition of guelder rose fruits is determined by the refractometric method of measuring the SS content. Moreover, the mass content of sugars is determined by the direct titration of an aqueous extract.

The authors perform statistical data processing utilizing the Microsoft Office Excel 2016 software package. The significance of the differences between the specimens is assessed using the parametric Student’s t-test. The data is considered statistically significant at $p<0.05$. Selyaninov’s HTC is calculated to characterize the growing season.

The growing season in the studied years was warmer and more humid in 2014 (HTC=1.4), hot and insufficiently humid in 2015–2016 (HTC=1.2), and warmer and insufficiently humid in 2018–2019 (HTC=1.2 and HTC=1.1, respectively).

Results

Soluble solids. The SS content in guelder rose fruits depends on weather conditions during the growing season and the biological features of its genotypes [3; 6; 12; 13; 14].

During the studied period, the SS content in guelder rose fruits varies from 10.2% (hybrid 17-6-09) to 18.2% (hybrid 13-34-09), with an average coefficient of variation (V=14%). Seven hybrids exhibit high accumulation of SS (14%–18%): 4-31-08, 17-3-09, 5-2-08, 2-1-08, 5-9-08, 3-19-13, 13-34-09. These genotypes are 6%–37% higher in the SS content than the control (13.3±0.5%) (Fig. 1).

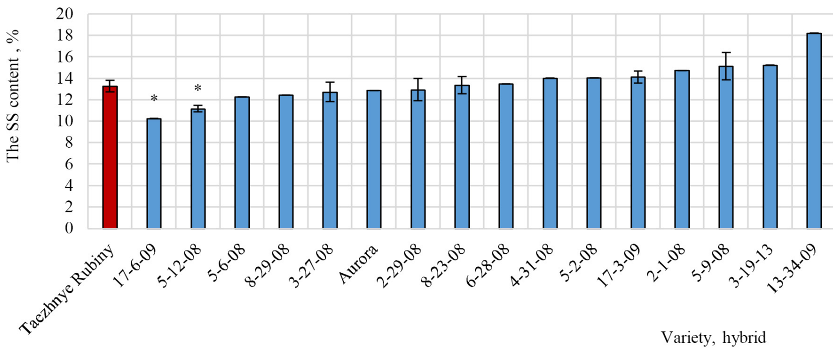

Fig. 1. The SS content in fruits of *V. opulus* L.
Note:*: Significance of variations versus control: * –p<0.05

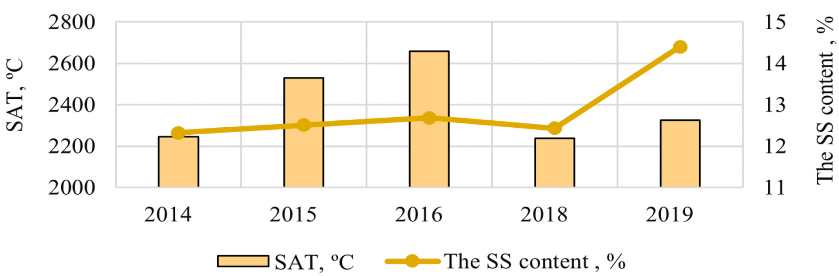

Fig. 2. Dynamics of the SS content in fruits of *V. opulus* L. depending on SAT

A total of 82% of the analyzed specimens exhibit stable accumulation of SS over the years, which has been confirmed by the low variation values (0%–8%).

The average variation in this indicator reported for three hybrids (8-23-08, 8-29-08, and 5-6-08) amounts to 10%, 11%, and 13%, respectively. In terms of the SS content, most guelder rose genotypes do not differ significantly from the control, except for the fruits of hybrids 17-6-09 and 5-12-08 ($p<0.05$).

Many scholars argue that fruits and berry crops tend to accumulate more SS at high values of the sum of active temperatures (SAT) during the growing season [7; 9; 16]. The research does not reveal a correlation between these features in the general population (r=-0.08) (Fig. 2).

The analysis of the correlation between SAT and the SS content in genotypes (Fig. 3) demonstrates a weak positive correlation between features in hybrid 8-23-08 (r=+0.1). Other genotypes display an inverse correlation with the change in the temperature factor: average correlation in hybrids 5-12-8 and 5-6-08 (r=-0.56 and r=-0.30), a strong correlation in the control (r=-0.72), and in hybrids 8-29-08 and 5-2-08 (r=-0.82 and r=-0.87, respectively).

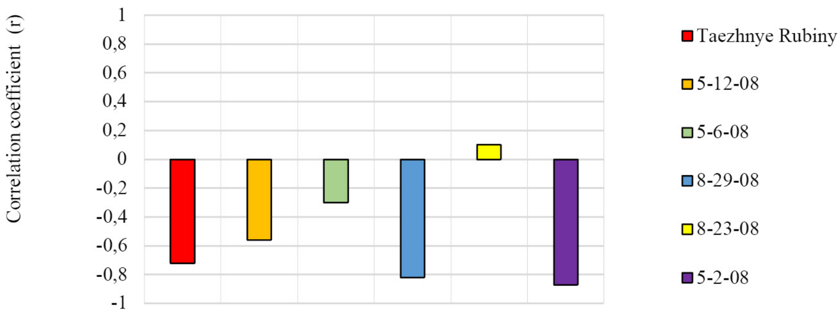

Fig. 3. Correlation coefficient between SAT and the SS content in fruits of *V. opulus* L.

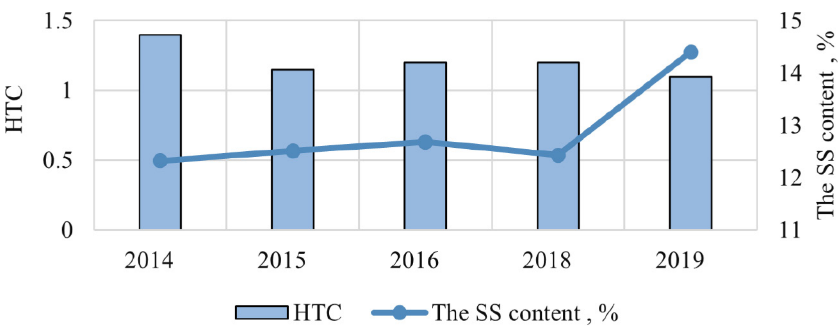

Fig. 4. Dynamics of the SS content in fruits of V. opulus L. depending on HTC in the growing season

The hydrothermal coefficient is highly significant for the accumulation of SS [1]. Statistical data processing demonstrates an average correlation between SS and the water availability coefficient (r=-0.62 [Fig. 4]).

Most studied guelder rose genotypes possess an inverse correlation between SS content and HTC (Fig. 5). A high positive correlation is found only in the control group (r= 0.93). Hybrids 8-29-08, 5-2-08, and 8-23-08 exhibit a solid negative correlation between the biochemical features and the water availability coefficient (r=-0.74…-0.88); hybrid 5-6-08 demonstrate an average correlation (r=-0.65).

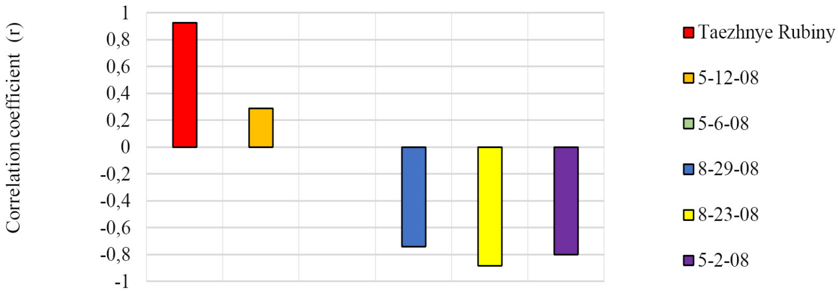

Fig. 5. Correlation coefficient between the SS content in fruits of V. opulus L. and HTC

The analysis reveals the most promising genotypes for further selection: hybrids 5-2-08 and 5-12-08 (5%), Taezhnye Rubiny (7%), and 5-9-08 (9%) demonstrate high stability of SS accumulation; hybrid 13-34-09 possesses the highest SS content (18.2%). A strong correlation is established between the SS content and HTC in Taezhnye Rubiny (r=+ 0.93) and in three hybrids 8-29-08 (r=-0.74), 5-2-08 (r=-0.80), and 8-23-08 (r=-0.88). The effect of SAT on SS accumulation is not revealed.

Sugars. The sugar content in guelder rose fruits is affected by the varietal features of the culture and the plant habitat [4; 6; 8; 11].

During the studied years, the sugar content in fruits of the analyzed genotypes varies from 7.3% (hybrid 4-31-08) to 10.0% (hybrid 13-34-09) with average variation (V=10%). More than 35% of genotypes are sweet-fruited: the sugar content in their fruits exceeds the control level (8.5 ± 0.9%) by 0.1%–1.5%. However, one observes no significant differences between the genotypes and the control. The variation coefficient of this feature in all hybrids and the Avrora variety is insignificant (0%–9%). In the control, it is at the medium level (V=18%).

Numerous studies report a strong correlation between sugar accumulation and SAT in many fruit crops [7; 13; 16]. However, the sugar content in *V. opulus* L. primarily depends on the genotype [11]. The research does not reveal any correlation between sugar content in guelder rose fruits and SAT (r=-0.08) (Fig. 6).\

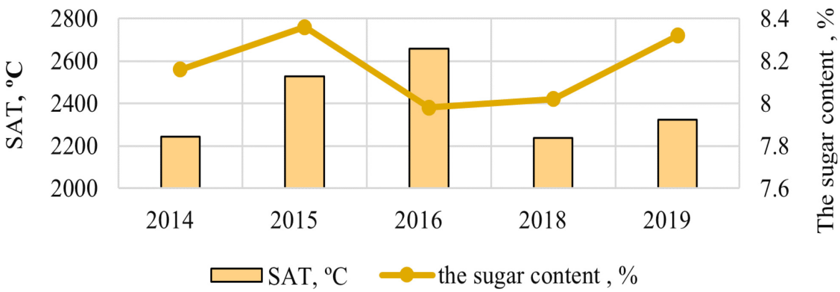

Fig. 6. Dynamics of the sugar content in fruits of V. opulus L. depending on SAT

All genotypes demonstrate an inverse correlation between features: an average adverse correlation is observed in four hybrids: 5-6-08 (r=-0.46), 5-12-08 (r=-0.55), 8-23-08 (r=-0.55), 5-2-08 (r=-0.68), and a high adverse correlation is found for hybrid 8-29-08 (r=-0.92) (Fig. 7).

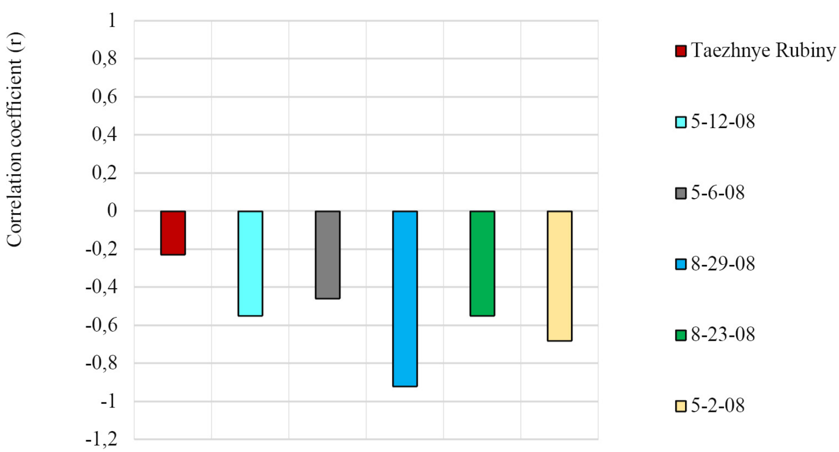

Fig. 7. Correlation coefficient between the sugar content in fruits of V. opulus L and SAT

The hydrothermal coefficient possesses a minor effect on sugar accumulation in guelder fruits, and it occurs due to a weak correlation between the accumulation of fructose and various disaccharides and abiotic factors [11]. The authors establish an average adverse correlation (r=-0.34) between the sugar content in fruits and the water availability coefficient (Fig. 8).

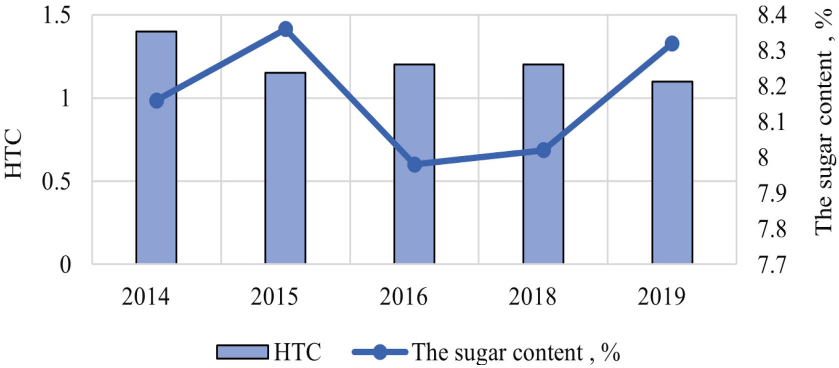

Fig. 8. Dynamics of the sugar content in fruits of V. opulus L. depending on HTC

A strong direct correlation between features is observed only in the control (r=+ 0.95), and an inverse correlation is found for other hybrids: average correlation for three hybrids 5-12-08, 8-23-08 (r=-0.52), 5-6 -08 (r=-0.61), and strong correlation for 2 hybrids 5-2-08 (r=-0.77), 8-29-08 (r=-0.96) (Fig. 9).

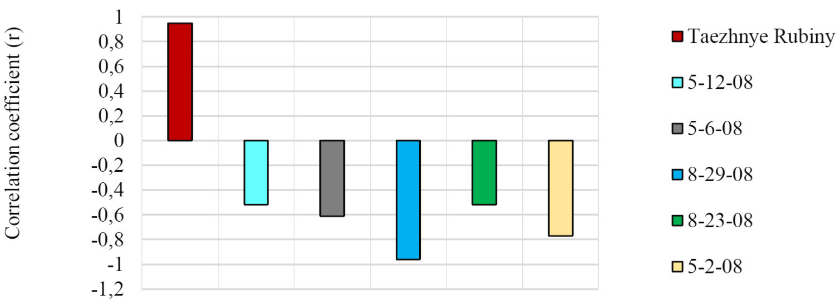

Fig. 9. Correlation coefficient between the sugar content in fruits of V. opulus L. and HTC

Therefore, the authors identify the most promising genotypes for further selection among the studied varieties and hybrids. Hybrids 5-6-08, 5-12-08, and 8-23-08 (V=5%), 5-2-08, 5-9-08, and 8-29-08 (V=9%) are genotypes with high feature stability; hybrids 5-2-08 (r=-0.77) and 8-29-08 (r=-0.96) are genotypes with a strong inverse correlation between the sugar content in fruits and HTC.

Discussion

The evaluation of fruit and berry raw materials is one of the priority areas of research programs primarily targeting the adequate nutrition of the population. Plant raw materials, including berries and fruits, are particularly relevant because of the macro- and micro-nutrients in their composition. Guelder rose growing in different climatic conditions, both within one region and in the country/worldwide, exhibits variability in the accumulation of biologically active compounds, which indicates the adaptive potential of the crop. Incidentally, the SS content in guelder rose fruits in the Voronezh region is 15%–22% [15]. In Belarus, it attains 9.7%–14.2% [5]. The limits set by the authors (10.2%–18.2%) are not inferior to those in the indicated ranges of European regions. The content of sugars accumulated in plants growing in Voronezh (6.5%–10.4%) and Tambov (7.3–9.6%) regions is similar to that recorded in the studied region (7.3%–10.0%). There is an opinion that the SS content in fruits is the most stable chemical feature [1]. The authors' analysis reveals that, in general, SS and sugars are average variable indicators in the population, but the variability of these features in most genotypes is low (up to 10%).

Conclusion

Therefore, in the South of Western Siberia conditions, fruits of *V. opulus* L. in 2014–2019 demonstrated the average variation in the content of SS (V=14%, max 10.2%–18.2%) and sugars (V=10%, max 7.3–10.0%). An average negative correlation has been found between HTC and the accumulation of SS (r=-0.62) and sugars (r=-0.34), as well as a strong effect of HTC on the indicated biochemical features of the Taezhnye Rubiny variety (r=+0.93/r=+0.95).

Stable accumulation of SS over the years is revealed in 14 (82%) genotypes; stable accumulation of sugars is found in six (35%) hybrids. A total of six hybrids (8-29-08, 5-9-08, 6-28-08, 2-1-08, 5-2-08 and 13-34-09) exhibit the high content of sugars (8.6%–10.0%). This factor enables directed selection that targets a stable increase in the sweetness of the fruits of this plant.

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