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Review: EXTRACTION OF ANTHOCYANINS FROM SUMAC FRUITS (*Rhus coriaria* L.) AND EVALUATION OF SOME FACTORS INFLUENCING THEIR STABILITY

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ABSTRACT

This study aimed to extract anthocyanin pigments from sumac (*Rhus coriaria* L.) fruit powder using different solvents, including deionized water, 80% ethanol, and ethanol acidified with 5% citric acid, at various solid-to-solvent ratios (1:10, 1:20, 1:30). Extractions were performed at 30, 50, and 70 °C for 30 and 60 minutes to determine the optimal conditions for obtaining the highest pigment concentration. The study also evaluated the stability of anthocyanins under different pH values (1–9) and storage temperatures ranging from −18 to 100 °C for 60 minutes. Results showed that the best extraction conditions were achieved using ethanol acidified with 5% citric acid at a 1:10 ratio, 70 °C, and 30 minutes, yielding an anthocyanin concentration of 20.67 mg/100 g, based on the least significant difference test (LSD=0.298). Furthermore, lower pH values significantly enhanced pigment stability, with the highest concentration (23.05 mg/100 g) observed at pH 2, which decreased to 8.42 mg/100 g at pH 9. Similarly, lower storage temperatures contributed to greater anthocyanin stability, as the concentration reached 21.06 mg/100 g at −18 °C, while it declined to 4.67 mg/100 g at 100 °C, according to the least significant difference (LSD = 0.298). These findings emphasize the importance of extraction parameters and environmental conditions in optimizing the recovery and stability of anthocyanins from sumac fruits.

1-INTRODUCTION

In recent years, there has been an increasing trend among consumers and subsequently the food industry to replace synthetic additives with natural compounds. Concerns about the negative health effects of some synthetic colours, flavours, and preservatives, as well as the growing demand for “clean” products with simple labels, have been the main drivers of this fundamental transformation [1]. Among them, natural food colours are considered one of the most challenging alternatives, since many natural pigments are not sufficiently stable against food processing and storage factors such as temperature, pH, light, and oxygen [2].

Anthocyanins, as a large and important group of water-soluble pigments, have occupied a special place in this field. These compounds are not only responsible for the attractive red, purple and blue colours in fruits and vegetables, but are also recognized as compounds beyond a simple pigment due to their proven health-promoting properties such as antioxidant, anti-inflammatory and anticancer activities. However, the widespread use of anthocyanins in food product formulations is strongly influenced by their stability [3].

Sumac (Rhus coriaria L.) is a valuable but less studied source for the extraction of anthocyanins. This fruit, which is traditionally used as a spice and also in traditional medicine, has a significant content of phenolic compounds and especially anthocyanins, which are responsible for its deep purple-red colour. Based on the research background, it seems that sumac anthocyanins have a high potential for use in the food industry as a natural colourant as well as a functional ingredient [4].

However, to exploit this potential industrially, two essential steps need to be taken: first, optimization of the extraction method to achieve the highest yield and purity, and second, comprehensive evaluation of factors affecting the stability of extracted anthocyanins under simulated food processing and storage conditions. Factors such as pH, which varies across a wide range of food products, temperature, which is critical in thermal processes such as pasteurization and sterilization, and the presence of other compounds, directly affect the final colour and its shelf life in the product. Therefore, this research was designed with the aim of "extracting anthocyanins from sumac fruit and evaluating some factors affecting their stability". In this study, we extracted these valuable pigments and then examined their stability against key factors of the food industry, including different pH and heat treatments. The results of this research can provide valuable scientific data to food industry professionals so that they can use natural sumac anthocyanins as a healthy and sustainable alternative in the production of products such as beverages, dairy products, configure, sauces and processed meats and take a step towards improving the quality and health of food products.

2-MATERIALS AND METHODS

Sample preparation

During the 2022-2023 agricultural season, ripe sumac (Rhus coriaria L.) fruits were collected in October from sites grown in Akre, Duhok Governorate, Kurdistan Region. The sample was taxonomically documented at the Plant Taxonomy Laboratory, College of Science, University of Kufa. The fruits were cleaned and ground, and the resulting powder was placed in opaque glass containers and stored in a refrigerator (4°C) until subjected to subsequent analytical procedures.

Extracts preparation

The method described by Jaberı et al. (2022) was followed to extract anthocyanin pigments from dried sumac fruit powder, with some modifications, using three solvents: deionized water, 80% ethyl alcohol, and 80% ethyl alcohol acidified with 5% citric acid. The extraction was conducted at three solid-to-solvent ratios (1:10, 1:20, and 1:30, w/v) and three temperatures (30, 50, and 70°C). The mixture was heated on a magnetic hot plate after sealing the beaker opening. The extract was initially filtered through filter paper (Whatman No. 1), after which it was centrifuged at 6000 rpm for 15 minutes. It was then concentrated using a rotary evaporator at 40 °C and subsequently dried in a hotair oven at the same temperature. Finally, the dried extracts were stored in dark containers under lowtemperature conditions until further analysis [5].

Total anthocyanin estimation

The total anthocyanin content in sumac fruit extracts was determined according to the method of AlSharif and Al-Ali (2022). Absorbance was measured using a Scanning UV–Visible Spectrophotometer (SHIMADZU) within the wavelength range of 300–700 nm to identify the maximum absorbance peak (λ max) [6]. The anthocyanin concentration was then calculated using the equation described by Ramadan and El-Hadidy (2015), The results were expressed as milligrams of anthocyanins per 100 grams of dry weight (mg/100 g DW), based on delphinidin-3-glucoside as a reference compound [7]. The concentrated extracts were subsequently stored in dark glass containers under refrigerated conditions until further use.

$$TAC\ (mg/100g) = \frac{A \times DF}{W \times 55.9} \times 100 \quad : (1)$$

Where $TAC\ total\ anthocyanin$ content; A: absorbance DF: inverted dilution; W: weight of the sample.

Analytical study Effect of pH on anthocyanins stability

The procedure described by Huang and Elbe (1986) [8] and later applied by Akther et al., (2020) [9] was employed to evaluate the influence of pH on the stability of anthocyanin pigments extracted from dried sumac fruit powder. Buffer solutions with different pH values (1, 2, 3, 4, 5, 7, and 9) were prepared at a concentration of 0.1 M. Citrate buffer was used for pH values 1–5, phosphate buffer for pH 7, and Tris-HCl buffer for pH 9. A 0.3 g portion of the pigment concentrate was mixed with 10 ml of the respective buffer in 15 ml screw-cap test tubes. The mixtures were kept at room temperature for 30 minutes and subsequently centrifuged at 6000 rpm for 15 minutes. Absorbance was recorded in the wavelength range of 300–700 nm to identify the pH that exhibited the highest absorbance at the anthocyanin maximum wavelength. Pigment concentration was then calculated according to the equation shown in above.

Effect of Temperature on Anthocyanin Stability

The procedure described by Al-Shurait and Al-Ali, (2022) was employed to examine the influence of temperature on the stability of anthocyanins extracted from dried sumac fruit powder [6]. Samples were prepared by mixing 0.3 g of the pigment concentrate with 10 ml of deionized water in screwcap test tubes and exposed to different temperatures (−18, 7, 25, 40, 60, 80, and 100 °C). After 30 min, the mixtures were centrifuged at 6000 rpm for 15 min, and absorbance was measured within the wavelength range of 300–700 nm to identify the temperature providing the highest absorbance at the anthocyanin λ max. Pigment concentrations

were calculated according to the equation described previously.

Statistical analysis Data were analysed by using statistical analyses system, according to CRD (Factorial experiment - ANOVA) to determine the effect of the optimal extraction conditions on the concentration of anthocyanins, and the effect of storage conditions on their stability [10].

3-RESULTS AND DISCUSSION

Optimal conditions for anthocyanin extraction Type of extraction solvent

The results in Figure (1) show that the type of solvent used plays a vital role in improving the efficiency of anthocyanin extraction from sumac fruit improving its qualitative properties, when other extraction conditions were considered. Since the solubility of anthocyanin compounds depends mainly on the polarity of the extraction solvent, the alcoholic solvent acidified with 5% citric acid was the most suitable for the extraction process, with an anthocyanin pigment concentration of 21.413 mg/100 ml at an absorbance value of 1. 710 recorded at the maximum wavelength (λ max) of 527 nm, followed by the alcoholic solvent with a concentration of 19.748 mg/100 ml and an absorbance value of 1.577 recorded at a maximum wavelength of 525 nm. while the aqueous solvent yielded or produced the lowest concentrations for anthocyanin dyes, reaching 16.62 mg/100 ml at an absorbance value of 1.327 recorded at a maximum wavelength of 521.5 nm. Table (1) demonstrates a statistically significant difference ($P \leq 0.05$) in favour of the alcoholic solvent acidified with 5% citric acid, which yielded the highest mean anthocyanin concentration of 16.53 mg/100 ml. In contrast, the aqueous solvent was the least efficient, with an average concentration of 9.61 mg/100 ml. Although the alcoholic solvent recorded a higher mean concentration (10.4 mg/100 ml), the difference between it and the aqueous extract was not statistically significant despite the apparent numerical variation. The least significant difference (LSD) value among solvents was 1.1216. These results highlight the importance of solvent type in enhancing anthocyanin extraction, as these pigments are soluble in polar solvents owing to their chemical structure, which is abundant in hydroxyl and sugar moieties. Glycosidic derivatives are generally more soluble in water, whereas aglycones and glycosides can dissolve effectively in alcohol [11]. Moreover, the addition of organic acids to the solvent enhances pigment recovery by disrupting plant cell walls and facilitating the release of intracellular compounds. Nevertheless, only low concentrations of acid should be employed, since excessive acidity may hydrolyse the glycosidic bonds linking anthocyanins with other molecules such as minerals or copigments. At appropriate levels, acidification contributes to the stability of extracted anthocyanins [12,13]. The results were consistent with those obtained by Jaberı et al. [7] in their study, which relied on the use of different types of solvents, including ethyl alcohol acidified with 2% hydrochloric acid, ethyl alcohol acidified with 2% citric acid, and 2% acetic acid-acidified ethyl alcohol to extract anthocyanin pigments from barberry (Berberis vulgaris L.), an ornamental plant, proving that the best solvent for extraction is ethyl alcohol acidified with 2% citric acid, noting that the use of organic acids in extraction processes enhances the extraction of anthocyanins from the plant by preventing the degradation of glycosidic bonds that may occur due to hydrolysis. The use of acidified solvent also contributes to obtaining the positive flavylium, which is the most stable form of anthocyanin in an acidic medium [5]. The results were consistent with another

study conducted by Mazzara et al., (2023) on five samples of Sicilian sumac collected from different regions to determine their anthocyanin content, which ranged between 2.50 -24.07 mg/g dry weight, estimated on the basis of cyanidin [14].

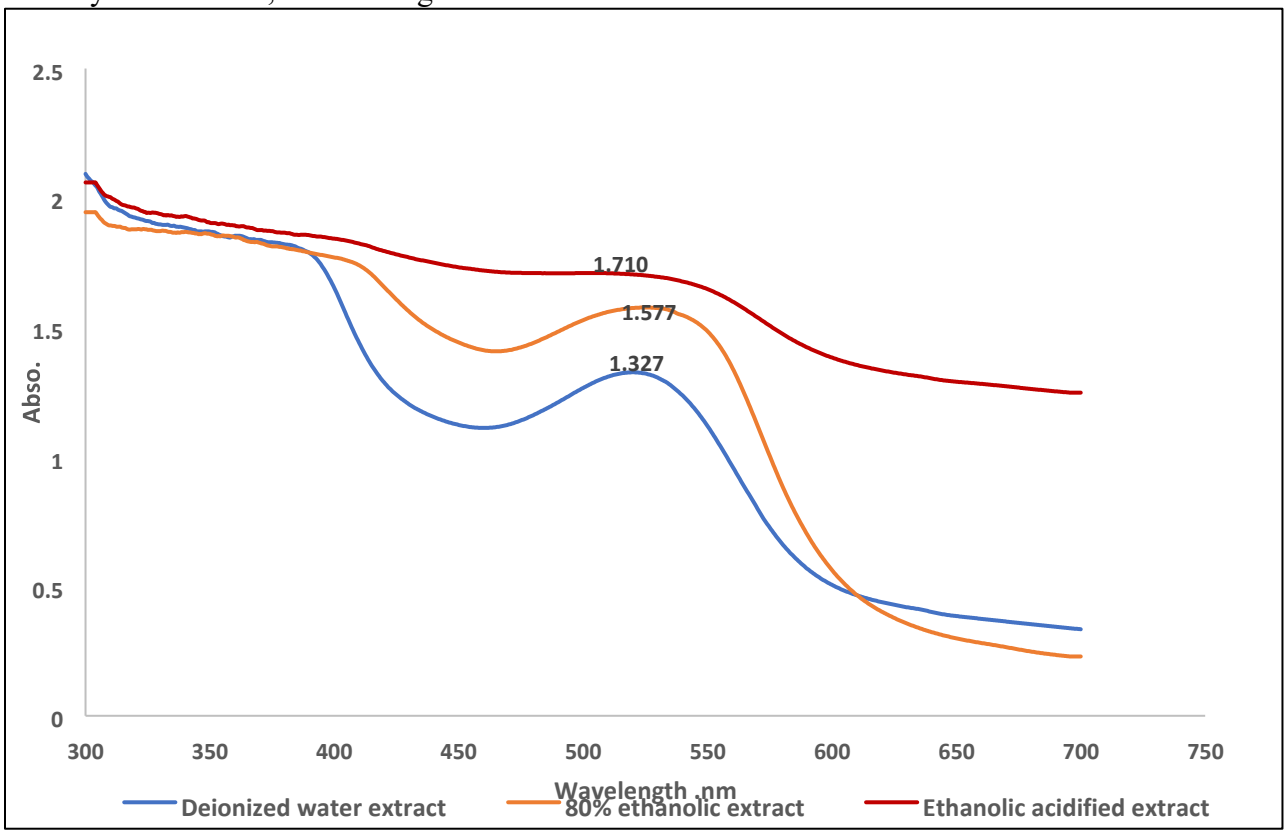

Figure (1). Effect of Extraction Solvent Type on Anthocyanin Absorbance at λ max in Sumac Fruit Extracts

Table 1. Effect of solvent type and mixing ratios on the concentration of anthocyanin pigments extracted from sumac fruit

solvent type	Sample weight (g) / Solvent volume (ml) 1:10	1:20	1:30	mean
aqueous solvent	11.10 c	11.14 c	6.59 d	9.61 B
alcoholic solvent80%	16.80 b	9.63 c	4.63 e	10.35 B
alcoholic solvent acidified with 5% citric acid	20.67 a	18.16 b	10.74 c	16.53 A
mean	16.19 A	12.97 B	7.32 C	

LSD (solvent type) = 1.1216, LSD (interaction)=1.9427, LSD (Solvent volume) = 1.1216

Solvent volume

The results presented in Figure (2) indicate significant differences ($p \leq 0.05$) among the applied solvent-to-sample mixing ratios, with the 1:10 ratio showing a clear superiority over the other ratios in yielding the highest anthocyanin concentration extracted from sumac fruit powder across all tested solvents. The mean yield at this ratio reached 16.19 mg/100 g. This was followed by the 1:20 ratio, which produced a significantly higher concentration than the 1:30 ratio, with a mean of 12.97 mg/100
g. In contrast, the 1:30 ratio recorded the lowest anthocyanin yield, averaging 7.32 mg/100 g. The least significant difference (LSD) value for solvent volume was 1.1216, confirming that the 1:10 ratio is the most efficient for maximizing anthocyanin extraction from sumac powder. Furthermore, the results show in Table (2) demonstrate a significant interaction between solvent type and solvent volume in anthocyanin extraction. The most effective combination was the acidified ethanol solvent (5% citric acid) at a 1:10 ratio, yielding 20.67 mg/100 g. Conversely, the lowest yield (4.63 mg/100 g) was obtained with 80% ethanol at the 1:30 ratio. The LSD value for this interaction was 1.9427, further supporting the conclusion that the 1:10 ratio consistently provided the highest anthocyanin recovery across all solvents tested. These findings are in agreement with those reported by Kossah and Zhang, (2010), who evaluated different solvent-to-sample ratios (5:1, 10:1, 15:1, 20:1, and 25:1) for anthocyanin extraction from sumac fruits, noting that the 15:1 ratio yielded the highest pigment recovery [15]. Similarly, our results are consistent with the study of Aparna et al., (2023), who reported that acidified ethanol (2% citric acid) at a 10:1 ratio produced the highest anthocyanin yield when extracting from mangosteen (Garcinia mangostana L.) peels, reaching 23.54 mg/100 g in fresh peels and 20.83 mg/100 g in dried peels [16]. The decrease in anthocyanin yield observed at higher solvent-to-sample ratios attributed to the dilution effect, whereby solute particles become dispersed in excess solvent, thereby requiring extended extraction time, which could promote anthocyanin degradation or oxidation. Conversely, very low ratios may result in the raw material absorbing much of the solvent, thus limiting diffusion and extraction efficiency. Therefore, selecting an appropriate and balanced solvent-to-sample ratio is essential for optimizing anthocyanin recovery. Additionally, the interaction between solvent type and solvent volume plays a decisive role in determining extraction efficiency, as emphasized by previous reports [14,17,18].

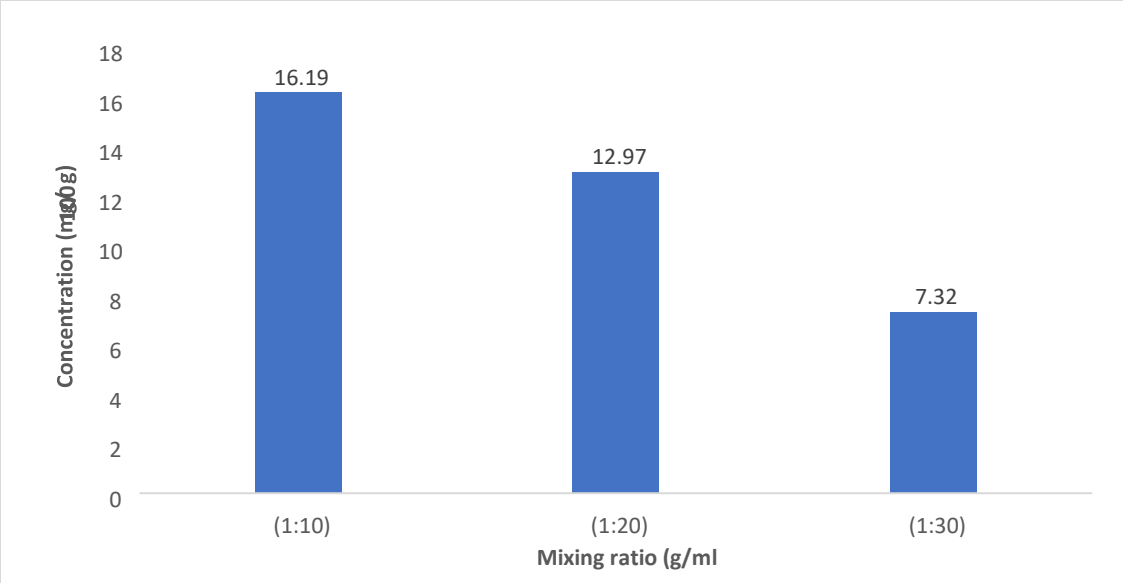

Figure 2. Effect of mixing ratios on the concentration of anthocyanin pigments extracted from sumac fruit powder

Extraction temperature

The results in Table (2) show that the extraction temperature affected anthocyanin production from sumac fruit powder. The highest pigment content (13.23 mg/100 g) was recorded at 70°C, while the lowest content (11.61 mg/100 g) was recorded at 30°C. Although no statistically significant differences were observed between temperatures, the interaction between solvent type and temperature was statistically significant ($p \leq 0.05$). The highest yield (17.59 mg/100 g) was achieved using ethanol acidified with 5% citric acid at 70°C, while aqueous extraction at 50°C yielded the lowest value (8.25 mg/100 g). Increasing the temperature enhanced the release of anthocyanins into aqueous solvents, while ethanol showed the best extraction capacity at 50°C (11.65 mg/100 g), and this capacity declined at higher temperatures. This suggests that moderate heating improves cell wall disintegration and facilitates pigment diffusion, while excessive heating may reduce yield. Khoo *et al*., (20) reported similar results, noting that lower temperatures limited pigment release due to reduced cell wall degradation. Similarly, Li *et al.*, (2019) found that 50°C enhanced anthocyanin extraction from Carissa carandas fruits, while higher temperatures reduced yield through coextraction of interfering compounds [18]. Meng *et al*., (2025) also confirmed that 50°C is the optimal temperature for purple cabbage leaves, attributing this to membrane softening and accelerated pigment release. In contrast, the ethanol extract acidified at 70°C showed superior stability, suggesting that low pH enhances the pigment's resistance to thermal degradation [19]. These results are consistent with Ekici *et al*., (2014), who confirmed that the stability of anthocyanins varies depending on the plant source and extraction parameters such as solvent type, temperature, and extraction duration [20].

Table 2. Effect of extraction temperature on the concentration of anthocyanin pigments extracted from sumac fruit powder

solvent type	Extraction temperature (℃)			mean
	30	50	70	
aqueous solvent	9.13 cb	8.25 c	11.45 cb	9.61 B
alcoholic solvent80%	8.75 cb	11.65 b	10.65 cb	10.35 B
alcoholic solvent acidified with 5% citric acid	16.95 a	15.03 a	17.59 a	16.53 A
mean	11.61 A	11.65 A	13.23 A	

LSD (solvent type) = 1.8558 ,LSD (interaction)= 3.2144, LSD (temperature)= 1.8558

Extraction time

Table (3) demonstrates that extraction time (30 and 60 min) exerted no statistically significant effect on the concentration of anthocyanins recovered from sumac fruit powder (LSD = 1.5383). Although numerical variations were observed, with the highest mean yield recorded at 60 min (12.66 mg/100 g) compared to 30 min (11.66 mg/100 g), the results indicate that equilibrium was essentially reached within the initial extraction period. Extending the duration to 60 min did not contribute to a further significant increase in anthocyanin yield [21]. In contrast, solvent type played a decisive role. The ethanol extract acidified with 5% citric acid produced the highest concentration (16.53 mg/100 g), showing significant superiority ($p \leq 0.05$) over other solvents. This improvement is attributed to the stabilizing effect of citric acid on the flavylium cation and its ability to enhance pigment solubility. The aqueous extract recorded the lowest concentration (9.61 mg/100 g), while the non-acidified ethanol extract yielded 10.35 mg/100 g, without a statistically significant difference between them despite the numerical variation. A significant interaction ($p \leq 0.05$) was also detected between solvent type and extraction time. Acidified ethanol yielded the maximum concentration (16.84 mg/100 g) at 60 min, whereas water at 30 min resulted in the lowest value (8.71 mg/100 g), with an LSD for the interaction of 2.6644. These outcomes are consistent with Karaaslan and Yaman (2017), who emphasized solvent characteristics, solvent-to-solid ratio, temperature, and extraction time as key determinants for optimizing anthocyanin recovery, and who reported that acidified ethanol provided the highest yields under short extraction times (30 min) at room temperature [22]. Comparable findings were reported by Pashazadeh et al., (2025), who identified an optimal extraction time of 40.5 min for anthocyanins from okra (Abelmoschus esculentus) flower [23].

Table (3) Effect of extraction Time on the concentration of anthocyanin pigments extracted from sumac fruit powder

solvent type	Extraction time (minutes)		mean
	30	60	
aqueous solvent	8.71 b	10.51 b	9.61 B
alcoholic solvent%80	10.07 b	10.62 b	10.35 B
alcoholic solvent acidified with 5%	16.20 a	16.84 a	16.53 A

	citric acid		
	mean	11.66 A	12.66 A

LSD (solvent type) = 1.884, LSD (interaction)= 2.6644, LSD (Extraction time) =1.5383

pH effect on anthocyanin stability

The results in Figure (3) show the effect of different pH values on the stability of anthocyanin pigments in sumac fruit powder extract, which was prepared under optimal extraction conditions using ethanol acidified with 5% citric acid as a solvent at a mixing ratio of 10:1 (w/v), at a temperature of 60°C and an extraction time of 60 minutes. Different pH levels (pH1, pH2, pH3, pH4, pH5, pH7, pH8, and pH9) were tested on the anthocyanin extract of sumac fruit powder to determine their effect on the concentration of the extracted pigments within 30 minutes at laboratory temperature and in the presence of light. The results confirmed a significant difference ($p \leq 0.05$) in the effect of different pH values on the concentration of extracted anthocyanin pigments, with the highest average concentration reaching 23.05 mg/100 g at pH2, and the lowest average was 8.415 mg/100 g at pH 9. In detail, we see that low pH values from pH1 to pH 3 were the best in maintaining the stability of the extracted anthocyanin pigments, as the highest averages for anthocyanin concentration ranged between 22. 2-23.05 mg/100 g. This is attributed to the stability of anthocyanin pigments in the form of Flavylium Cation, which is responsible for the red colour and has maximum absorptivity at the wavelengths specific to anthocyanins. And is more stable at pH values below 3, which is consistent with what Saidji et al., (2024) mentioned in their study of the factors affecting the stability of anthocyanins extracted from Hibiscus sabdariffa flowers, noting that the best results for the stability of extracted anthocyanins were obtained at low pH values [24]. The results also revealed a gradual decrease in the average concentration of anthocyanin pigments at pH values of pH4-pH7, ranging from 20.25 to 19.02 mg/100 g, respectively. This can be attributed to the conversion of the positive flavylium cation into other forms that are less stable, such as the quinoidal base which occurs due to the withdrawal of a proton from the hydroxyl group at the 4C or C5 carbon atom in ring B, resulting in a negative charge that causes a change in the distribution of electrons in the anthocyanin molecule and a rearrangement of its structural composition [25]. This, in turn, absorbs light differently than the flavylium cation and produces different colours that range from blue to violet [26] or are pseudocardinal bases, which are mostly produced by the binding of dyes to water molecules [20]. At values where the pH rises above 7, the Chalcone phenomenon may occur phenomenon may occur, which is caused by the decomposition of the carbonyl base, leading to the dyes turning yellow or becoming colorless, thereby reducing the absorbance values, which in turn leads to a decrease in the concentration of anthocyanin dyes [27]. At a pH value of 8, we observed a significant difference in the results, with a slight and unexpected increase in the average pigment concentration of 21.08 mg/100 g compared to a pH value of 7, where the average anthocyanin concentration was 19.02 mg/100 g. This increase may be due to co-pigmentation, a phenomenon where anthocyanins interact with other compounds like minerals or phenols, enhancing their stability [28]. Our results show that anthocyanin pigments are generally more stable in acidic environments, while their concentration and stability decrease in

alkaline or near-neutral environments, indicating their potential use in the manufacture of acidic foods [29].

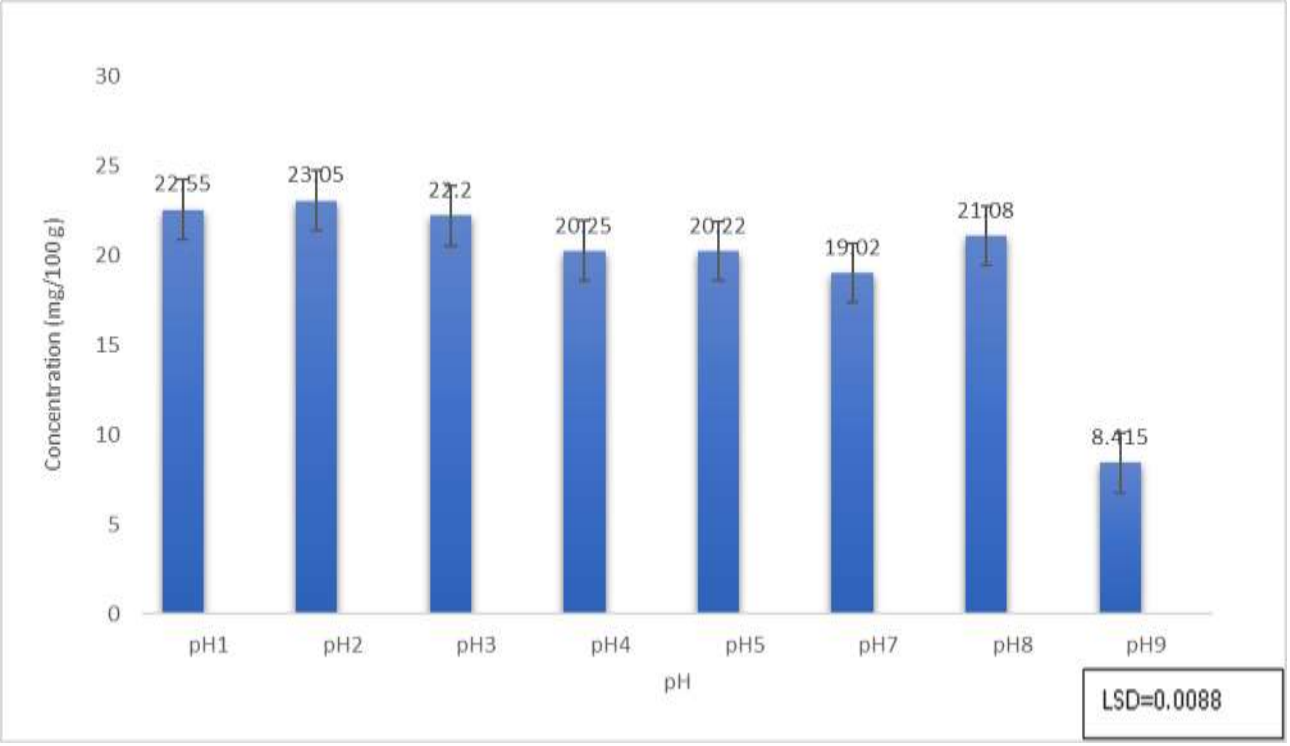

Figure (3) Effect of pH values on the stability of anthocyanin pigments

Temperatures effect on anthocyanin stability

Figure (4) illustrates the effect of different temperatures (−18, 5, 25, 40, 60, 80, 100°C) on the stability of anthocyanin pigments extracted from sumac fruit powder over a period of 60 minutes. The results indicate significant differences ($p \leq 0.05$) due to the adverse influence of heat treatment on the mean pigment concentration. Freezing temperature achieved the highest anthocyanin stability, with a mean concentration of 21.06 mg/100 g, whereas heating at 100°C exerted the most detrimental effect, resulting in the lowest concentration 4.67 mg/100 g. With the least significant difference (LSD) = 0.298, no significant variation was observed between 5°C and 25°C, although cooling 20.84 mg/100 g yielded slightly higher concentrations than room temperature 20.60 mg/100 g. The findings demonstrate that lower or moderate temperatures (−18, 5, 25°C) were more favourable for maintaining anthocyanin stability compared to elevated heat treatments. Notably, significant reductions ($p \leq 0.05$) were observed at 40°C, where the mean concentration decreased from 20.60 to 18.45 mg/100 g relative to room temperature. Further declines were recorded at 60°C and 80°C, with mean values of 17.94 and 14.72 mg/100 g, respectively. A pronounced degradation was evident at 100°C, which produced the lowest anthocyanin concentration. Temperature is therefore one of the most critical factors influencing the stability of anthocyanin pigments. Exposure to elevated temperatures may trigger anthocyanin degradation, lowering both their

concentration and biological activity, including antioxidant potential [30]. This occurs through several mechanisms, particularly Hydrolytic Deglycosylation, since anthocyanins are glycosides composed of a sugar moiety Glycine and a non-sugar moiety (Aglycone) [31]. Under high heat, cleavage of the glycosidic bond converts anthocyanins into anthocyanin, which are less stable and more prone to hydrolytic breakdown [32]. It is also important to note that the degree of anthocyanin sensitivity to heat is influenced by other factors, such as the type of anthocyanin compounds, pH of the medium, and the presence of minerals or sugars that may contribute to pigment stabilization [33,34]. Our results are consistent with the findings of Liu et al., (2018), who reported that lower temperatures and acidic pH values enhanced the stability of anthocyanins extracted from blueberries [35]. Similarly, Aljabary (2023) observed that high heat treatment negatively affected anthocyanin stability in mango peel powder, where heating at 80°C reduced the mean pigment concentration from 2.11 to 1.62 mg/100 g within 30 minutes of treatment [36].

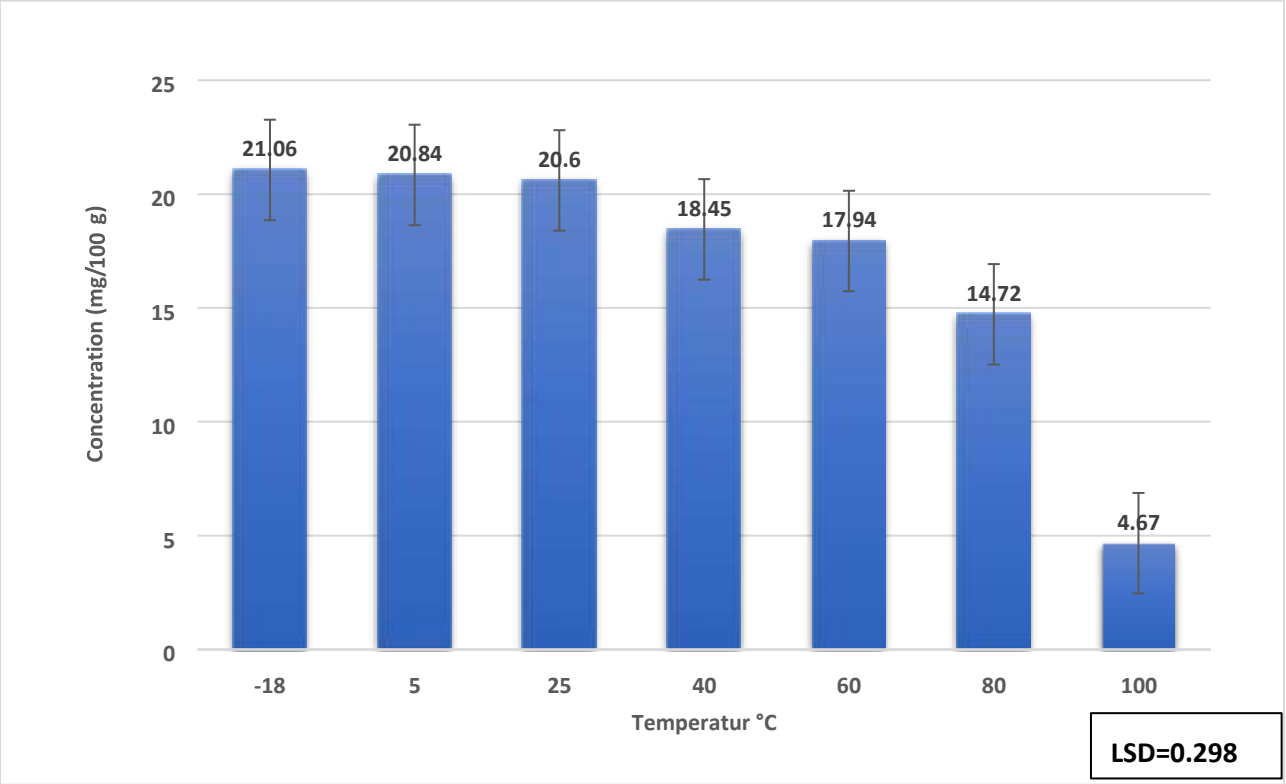

Figure 4. The effect of temperature on the stability of anthocyanin pigments.

4- Conclusion

The results of this study emphasize the importance of extraction parameters and environmental conditions in optimizing the recovery and stability of anthocyanins from sumac fruits. The results show that key optimal conditions included acidified ethanol at a ratio of 1:10, 70 °C, and high stability of anthocyanins at pH 2 and 18 °C. Overall, the findings of this study clearly indicate that the fruit of sumac is a rich and promising source of anthocyanins with high potential for application in the food industry. Although the stability of these valuable pigments is

affected by various factors such as pH and temperature, the precise identification of these critical conditions paves the way for their targeted use. By taking advantage of this knowledge, anthocyanins extracted from sumac can be used as a stable natural colourant and a functional compound in the formulation of a wide range of food products, taking an effective step towards replacing synthetic additives and developing healthier products that meet today's consumer preferences.

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