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Spectrophotometric determination of Tartrazine in soft drink powder and pharmaceutical dosage form

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Abstract

Simple and rapid spectrophotometric methods were utilized for the determination of tartrazine (E-102) (TZ) in soft drink powder and pharmaceutical dosage forms. A study of the absorption spectra of tartrazine coloring agent has been carried out by studying various parameters such as the effect of pH, type, and volume of surfactant and time. The optimum analytical parameters and their effects are investigated. Beer's law is obeyed in the range 2.0–20 µg mL^{-1} at λ_{max} = 427 nm. For more accurate analysis, Ringbom optimum concentration range is found to be 5-19 µg mL^{-1}. The molar absorptivity and Sandell sensitivity were determined. The suggested method was successfully applied to the determination of the examined coloring agent in soft drink powder and pharmaceutical dosage form.

Keywords: Spectrophotometry, Tartrazine, Coloring agents, Drug, Soft drink powder.
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1. Introduction

Synthetic dyes are usually added to foodstuffs and soft drinks not only to improve appearance, color, and texture but also to maintain the natural color during process or storage. Synthetic dyes show several advantages compared with natural dyes such as high stability to light, oxygen and pH, color uniformity, low microbiological contamination, and relatively lower production costs. However, many of them may exhibit adverse health effects (allergy, respiratory problems, thyroid tumors, chromosomal damage, urticaria, hyperactivity, abdominal pain, etc.) [1-3]. On the other hand, in some cases, the use of food dyes is also indicative of foodstuff adulteration such as in their addition to Fruit juices. Thus, the use of synthetic dyes is strictly controlled by laws, regulations and acceptable daily intake (ADI) values [4]. These regulations frame the role of the analytical chemist who has to test for the levels of dyes added to food. Amaranth (E123), sunset yellow FCF (E110) and Tartrazine (E102) are among the synthetic dyes mainly used in non-alcoholic beverages [5-8]and the ADI values are between 0-0.5 mg kg^{-1} for amaranth, 0-2.5 mg $kg^{-1}$for sunset yellow and 0-7.5 mg kg^{-1} for Tartrazine. Also, Argentine Alimentary Code establishes a maximal concentration for non-alcoholic drinks of 50 mg L^{-1} of amaranth and 100 mg L^{-1} for sunset yellow FCF and Tartrazine [9]. Figure (1) shows the chemical structure of Tartrazine. The main target of the present work is to describe the development of simple, cheap and rapid spectrophotometric methods for the determination of Tartrazine in food and drug samples.

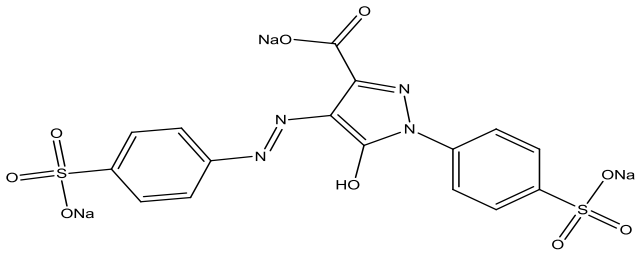

Fig (1): The chemical structure of tartrazine

2. Experimental

2.1. Materials and reagents

Tartrazine E 102 (85%) was obtained from kamena for synthetic colors company (Kafr Tohorms), Giza, Egypt. Tang Mango (25 g) produced by Mondelez Egypt Food S.A.E., Egypt. Triton X-100 purchased from Alpha Chemika Company, India. Sodium Dodecyl Sulphate (SDS), Cetyltrimethylammonium Bromide (CTAB) ad Tween 80 purchased from El Naser Pharmaceutical Chemicals Company (ADWIC), Egypt. Antinal tablets were purchased from Amoun pharmaceutical Co. S. A. E., Egypt. All chemicals used in our study were of analytical grade with the highest purity possible and utilized without further purification. Freshly bidistilled water was used in our study and all solutions were day by day prepared.

2.2. The preparation of universal buffer solutions:

A series of universal buffer solutions of pH range 2.68–12.05 were prepared by using as recommended by Britton [10].

2.3. The preparation of stock solution:

A stock solution of Tartrazine (TZ, 100 µg mL^{-1}) was prepared by dissolving 10 mg of Tartrazine in 20 mL of deionized water in 100 mL measuring flask and then

completed to the mark with deionized water. The obtained solution kept on the magnetic stirrer for 5 minutes to complete the solubility of the dye.

2.3. The preparation of tartrazine samples from pharmaceutical drugs and soft drink powder:

Stock solution of Tartrazine TZ (100 µg mL^{-1}) was prepared by dissolving an exact weight (10 mg) of TZ in 20 mL deionized water in 100 mL measuring flask on a magnetic stirrer for 5 minutes then completed to the mark with deionized water. The soft drinks were used in this study such as (Tang Mango 25 g (produced by Mondelez Egypt Foods S.A.E), Mountain Dew 330 mL kanz (produced by PepsiCo, Egypt) and Miranda Green Apple 330 mL kanz (produced by PepsiCo, Egypt). The drug was used in this study such as (Antinal capsules produced by Amoun Pharmaceutical CO.S.A.E and Oxalepetal tablets produced by Mash Premiere Badr city).

Accurate weight of powder (Antinal capsule, 2.0 g) dissolved in 15 ml of deionized water on a magnetic stirrer for 15 min and diluted to the limited mark in 25 mL measuring flask. The obtained solution was filtrated, and the filtrate was considered as the starting sample. The optimum conditions (pH= 6.54, the volume of the buffer of 2.0 mL) for tartrazine dye was applied to the obtained filtrate. The absorbance of the obtained solution was measured at 427 nm. 3.0 g of Oxalepetal powder dissolved in 25 mL of deionized water on a magnetic stirrer for 15 min and diluted to the limited mark in 50 mL measuring flask. The obtained solution was filtrated, and the filtrate was considered as the starting sample. The optimum conditions for tartrazine dye were applied to the obtained filtrate. The absorbance of the obtained solution was measured at 427 nm.

Accurate weight of powder (0.5 g of Tang Mango) dissolved in 25 mL of deionized water on a magnetic stirrer for 15 min then makes dilution to the limited mark in 50 mL measuring flask. The obtained solution was filtrated, and the filtrate was considered as the starting sample. The optimum condition (pH= 6.54, the volume of the buffer of 2.0 mL) for tartrazine was applied to the obtained filtrate. The absorbance of the produced solution was measured at 427 nm. The sample solution prepared by using different volumes of Miranda green apple varied from (1.0 to 8.0 mL) from the bottle, 2.0 mL of buffer (pH= 6.54) and completed with deionized water to the mark in 10 mL measuring flask and shake well. The absorbance of the obtained solution was measured at 427 nm against the blank. The Mountain dew samples solution was prepared in the same way and similar to Miranda green apple. The absorbance of the obtained solution was measured at 427 nm against the blank.

2.4. General procedure

In a 10 mL calibrated flask, aliquots of the different reagent stock solutions to obtain final concentration between 10 to 100 µg mL^{-1} of TAR between 10 to 100 µg mL^{-1} were introduced to adjust the volume 20 mL of 0.2 M sodium hydroxide solution and 100 mL acidic mixture (0.4 M) were added. The solution was diluted to the mark with deionized water. The absorption spectra were recorded between 300 and 650 nm. The spectra of all solutions were measured against a blank of deionized water with 4 ml of buffer. The measurements were carried out at 25 ± 0.5 ^{0}C. For the determination of tartrazine dye, the absorption spectra of aqueous solutions of Tartrazine (TZ) were recorded in the wavelength range of 390-630 nm.

2.5. The procedure of the standard addition method

A typical procedure involves the preparation of several solutions containing the same amount of unknown and mixed with different amounts of the standard solution of Tartrazine in a 10 mL measuring flask. The idea of this procedure is that the total concentration of the sample is the combination of the unknown and the standard and that the total concentration varies linearly. The concentration of unknown determined by the relation between the recording absorbance and the concentration of standard tartrazine dye.

2.6. Instrumentation

All absorption spectra are made using JASCO V-670 (UV-Visible) Spectrophotometer (JAPAN) with scanning speed (10- 4000 nm/min) and spectral bandwidth (0.1 to 10 nm) for (UV-Vis region) and equipped with 10 mm matched quartz cells. The pH of all solutions was adjusted to the required value using pH-Meter type ad1030 Adwa (Romania) and Sigma 3-30 KS Cooling Centrifuge speed from (1000-2400 rpm Germany).

3. Results and discussion

3.1. Study of the optimum conditions for determination of tartrazine:

To estimate the optimum conditions for tartrazine with other materials and the effect of different experimental variables were investigated and recorded.

3.2. The effect of pH

For determination of optimum pH for tartrazine, the absorbance of the prepared samples measured against the blank within the wavelength range of 800-200 nm. The sample prepared by mixing 1 mL of stock solutions, 4 ml of the buffer solution, (universal buffer varies from pH 2 to 12) and completed the solution by deionized water to the limited mark in 10 mL measuring flask. The blank also prepared in the same way without the stock sample solution. Figure 2(a) shows the absorption spectra of the effect of the pH 2.0-12 on the absorption of tartrazine. Figure 2(b) shows the value of absorption of tartrazine with different pH 2.0-12. Extracted data from Figure 2(b) show that maximum absorption by using buffer solution with pH 6.54 at λ_{max}= 427 nm and the absorption decreases with increasing ph.

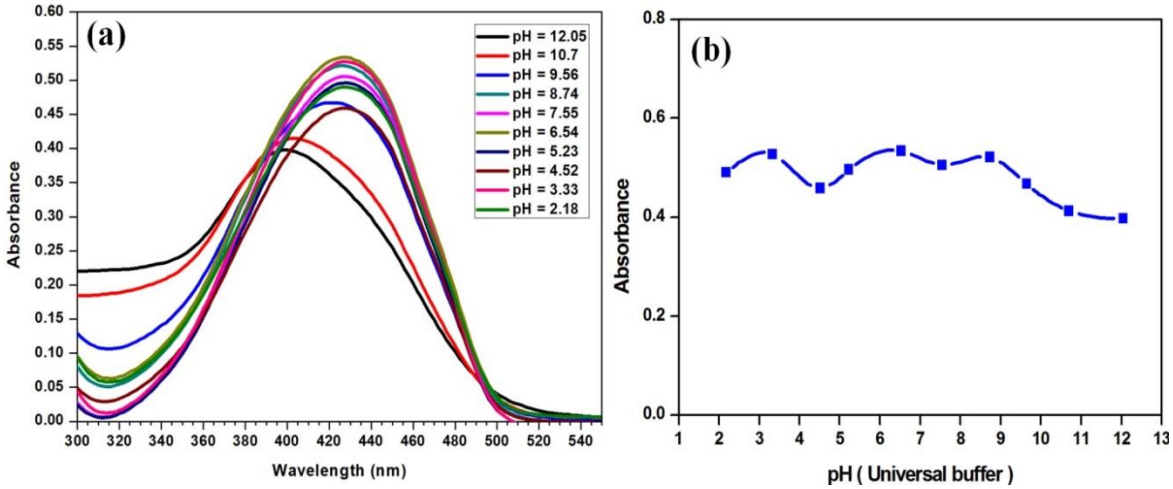

Fig (2): Absorption spectra of tartrazine at λ_{max}= 427 nm (a) and the absorption value of tartrazine (b) using a universal buffer with different pH [pH=2-12].

3.3. Effect of volume of the buffer:

In this part, the effect of buffer volume was studied on the absorption of tartrazine by the addition of a constant volume of tartrazine 1 mL to a different volume of buffer solution (1, 2, 3, 4, 5 and 6 mL) with pH 6.54. The obtained solution completed with deionized water to the limited mark in 10 mL measuring flask with shaking well. The blank prepared in the same way without the stock solution of tartrazine. The absorbances have been measured versus a blank solution at λ_{max}= 427 nm.

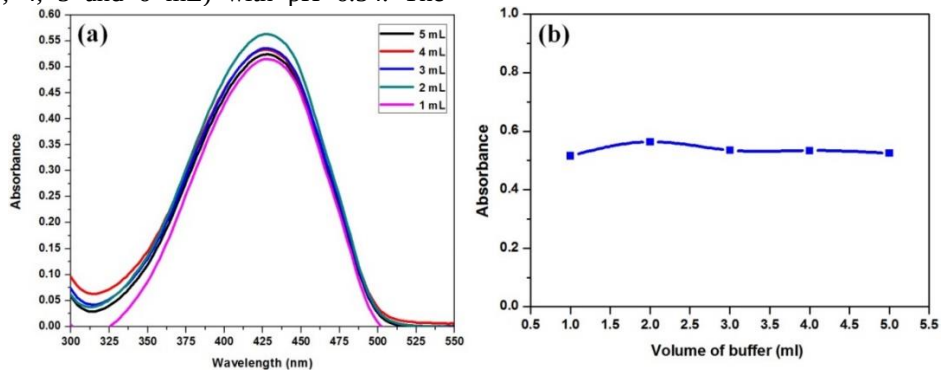

Fig (3): Absorption spectra of tartrazine (a) and the absorption value of tartrazine (b) using various volumes of universal buffer.

Figure 3(a) shows the absorption spectra of tartrazine with various volumes of buffer solution. Figure 3(b) shows the relation between the absorption of tartrazine with a different value of buffer solution. The extracted data from Figure 3(b) show that 2 mL gives the maximum absorption of tartrazine at λ_{max}= 427 nm.

3.4. Effect of surfactants:

In this part, the effect of different types of surfactants (Triton X-100, CTAB, Tween 80, and SDS) was studied on the absorption of tartrazine samples. The sample prepared by mixing 1 mL of tartrazine sample, 2 mL buffer solution (pH= 6.54) and 1 mL of surfactant (0.5 %). The obtained solutions were completed by the addition of deionized water to the limited mark in 10 mL measuring flask. The blank prepared in the same way without the sample under study. The absorption of obtained solutions measured against the blank. Figure (4) shows the effect of surfactants on the absorption of tartrazine. The data showed no positive response on the absorption of tartrazine in the presence of surfactants except Tween 80 which gives absorbance value near absorbance value of solution sample without surfactants.

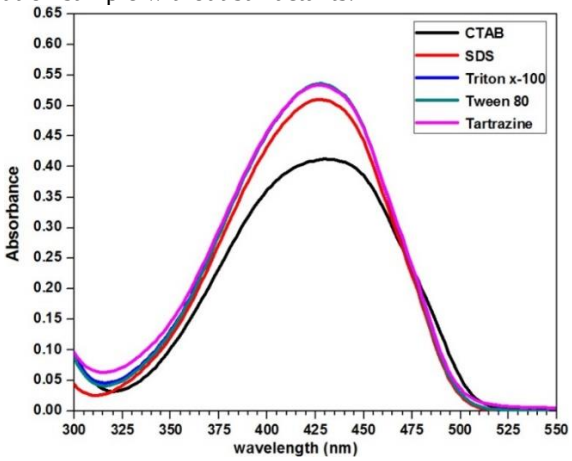

Fig (4): Absorption spectra of tartrazine without surfactant and by using different surfactants.

3.5. Effect of volume of surfactant:

From the previous study, the presence of Tween 80 surfactant increased the absorption of tartrazine comparison with the sample without surfactants at optimum conditions. In this part, the effect of Tween 80 volume on the absorbance of tartrazine samples was studied. Sample solution prepared by mixing 1 mL of tartrazine sample, the various volume of Tween 80 (from 0.25 to 3 mL) and 2 mL of buffer solution (pH= 6.54). The obtained solution was completed by deionized water to the limited mark in a 10 mL measuring flask. The blank also prepared in the same way without the tartrazine sample. The absorbance measured against the blank for all samples. Figure 5(a) shows the absorption spectra of the tartrazine sample with different volumes of Tween 80 surfactant. The extracted data from Figure 5(b) show that the addition of 2 mL of Tween 80, producing the best absorbance of tartrazine. But it was a low absorbance volume comparison by the sample without surfactants. It is shown that the presence of various surfactants did not affect the absorbance value of tartrazine samples.

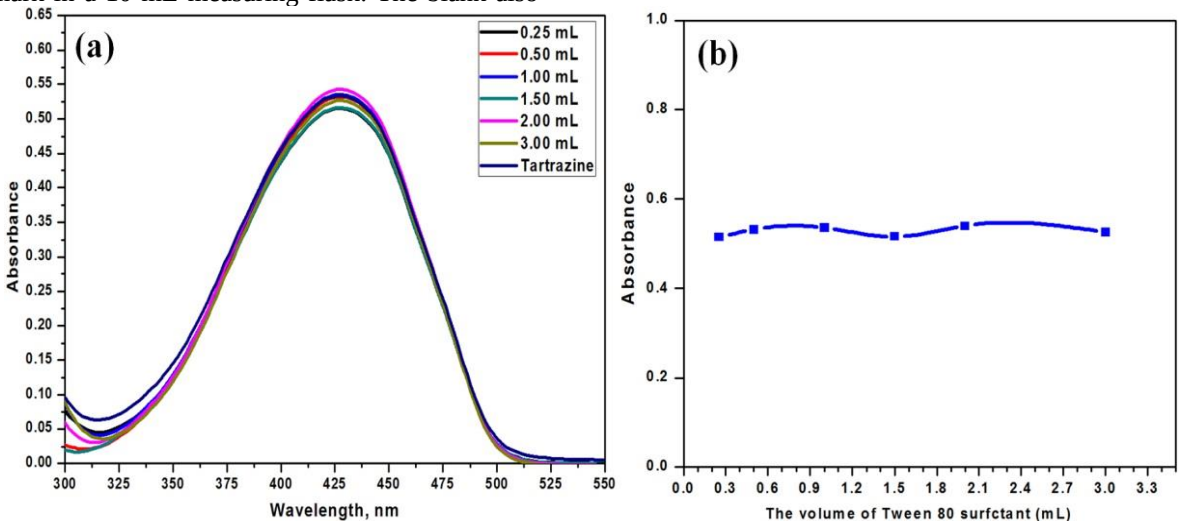

Fig (5): Absorption spectra of tartrazine without and with Tween 80 surfactant (a) and the effect of Tween 80 volumes on the absorbance values of tartrazine (b).

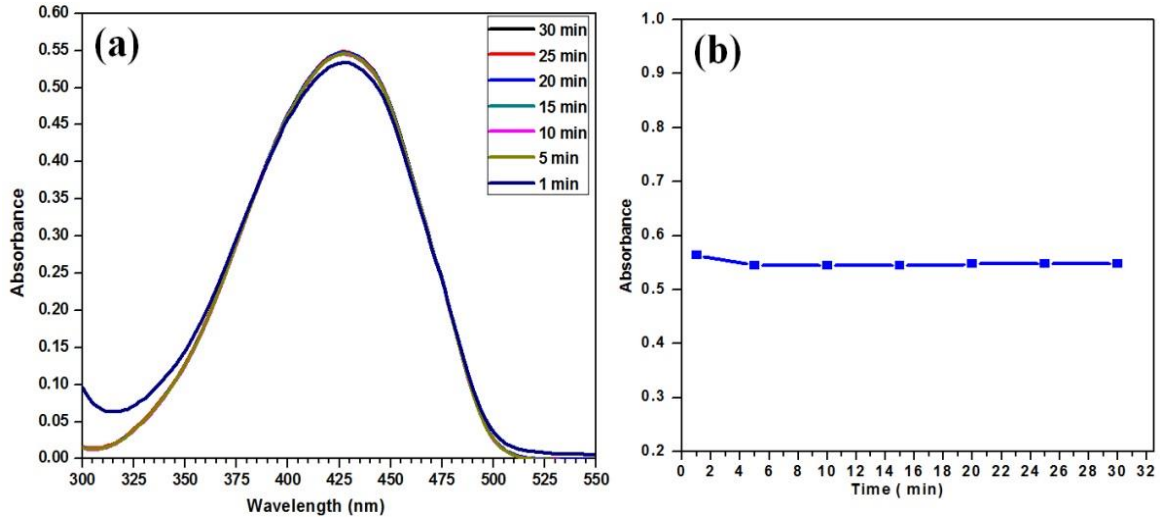

Fig (6): The effect of time on the absorption spectra (a) and the absorbance value with time (b) of tartrazine.

3.6. Effect of time:

In this part, the effect of time was investigated on the absorbance of tartrazine samples at optimum conditions. Samples prepared by the addition of 1 mL of tartrazine solution, and 2 ml of buffer solution (pH=6.54). The obtained solution was diluted by deionized water to the limited mark in 10 mL measuring flask with shake well. The absorbance of the prepared samples measured against the blank. It was found that the time has no positive response on the absorption of tartrazine as shown in Figures 6(a and b).

3.7. Effect of dye concentration:

In this part, the effect of concentration of tartrazine was studied by using the various volume of tartrazine standard solution at optimum conditions. Samples solutions prepared by adding different volumes of tartrazine standard solution to 2 mL universal buffer solution (pH= 6.54). The obtained solution was diluted by deionized

water to the limited mark in 10 mL measuring flask with shake well. It found that the absorbance increases with the addition of tartrazine dyes as shown in Figure 7(a).

3. 8. The validity of Beer's law:

From the extracted data from Figure 7(a) the calibration graph of Beer's law was constructed by the relation between the concentration of tartrazine standard samples and the recording absorbance at optimum conditions as shown in Figure 7(b). Limits of Beer's law, Sandell sensitivity, molar absorptivity, and other analytical data were calculated and listed in Table (1).

3. 9. Ringbom optimum range:

Ringbom method is used for more accurate analysis and is constructed by plotting the percent transmittance (%T) and the logarithm of the concentration of the sample under study [11]. Ayres pointed out that the straight line obtained in the curve of the law of Beer's does not directly show the range of concentration by which accurate identification of colored species can be made [12]. From the extracted data from Figure 7(a) the standard graph of Ringbom were constructed by the correlation between the concentration of tartrazine standard samples and the present transmittance %T at optimum conditions as shown in Figure 8.

3. 10. Accuracy and precision

The accuracy and precision of the suggested method were examined by using different concentrations of the sample understudy in the range of beer's law and Ringbom methods. The solutions of the prepared samples were analyzed in six replicates. The collection data obtained from this research part are summarized in Tables (2). The extracted data considered favorable for the concentrations of the sample under investigation. Tables (3 and 4) show the evaluation of the accuracy and precision of the proposed method for the determination of tartrazine in pharmaceutical drug and food samples. Table (5) introduces **a** comparison between determinations of tartrazine by Beer's law and standard addition method in pharmaceutical drug and food samples**.**

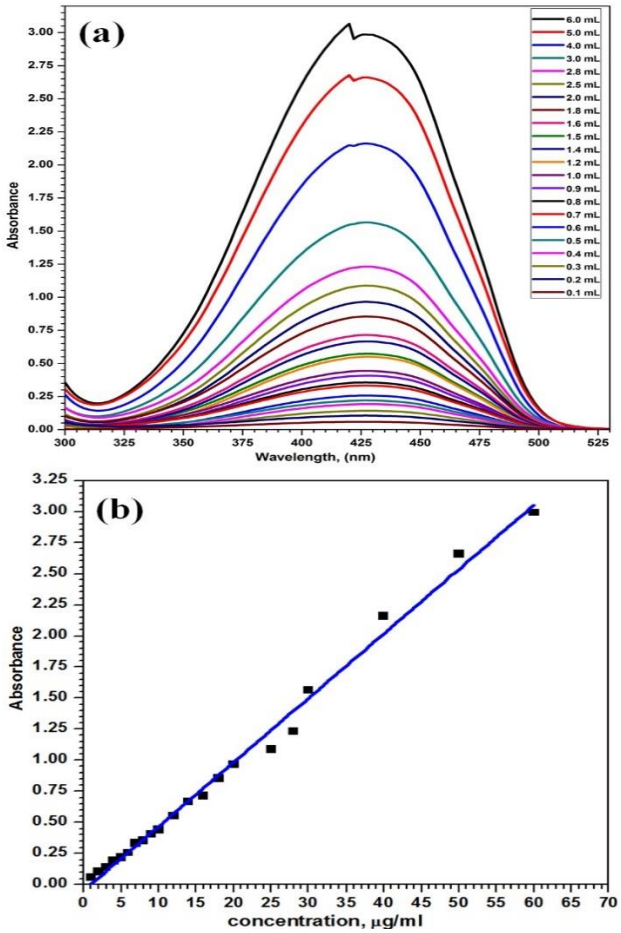

Fig (7): The absorption spectra of tartrazine with various concentrations (0.1 – 6 mL) and application of Beer's law for tartrazine using optimum conditions.

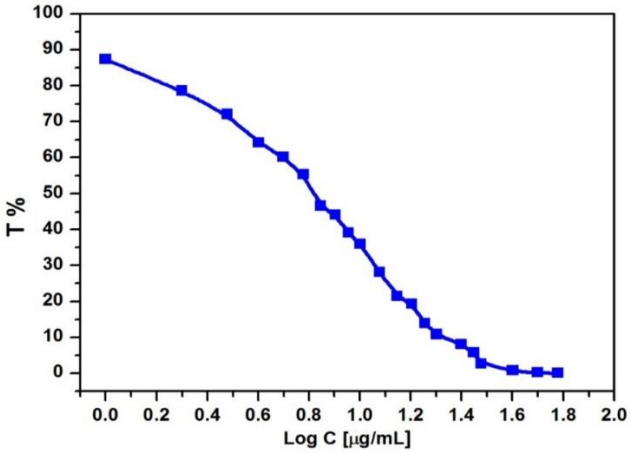

Fig (8): Ringbom plot for tartrazine by using optimum conditions.

Table (1): Analytical data, precision, and accuracy of tartrazine:

Parameters	Tartrazine
pH	6.54
Wavelength λ_{max} (nm)	427
Beer's law limits (µg mL^{-1})	2 - 20
Ringbom limits (µg $mL^{-1)}$	5.0 - 19.95
Molar absorptivity (L $mol^{-1}cm^{-1}$)	5.377 x 10^5
Sandell sensitivity (µg cm^{-2})	9.938 x 10^{-4}
Detection limits (µg mL^{-1})	1.910
Quantification limits (µg mL^{-1})	5.79
Regression equation	
Slope	0.05169
Intercept	-0.05031
Correlation coefficient	0.992
Student t-test	2.0617
Standard deviation (SD)	0.02993
Relative standard deviation (RSD %)	4.628
The standard error of the mean (SEM)	0.0122
Mean value ($\bar{x}$)	0.6466
Standard error	0.02477

Table (2): Evaluation of the accuracy and precision of Tartrazine material:

sample	Taken (µg mL^{-1})	Found (µg mL^{-1})	Recovery **(%)**
Tartrazine	8	7.968	99.6
	9	8.984	99.82
	10	9.686	96.864
	12	11.77	98.089

Table (3) Evaluation of the accuracy and precision of the proposed method for determination of tartrazine in pharmaceutical drugs

Parameters	Antinal capsule	Oxalepetal
Standard deviation **(SD)**	0.02089	0.03479
Mean value ($\bar{x}$)	0.59586	0.410334
Relative standard deviation (RSD %)	3.5	8.478
Standard error of the mean (SEM)	8.528 x 10^{-3}	0.0142
Student t-test	3.045	2.3039
N	6	6

N= number of observations in the sample equal six replicate determinations

The second part contains the spectrophotometric procedures for determination of tartrazine dye in pure form, in pharmaceutical drugs and food samples. Some experimental variables are studied for the determination of the sample understudy in the pure form such as pH, buffer volume, type of surfactant, the volume of surfactant, time and the concentration of the sample (Beer's law). The results showed that the best pH= 6.54, the volume of buffer about 2 mL, Tween 80 as a surfactant, 2 mL of Tween 80, no effect of time on dye. Beer's law is obeyed within the concentration range 2-20 µg mL^{-1} for tartrazine. For more accurate results, Ringbom optimum

concentration ranges are determined. Molar absorptivity, Sandell sensitivity, detection, and quantitation limits are calculated. To determine the accuracy and precision of the suggested methods, solutions containing different concentrations of the studied materials are prepared and analyzed in six replicated. The recovery, the relative standard deviation, the relative error is calculated.

The suggested methods can successfully be applied to determine the pure material (tartrazine) and their pharmaceutical drugs and food samples. The results obtained compared to statically by the student's t-test. So the proposed spectrophotometric methods can be applied routine analysis for determination of the studied materials in pure form, pharmaceutical drugs such as (Antinal capsule, Oxalepetal 600 mg) which found contain (83.58 and 90.26) µg mL^{-1}, respectively, and food samples such as (Miranda green apple kanz, Mountain Dew and Tang mango) also contain about (397.84, 310.56 and 2260.78) µg mL^{-1}, Respectively. Standard addition method applied to pharmaceutical drugs and food samples and the data match and near the data from the calibration curve of Beer's law which deduce the validity of the method.

Table (4): Evaluation of the accuracy and precision of the proposed method for determination of tartrazine in food samples

Parameters	Tang mango	Mountain dew	Miranda green apple
Standard deviation (SD)	0.015355	0.0075	0.0210
Mean value ($\bar{x}$)	0.4112	0.25717	0.3435
Relative standard deviation (RSD %)	3.734	2.916	6.1127
Standard error of the mean (SEM)	6.2686×10^{-3}	3.0618×10^{-3}	8.5732×10^{-3}
Student t-test	1.4397	2.5233	1.11988
N	6	6	6

N= number of observations in the sample equal six replicate determinations

Table (5): comparison between determinations of tartrazine by proposed method and standard addition method

Sample name	Beer's law curve	Standard addition method	Standard reference (ADI)
Antinal capsule	34.825 µg/g	34.725 µg/g	7.5 (mg. kg $bw^{-1}day^{-1}$) [13]
Oxalepetal	15.043 µg/g	15.0766 µg/g	
Tang mango	90.431 µg/g	90.4448 µg/g	
Miranda green apple kanz	1.2055 µg/mL	1.204545 µg/mL	
Mountain dew	0.9411 µg/mL mL	0940393 µg/ mL	

4. Conclusion:

Simple, accurate, readily available and inexpensive spectrophotometer method was utilized for the determination of Tartrazine (TZ) in soft drink powder (such as tang mango, mountain dew, and miranda green apple) and pharmaceutical dosage form (such as antinal capsule and oxalepetal). The experimental conditions were studied for pure Tartrazine dye and applied to the pharmaceutical and food samples. So the proposed spectrophotometric methods can be applied routine analysis for determination of the studied materials in pure form, pharmaceutical drugs such as (Antinal capsule, Oxalepetal 600 mg) which found contain (34.825 and 15.043) µg g^{-1}, respectively, and food samples such as (Miranda green apple kanz, Mountain Dew and Tang mango) also contain about (90.431 µg/g, 1.2055 µg mL^{-1} and 0.9411 µg mL^{-1}), Respectively. Standard addition method applied to pharmaceutical drugs and food samples and the data match and near the data from the calibration curve of Beer's law which deduce the validity of the method. The results demonstrated that the method is accurate for Tartrazine dye in pure form and pharmaceutical form and soft drink powder.

Acknowledgments

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