



## Double beam UV-Vis spectrophotometric determination of sunset yellow (E110) in soft drink and ice cream samples at the local Saudi markets

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### Abstract

The spectrophotometric behavior of sunset yellow (E110) was investigated using quartz cell and distilled water as a solvent; over the wavelength range of 400 nm to 800 nm, spectral band width of 2 nm, speed scan 120 nm/min, Xenon lamp and 2 nm graph high. It was given a well-developed spectrophotometric peak over this wavelength range. The repeatability, stability, calibration curve and detection limit were also evaluated. The concentration of  $5 \times 10^{-5}$  mol L<sup>-1</sup> of E110 was repeated five times for the repeatability study, yielded the relative standard deviation (RSD%) of 0.042%. The stability for the analytical signal of the E110 concentration  $5 \times 10^{-5}$  mol L<sup>-1</sup> was monitored for 90 minutes, resulted the spectrophotometric signals approximately fixed within this period. A calibration curve was studied over the range of  $1 \times 10^{-5}$  -  $1 \times 10^{-4}$  mol L<sup>-1</sup> for the (E110) dye to be resulted in a linear relationship with 0.984 correlation coefficient ( $r^2$ ) for six measurements (n=6). Detection limit (LOD) was calculated to be  $5.77 \times 10^{-8}$  mol L<sup>-1</sup> (0.026 ppm). Spectrophotometric technique was applied for the determination of sunset yellow (E110) in soft drinks and ice cream samples of the local Saudi markets.

*Keywords:* Spectrophotometry, sunset yellow, soft drinks, ice creams, Saudi markets

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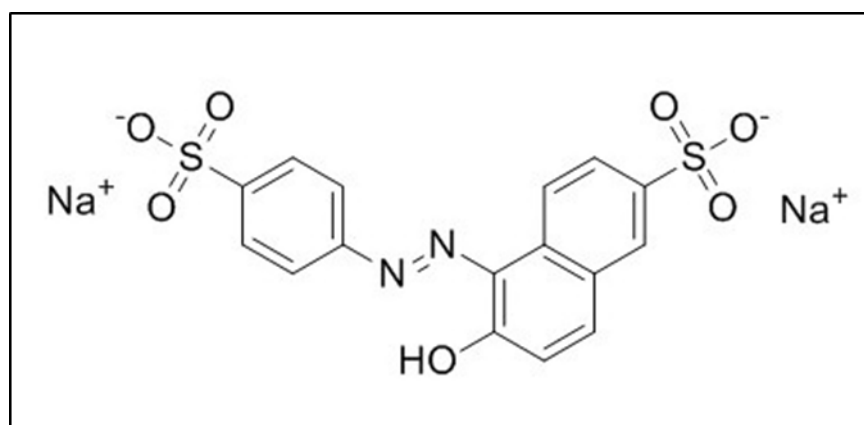
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## 1. Introduction

Spectrophotometry is based on the principle of spectra produced by the component wavelengths of light, spectrophotometry nowadays includes other types of electromagnetic radiation, such as X-ray, ultraviolet, infrared, microwave and radio-frequency radiation spectroscopy. Spectrophotometry is one of the most useful methods for quantitative analysis in various fields such as chemistry, physics, biochemistry and clinical applications [1-8]. A spectrophotometer is an instrument that measures the amount of photons (the intensity of light) absorbed after it passes through sample solution. With the spectrophotometer, the amount of a known chemical substance (concentrations) can also be determined by measuring the intensity of light detected. Depending on the range of wavelength of light source, it can be classified into two different types: UV-visible spectrophotometer which uses light over the ultraviolet range (185 - 400 nm) and visible range (400 - 700 nm) of electromagnetic radiation spectrum, and IR spectrophotometer which uses light over the infrared range (700 - 15000 nm) of electromagnetic radiation spectrum [9]. In visible spectrophotometry, the absorption or the transmission of a certain substance can be determined by the observed color. For instance, a solution sample that absorbs light over all visible ranges (i.e., transmits none of visible wavelengths) appears black in theory. On the other hand, if all visible wavelengths are transmitted (i.e., absorbs nothing), the solution sample appears white. If a solution sample absorbs red light (~700 nm), it appears green because green is the complementary color of red. Visible spectrophotometers, in practice, use a prism to narrow down a certain range of wavelength (to filter out other wavelengths) so that the particular beam of light is passed through a solution sample [10]. Under controlled experimental conditions the amount of radiation absorbed can be directly related to the concentration of the analyte in solution (Beer's law; see below). It can be used to quantify both organic (primarily in the near-UV) and inorganic (primarily in the visible) species [11]. A double beam spectrophotometer compares the light intensity between two light paths, one path containing a reference sample and the other one containing the test sample. In such systems, the grating is fixed and the intensity of each wavelength of light is measured by a different detector in the array, this gives the advantage of reading for both, reference and test sample at the same time [12]. The purpose of double beam instrument is to determine the amount of light of a specific wavelength absorbed by an analyte in a sample, the samples can be gases or liquids. In the infrared, solid pellets using an IR transparent matrix like a high purity salt such as KBr can be used for solid analyte. Thin disks are made using a pellet press and the disk suspended in the sample cell through which the sample beam passes [13]. There are many published articles using spectrophotometry technique for the determination organic and inorganic compounds [14- 21].

Sunset Yellow FCF, (Scheme 1) consists principally of the disodium salt of 6-hydroxy5-[(4-

sulfophenyl)azo]-2-naphthalenesulfonic acid and subsidiary coloring matters together with sodium chloride and/or sodium sulfate as the principal uncolored components. Sunset yellow is soluble in water, but sparingly soluble in ethanol [22]. It is extensively used in almost every type of food preparation like sweets, jams and jellies, soft drinks, candies, ice cream, canned juice, sauces, pickles, and so forth. In the past few years, use of some food dyes including sunset yellow was banned in United States and Japan owing to its mutagenicity which has been evidenced from several mammals bioassays [23]. The sunset yellow dye (E110) was determined using different analytical methods such as spectrophotometric method [24-29], Electrochemistry [30-33], liquid chromatography [34-37] and immunological and health studies [38].



**Scheme 1.** Structural formula of sunset yellow (E110)

## 2. Materials and methods

### 2.1 Apparatus

The spectrophotometric measurements were carried out by an evaluation 300 PC Thermo Fisher Scientific, USA, its connection with Dell computer. Beam geometry is double-beam, the cell holder is quartz coated and Xenon lamp is the flash lamp with 100-240 VAC, 50/60 HZ and 150 VA.

### 2.2 Chemicals

Standard stock solution of  $1 \times 10^{-3}$  mol L<sup>-1</sup> of sunset yellow dye was prepared by a suitable amount of E110 in 50 mL of distilled water. Standard solutions of sunset yellow with lower concentrations were prepared by diluting the stock solution with distilled water.

### 2.3 Procedure

Spectrophotometric method was carried out using double beam UV-Visible spectrophotometer with visionpro software, over the wavelength range of 400 nm to 800 nm, spectral band width of 2 nm, speed

scan 120 nm/min, Xenon lamp and 2nm graph high. In this work the distilled water was used in the plank cell for obtaining the baseline plank signal, while the sunset yellow dye concentrations were injected in the sample cell for all spectrophotometric measurements.

### **2.3.1 Preparation of soft drink and ice cream samples**

Two soft drinks of Fanta and Taurine which manufactured by Coca-Cola Company, Riyadh, Saudi Arabia and Mahmood Saeed beverage, Jeddah Saudi Arabia respectively, were poured inside the flask and shaken several times in order to release the gases from the sample. A 2.0 mL of each sample was injected in the cell sample inside the double beam UV-Visible spectrophotometer device to run the spectrophotometric procedure. On the other hand, and regarding the ice cream samples, two samples of ice cream that named Alamal and Lolly fruity ice creams which manufactured by the National supreme company, Jeddah, Saudi Arabia, were injected inside the beaker and exposed to the room temperature in order to make them liquid. They were filtered to purify the impurities and then 2 mL of each sample was taken to inject inside the sample cell of the double beam UV-Visible spectrophotometer device.

## **3. Results and discussion**

### **3.1 The Spectrophotometric behaviour**

In general, the theory of a spectrophotometer is a photometer that can measure the intensity of light as a function of its wavelength. Linear range of absorption and spectral bandwidth measurement are the important features of spectrophotometers. In a double beam spectrophotometer, before it reaches the sample, the light source is split into two separate beams. One beam passes through the sample and the second one is used for reference. This gives an advantage because the reference reading and sample reading can take place at the same time. The quantitative information can be obtained from the absorbance values while the qualitative data obtained from wavelength values. In this study, the visible double beam spectrophotometric behavior was investigated using quartz cell, distilled water solvent and the optimized parameters. A  $8 \times 10^{-5}$  mol L<sup>-1</sup> of sunset yellow (E110) was determined using the spectrophotometry method to give a well-developed spectrophotometric peak at  $\lambda_{\max} = 482$  nm over the wavelength range of 400 to 800 nm, as shown in [figure 1](#).

### **3.2 Analytical performance**

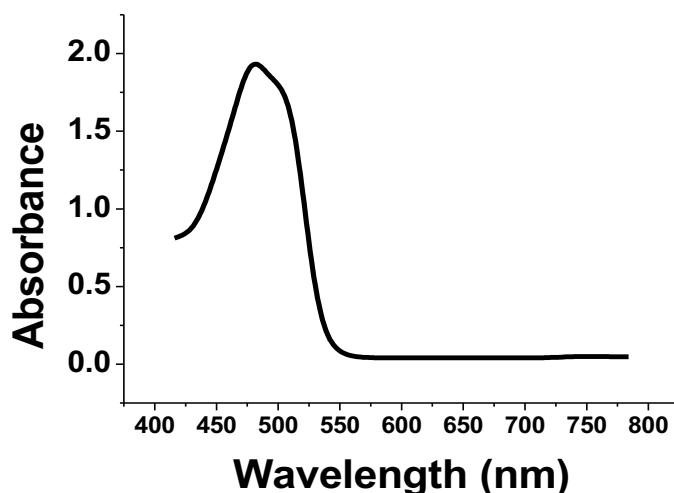
#### **3.2.1 Calibration curve**

A very good linear correlation was obtained between the measured spectrophotometric peaks and sunset yellow concentrations over the range of  $1 \times 10^{-5}$  to  $1 \times 10^{-4}$  mol L<sup>-1</sup> (see [figure 2](#)).

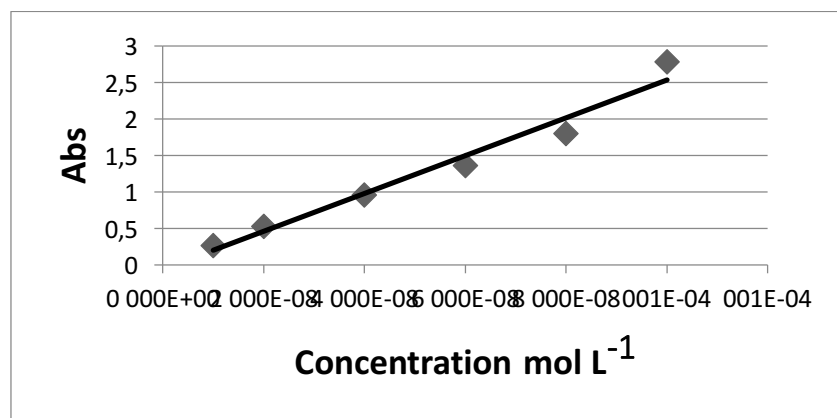
Least-square treatment of the calibration graph yielded the following regression equation:

$$A = 2.6 \times 10^4 C - 0.06, \quad r^2 = 0.984 \quad n = 6$$

Where, A is an Absorbance, C is the analyzed sunset yellow concentration,  $r^2$  is the correlation coefficient and n is number of measurements.



**Figure 1.** Visible spectrophotometry of  $8 \times 10^{-5} \text{ mol L}^{-1}$  of sunset yellow ( $A = 1.93$   $\lambda_{\text{max}} = 482 \text{ nm}$ )



**Figure 2.** Calibration curve for sunset yellow over the rang  $1 \times 10^{-5}$  to  $1 \times 10^{-4} \text{ mol L}^{-1}$

### 3.2.2 Detection Limit

The detection limit, defined as three times the signal to noise ratio which reached in the optimum conditions for monitoring this dye was  $5.77 \times 10^{-8} \text{ mol L}^{-1}$  (0.0261 ppm)

### 3.2.3 Repeatability and stability

The repeatability studies will be given more information about the analytical performance of the spectrophotometric method for the determination of sunset yellow. The concentration of  $5 \times 10^{-5} \text{ mol L}^{-1}$  of sunset yellow was repeated five times to record the relative standard deviation (RSD %) of 0.042% (see table 1). On the other hand, the stability of the analytical spectrophotometric signal was evaluated

by monitoring the spectrophotometric measurements of sunset yellow for 90 minutes yielded, the spectrophotometric signals approximately fixed within this analytical period.


**Table 1.** Spectrophotometric results of the repeatability study for sunset yellow dye

Sunset yellow concentration (mol L <sup>-1</sup> )	Absorbance (A)	Average ± SD	RSD%
5×10 <sup>-5</sup> mol L <sup>-1</sup>	1.192	1.1914±0.0005	0.042
	1.191		
	1.191		
	1.191		
	1.192		


### 3.3 Visible spectrophotometric applications

UV-Vis Spectrophotometric procedure was applied and developed for the determination of sunset yellow in soft drinks and ice creams. Sunset yellow content was determined directly by using visible spectrophotometric method to be obtained the spectrophotometric results as listed in tables 2,3,4 and 5 with figures 4,5 and 6 respectively.

**Table 2.** Determination of sunset yellow in Fanta soft drink


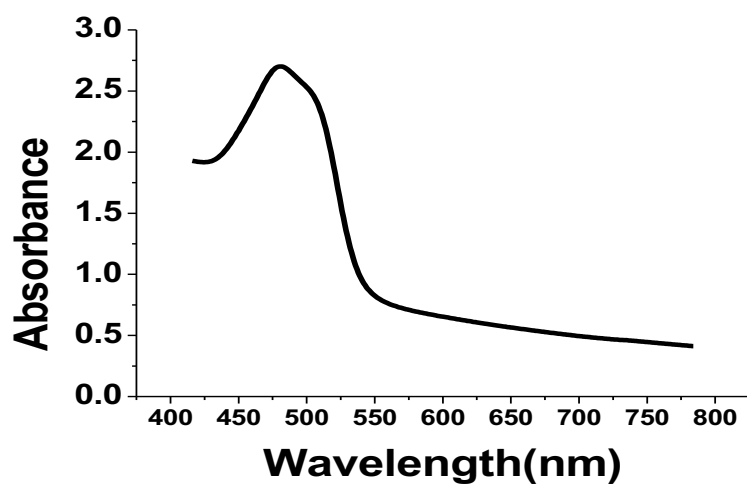
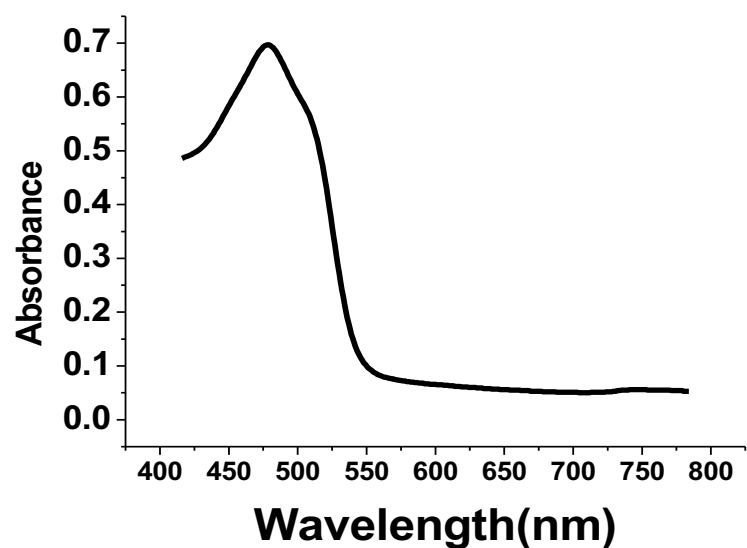
Found absorbance	Found concentration (mol L <sup>-1</sup> )	
2.703	1.062×10 <sup>-4</sup>	
2.694	1.06×10 <sup>-4</sup>	
2.658	1.045×10 <sup>-4</sup>	
2.656	1.044×10 <sup>-4</sup>	
2.656	1.044×10 <sup>-4</sup>	
Mean ± SD	1.051×10 <sup>-4</sup> ± 0.000001	

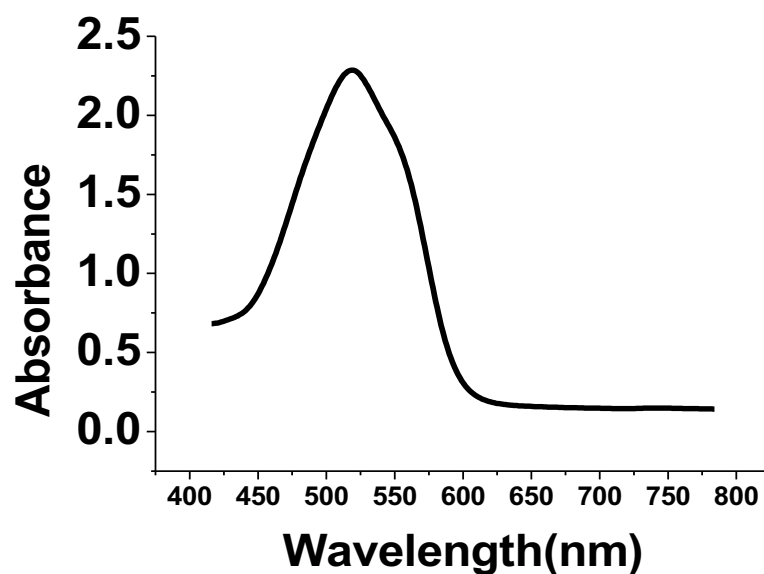
**Table 3.** Determination of sunset yellow in Taurine soft drink

Found absorbance	Found concentration (mol L <sup>-1</sup> )	
0.701	2.92×10 <sup>-5</sup>	
0.701	2.92×10 <sup>-5</sup>	
0.701	2.92×10 <sup>-5</sup>	
0.703	2.93×10 <sup>-5</sup>	
0.703	2.93×10 <sup>-5</sup>	
Mean ± SD	2.92×10 <sup>-5</sup> ± 0.0000005	

**Table 4.** Determination of sunset yellow in ice cream Alamal

Found absorbance(A)	Found concentration, mol L <sup>-1</sup>
2.983	1.170x10 <sup>-4</sup>
2.975	1.167x10 <sup>-4</sup>
2.973	1.166x10 <sup>-4</sup>
2.973	1.166x10 <sup>-4</sup>
2.972	1.166x10 <sup>-4</sup>
Mean ± SD	1.167×10 <sup>-4</sup> ±0.000000155



**Figure 3.** Spectrophotometric signal of sunset yellow (E110) in Fanta soft drink**Figure 4.** Spectrophotometric signal of sunset yellow (E110) in Taurine soft drink (W1)



**Figure 5.** Spectrophotometric signal of sunset yellow (E110) in ice cream Alamal

**Table 5.** Determination of sunset yellow in ice cream Lolly fruity

Found absorbance	Found concentration (mol L <sup>-1</sup> )
2.81	$1.104 \times 10^{-4}$
2.68	$1.053 \times 10^{-4}$
2.67	$1.05 \times 10^{-4}$
2.668	$1.049 \times 10^{-4}$
2.663	$1.047 \times 10^{-4}$
Mean $\pm$ SD	$1.0606 \times 10^{-4} \pm 0.00000218$



## Conclusion

Sunset yellow was determined by the double beam UV-Vis spectrophotometric method in soft drink and ice cream samples at the Saudi local markets. It was given a sensitivity visible spectrophotometric signal and low detection limit. Calibration curve, repeatability and stability were evaluated for analytical performance of the spectrophotometry method.

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**Conflict of Interest :** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.



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