Novel reactions for simple and sensitive spectrophotometric determination of piperine

Most of us look at spices as a way to perk up the plate, but did you know they have the potential to fight disease? Imagine going to your doctor with joint pain and leaving with a prescription for ginger. Before the advent of synthetic drugs that might have happened. Spices have a long history as folk medicine. The king of spices—Pepper stimulates the taste buds in such a way that an alert is sent to the stomach to increase hydrochloric acid secretion, thereby improving digestion. Danish physicist, Chemist and professor at the University of Copenhagen, Hans Christian Ørsted was the first to identify the compound piperine in pepper. Today, pepper and piperine is used heavily around the world. If you look almost every dinning table today will have both a salt and a pepper shaker. Piperine's original tangy and spicy taste is a large part of our everyday lives.

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Abstract

Two spectrophotometric methods for the determination of micro amounts of piperine in pre formulation were developed. Method A utilizes 3-methyl-2-benzothiazoline hydrazono hydrochloride hydrate (MBTH), an electrophilic coupling agent in presence of iron(III) in neutral medium. The bluish-green complex shows maximum absorbance at 640 nm. Method B is based on the reaction of piperine with iron(III) and subsequent reaction with ferricyanide under acidic condition which yields Prussian Blue product with maximum absorption at 760 nm and were stable for about 24 h. Beer's law was obeyed for piperine in the concentration range 0.4-2.6 and 1.0-10.0 μg mL⁻¹ for method A and B respectively. The reaction conditions and other important analytical parameters were optimized to enhance the sensitivity of the methods. Interference if any was also investigated. The methods were applied for the determination of piperine in presence of pharmaceutical additives and excipients. The performance of these methods were evaluated in terms of Student's t-test and variance ratio F-test to find out the significance of proposed methods over the reference spectrophotometric method (AOAC).

Keywords: Spectrophotometry; Nutraceuticals; Piperine; Piper nigrum; Piper longum; MBTH; Prussian Blue

Journal of Quantitative Spectroscopy and Radiant Analysis (Communicated)
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VIII.1. Introduction

Nutraceuticals encompass a large group of preventive and curative health ingredients that have been predominantly derived from long standing medical tradition such as Ayurveda, Tibetan, Chinese and Japanese medical systems. All these systems are primarily dependent upon plants, more commonly known as herbs, especially those with a well-established use as foodstuff. The blend of these pharmaceuticals and nutritional characteristics resulted in the name “Nutraceuticals” to denote the nutritional origins and the design molded on pharmaceuticals, that is, standardization, efficacy and predictability.

Black pepper (*Piper nigrum*) and long pepper (*Piper longum*) (family piperaceae) is a well-established foodstuff. It is a main ingredient of curry powders. It is also well known for its flavoring and digestive properties. Pepper is also a well-known indigenous herbal medicine, which exhibits a wide range of biological activities due to its active ingredient (3 – 8%) is piperine [1-piperoylpiperidine] [1], for example, protection against oxidative stress [2,3] inhibition of P450 isoenzymes and monoamine oxidases [4,5] antitumors [6,7], immunomodulatory [6,8] and antiprotozoic activities [9]. At a molecular level however, its mechanism of action is poorly understood. In brief, the vast success of the herbal medicine during last two decades has made piperine a major area in drug research laboratories and a branch of commercial importance in nutraceuticals.

The field of nutraceuticals, like modern analytical pharmacy demands separation of a desired component from
a complex dosage formulation / biological material(s) and its instrumental determination. The potential of piperine as an important class of nutraceuticals prompted the development of many analytical methodologies for the detection, determination, isolation and characterization.

Spectrophotometric estimation of piperine revolves on strong absorption of the piperine in organic solvents between 342 to 345 nm. Further, the evaluation of the total amount of piperine in a sample by the use of direct absorption measurement is valid, if the calculations are based on “pure standards”. Besides, the presence of the other compounds absorbing in the region 342 to 345 nm will strongly influence the results [10]. Thus, there is a great need to develop a simple, selective, sensitive and rapid spectrophotometric method for the determination of piperine.

Analytical techniques including chromatography [11-14] and optical methods [15-24] have been reported. However, these methods have proved to be deficient with respect to specificity, sensitivity, simplicity and or short analysis time. Quantitation of the constituents by TLC [25-26] is ruled out since it hardly leads to consistent results. HPLC is reliable analytical technique for identification of impurities in preformulation or of metabolites in biological matrices, rather than for routine quantitative analysis. Further, the cost of instrument is relatively high and maintenance demands sophistication. For routine nutraceutical applications optical methods such as spectrophotometry seems to be the most attractive analytical approach. It is convenient and simple, and can be relatively inexpensive. Further, this method provides

A discovery by Hans Christian Ørsted forever changed the way scientists think about electricity and magnetism. 1820 was a particularly important year for Ørsted’s career. In April he made the discovery of the connection between electrical and magnetic phenomena for which he is chiefly known. He wrote a short treatise on the discovery, but much of the important subsequent work relating to his finding was carried out by others, such as François Arago and André-Marie Ampère, the latter of whom made his greatest contribution to science by rigorously applying mathematics to the study of electromagnetism. 1820 was also the year that Ørsted became the first person to isolate piperine (a component of pepper), thus making his mark in chemistry as well as physics. A few years later, in 1825, Ørsted again experienced a notable success in the field of chemistry when he produced an impure form of metallic aluminum.

[www.magnet.fsu.edu/.../pioneers/orsted.html]
simple, precise and accurate measurement of suitable analytes.

The work described here is a novel and highly sensitive methods for the determination of piperine. Method A involves iron(III) salts in the presence of electrophilic coupling reagent 3-methyl-2-benzothiazoline hydrazono hydrochloride hydrate (MBTH) in neutral medium. Method B is based on the reaction involving the use of iron(III) salt, the reduced iron(III) in presence of potassium ferricyanide in acetic acid medium produces a blue color complex called Purssian Blue read at 760 nm. The proposed methods offer the advantage of simplicity with respect to reagents, high sensitivity and stability without extraction, heating or distillation and reliability due to reproducibility.

VIII.2. Experimental

VIII.2.1. Reagents

Piperine is gift samples from Samilabs India was used as received. MBTH (Sigma Adrich, USA), ferric chloride, potassium ferricyanide, (BDH, India), acetic acid, isopropyl alcohol (Ranbaxy, India). All reagents used were of analytical grade chemicals unless specified otherwise.

Stock piperine solution (1000μg ml⁻¹) was prepared by dissolving 1.00g of the sample in isopropyl alcohol and diluting quantitatively to 1000 ml with isopropyl alcohol. Required standard solution of (100 μg piperine ml⁻¹) was prepared by diluting 100 ml of standard piperine solution to 1000 ml with same solvent.
Stock solution (0.2 %, w/v) of MBTH, was prepared in distilled water and stored in amber bottle to protect from sunlight. Aqueous solution (0.1 %, w/v) of iron(III) chloride was prepared by dissolving in distilled water. A few drops of 2M hydrochloric acid were added to prevent precipitation of iron(III) as hydrated ferric oxide. Potassium ferricyanide (0.1 %, w/v) was prepared by dissolving in distilled water. 5M acetic acid was prepared by diluting qualitatively 287.35 ml of 99.5 % glacial acetic acid (Merck, Germany) to 1L with distilled water.

**VIII.2.2. Apparatus**

Specord 50 UV-vis spectrophotometer with 1.0-cm silica quartz matched cell was used for measuring the absorbance.

**VIII.2.3. General Procedures**

**VIII.2.3.1. Method A (Oxidative electrophilic coupling reaction using MBTH)**

To a series of 25 ml calibrated flasks different aliquots of piperine, 1.0 ml of MBTH (0.2 %, w/v) reagent and 1.0 ml of iron(III) chloride (0.1 %, w/v) were added and the mixture shaken thoroughly and allowed to stand for 15 min at room temperature and volume was made up with distilled water. Absorbances at 640 nm were measured in 1.0-cm quartz cell against reagent blank which was prepared without piperine.
VIII. 2.3.2. **Method B (Complexation reaction - Prussian blue method)**

Appropriate volumes of the standard piperine solution in concentration range of 1.0 – 10.0 µg ml\(^{-1}\) of piperine were transferred to a series of 25 ml standard flasks. To each flask, 2 ml each of iron(III) chloride, potassium ferricyanide and 5N acetic acid were added and allowed to stand for 30 min at room temperature. The volume was made up with distilled water. The absorbance was measured at 760 nm against the reagent blank.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Method A</th>
<th>Method B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Blue</td>
<td>Greenish blue</td>
</tr>
<tr>
<td>(\lambda_{\text{max}}) (nm)</td>
<td>640</td>
<td>760</td>
</tr>
<tr>
<td>Stability (h)</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Beer's law (µg ml(^{-1}))</td>
<td>0.4-2.6</td>
<td>1.0-10.0</td>
</tr>
<tr>
<td>Recommended concentration (µg ml(^{-1}))</td>
<td>1.2</td>
<td>4</td>
</tr>
<tr>
<td>Molar absorptivity (L mol(^{-1})cm(^{-1}))</td>
<td>(6.33 \times 10^4)</td>
<td>(2.19 \times 10^4)</td>
</tr>
<tr>
<td>Sandell's Sensitivity (µg cm(^{-2}))</td>
<td>(4.50 \times 10^4)</td>
<td>(1.30 \times 10^3)</td>
</tr>
<tr>
<td>Lower detection limit (µg ml(^{-1}))</td>
<td>0.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Regression equation(^a)</td>
<td>(y=ax+b) where (x) is the concentration of piperine in µg cm(^{-1}).</td>
<td></td>
</tr>
<tr>
<td>Slope (a)</td>
<td>0.0403</td>
<td>0.0478</td>
</tr>
<tr>
<td>Intercept (b)</td>
<td>-0.2056</td>
<td>0.0975</td>
</tr>
<tr>
<td>Correlation coefficient</td>
<td>0.9960</td>
<td>0.9944</td>
</tr>
<tr>
<td>Reaction time (min)</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>R.S.D(^b)% (n=5)</td>
<td>0.98</td>
<td>0.72</td>
</tr>
</tbody>
</table>

\(^a\) Spectral data for determination of piperine using method A (oxidative electrophilic coupling reaction using MBTH) and method B (complexation reaction - Prussian blue method)

\(^b\) Relative standard deviation.
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VIII.3. Results and discussion

The chemical reaction in Method A is the reduction of iron(III) chloride by MBTH, which subsequently couples with piperine in neutral medium to form blue colored product having maximum absorption at 640 nm.

MBTH is an electrophilic coupling reagent which reacts with different types of organic compounds. The results of the reaction of organic compounds with MBTH have often been applied in analysis pertaining to biochemical [27], pharmaceutical [28-33], insecticides [34] and in flow injection analysis [35,36].

The method B for determination of piperine involves the reaction of the piperine with ferric salt in the presence of potassium ferricyanide in acidic condition to produce a Prussian Blue colored product with maximum absorption at 760 nm. The reaction involves the reduction of iron(III) by piperine to form iron(II), which subsequently reacts with ferricyanide to give a prussian blue (PB) product in acidic medium. The blue pigment iron(III)-hexacyanoferrate(II) has been used for many decades to serve as a photostable material for making inks, paints, lacquers and the like [37]. In the recent past, other work described include dopant in modified electrode [38], composite films and codeposition of PB with polypyrrole [39]. Besides, PB has been extensively used as electrochemical sensor [40], biosensor [41-42], ion sensor [43] and as chemical resistor in the determination of alkaline metals [44]. Spectral [45-50] and voltammetric studies [51-52] give details of the structure, configuration and properties of PB.
Addition of a few drops of 2N HCl is necessary to prevent precipitation of iron(III) as hydrated ferric oxide. Besides, the addition of hydrochloric acid will bring down the pH of the solution in slightly acidic range. Neutral ferric chloride free from hydrochloric acid is reported to give different colors, green, purple or blue which have been extensively exploited as a confirmatory test of phenols in organic chemistry. The present work describes the details of the factors affecting the color development, reproducibility, sensitivity and adherence to Beer’s law. Spectral characteristics are tabulated in Table VIII.1.

VIII.3.1. Wavelength determination

In order to reduce the interferences, as far as possible it was necessary to identify optimum wavelength for piperine determination for the proposed methods. This wavelength must be specific for the quantitative and specific monitoring of the piperine. The wavelength of maximum absorbance was identified by scanning the products of piperine-MBTH-iron(III) and piperine-iron(III)-potassium ferricyanide over the range 400–800 nm with a Specord 50 UV-vis spectrophotometer. Wavelengths of 640nm and 760nm were found optimum for the above products to get best results.

VIII.3.2. Effect of reagents, acid concentration and time of reaction.

The effect of MBTH reagent was studied in the range of 0.50 – 5.00 ml (0.2 %, w/v) solution to achieve maximum color intensity. A volume of 1.0-5.0 ml of the

Prussian blue was manufactured first in Germany by a color maker named Diesbach. The process included heating equal amounts of saltpeter (KNO₃) and potassium tartrate in a red-hot crucible. Dry powdered cattle blood was added and the mixture was heated to an incandescence then washed with water and treated with a solution of alum [K₂SO₄; Al₂(SO₄)₃ · 24H₂O] and ferrous sulfate. A green precipitate was formed which turned blue with the addition of hydrochloric acid. Prussian blue is manufactured through the action of an oxidizing agent, such as potassium bichromate and sulphuric acid, upon a mixture of copperas (ferrous sulphate), sodium ferrocyanide and ammonium sulphate. The pigment precipitated from dilute solutions of those salts is a deep blue, finely divided compound which once settled is washed, filtered and dried. Although Prussian blue is deep blue, it can have reddish or green undertones, depending on the preparation conditions, oxidizing agents, pH, temperature and batch size.

[http://www.sewanee.edu/chem/Chem&Art/Detail_Pages/Pigments/Prussian_Blue]
solution gave good result. Hence, 1 ml (0.2 %, w/v) MBTH solution in 25 ml standard flask was selected for further studies under optimized conditions. Similarly, the same procedure was adopted to ascertain the amount of iron(III) (0.1 %, w/v) and potassium ferricyanide (0.1 %, w/v) required for getting maximum and constant color intensity. It was found that 1.0-5.0 ml of iron(III) chloride, 1.0-5.0 ml potassium ferricyanide were needed to get good results. Hence, 1ml of iron(III) solution for method A and 2 ml each of iron(III) and potassium ferricyanide for method B is sufficient to get reproducible results.

Maximum intensity of color was achieved in neutral medium for method A. However, acids like hydrochloric acid, sulphuric acid, nitric acid, phosphoric acid and acetic acid did not interfere but they were not effective in stabilizing the color. While, alkalies such as sodium hydroxide and ammonia were found to interfere.

Method B: Effect of different acids was studied such as hydrochloric acid, sulphuric acid, nitric acid, phosphoric acid and acetic acid. The best results were obtained with acetic acid. The optimum concentration of acetic acid was studied using different volume of 5N acetic acid in the range of 0.50 – 5.00 ml to fixed concentration of piperine. There was not much difference in absorbance after rise from 1.0 ml onwards and volume up to 5 ml of acetic acid had no effect on absorption of colored species. Hence, 1ml of 5N acetic acid was selected for further work.
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Experiments were carried out to optimize temperature and time of the reaction. It was found that the maximum color developed within 15 and 30 min at room temperature for method A and B respectively and remains stable for about 24 h. Increase in the temperature decrease the intensity of the color. Hence, 15 min for method A and 30 min for method B was selected for the routine analysis.

VIII.3.3. Order of addition of reactants

During the course of the study it was observed that the sequence of addition of reactants is also important as it influences to great extent intensity and the stability of the color product. The sequence of addition of piperine, MBTH and iron(III) chloride was studied via the formation of the blue complex. The study indicated that the sequence of addition of reactants had profound influence on the intensity and stability of the color. For example; (1) MBTH + iron(III) chloride + piperine and (2) iron(III) chloride + piperine + MBTH gave less intense and unstable color. While, the order (3) piperine + MBTH + iron(III) chloride gave more intense and stable color. In method B, the sequence of addition of piperine, iron(III) chloride, ferricyanide and acetic acid and was studied via the formation of the blue complex. Absorbance color the product did not change appreciably when the order of addition of these reactants was varied.

VIII.4. Analytical figures of merit

The proposed spectrophotometric methods were evaluated under the optimum conditions with regard to linearity, accuracy and precision. The linearity of the
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spectrophotometric method for the determination of piperine was evaluated under optimum conditions. The calibration curve was linear over the range 0.4-2.6 and 1.0-10.0 µg ml⁻¹ for method A and B respectively. The accuracy of the proposed methods was evaluated by comparing the results obtained with the proposed spectrophotometric methods.

The % R.S.D. was found to be <2.0 (n = 5). The proposed method was found to be accurate and precise (Table VIII.2). To further confirm the validity and accuracy of the proposed method, recovery tests were performed by the standard addition method with known amounts of standard solutions at two different levels. Each test was repeated five times. The results presented in the Table VIII.2 indicate the very good recoveries.

VIII.4.1. Method validation

To validate the proposed spectrophotometric method, Student's t-test was performed on the results (Tables VIII.2 and VIII.3). Comparison was made between the proposed spectrophotometric method and the standard method to find out whether the two methods give the same results at the 95% confidence level. The t-test with multiple samples was applied to examine whether the two methods for piperine determination differ significantly at the 95% confidence level.

The calculated Student's t-value and F-value did not exceed the tabulated value indicating that the proposed method is as accurate and precise as the official method [10].
Table VIII.2: Determination of piperine in different pharmaceutical additives or excipients using Method A (Oxidative electrophilic coupling reaction using MBTH)

<table>
<thead>
<tr>
<th>Pharmaceutical Additives</th>
<th>Piperine added (µg/ml)</th>
<th>Proposed method</th>
<th>Reported method</th>
<th>t-Value&lt;sup&gt;b&lt;/sup&gt;</th>
<th>F-Value&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Piperine recovered (µg/ml)</td>
<td>Recovered % ± RSD&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Piperine recovered (µg/ml)</td>
<td>Recovered % ± RSD&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Glucose</td>
<td>1.000</td>
<td>0.995</td>
<td>99.95 ± 0.66</td>
<td>1.003</td>
<td>100.38 ± 1.06</td>
</tr>
<tr>
<td></td>
<td>2.000</td>
<td>2.008</td>
<td>100.40 ± 1.50</td>
<td>1.996</td>
<td>99.28 ± 1.34</td>
</tr>
<tr>
<td>Lactose</td>
<td>1.000</td>
<td>1.003</td>
<td>100.33 ± 1.69</td>
<td>0.986</td>
<td>98.58 ± 0.96</td>
</tr>
<tr>
<td></td>
<td>2.000</td>
<td>2.018</td>
<td>100.90 ± 0.65</td>
<td>2.030</td>
<td>101.5 ± 0.92</td>
</tr>
<tr>
<td>Dextrose</td>
<td>1.000</td>
<td>0.991</td>
<td>99.10 ± 1.33</td>
<td>0.984</td>
<td>98.42 ± 1.18</td>
</tr>
<tr>
<td></td>
<td>2.000</td>
<td>2.014</td>
<td>100.70 ± 0.93</td>
<td>2.052</td>
<td>102.60 ± 1.54</td>
</tr>
<tr>
<td>Starch</td>
<td>1.000</td>
<td>1.003</td>
<td>100.36 ± 0.78</td>
<td>1.013</td>
<td>101.26 ± 1.08</td>
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<tr>
<td></td>
<td>2.000</td>
<td>2.014</td>
<td>100.72 ± 1.26</td>
<td>2.008</td>
<td>100.38 ± 0.76</td>
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<tr>
<td>Talc</td>
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<td>1.010</td>
<td>101.02 ± 1.23</td>
<td>1.007</td>
<td>100.72 ± 1.26</td>
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<td>2.000</td>
<td>2.032</td>
<td>101.60 ± 1.68</td>
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<td>102.6 ± 1.54</td>
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<td>Carboxymethylcellulose</td>
<td>1.000</td>
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<td>101.35 ± 1.05</td>
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<td>101.35 ± 0.99</td>
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<tr>
<td>Microcrystalline cellulose</td>
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<td>0.996</td>
<td>99.62 ± 0.86</td>
<td>1.013</td>
<td>101.26 ± 1.08</td>
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<tr>
<td></td>
<td>6.00</td>
<td>5.98</td>
<td>99.62 ± 0.86</td>
<td>6.08</td>
<td>101.26 ± 1.08</td>
</tr>
</tbody>
</table>

<sup>a</sup>Average of five determination ± relative standard deviation; <sup>b</sup>Tabulated t-value at 95% confidence level is 2.78  
<sup>c</sup>Tabulated F-value at 95% confidence level is 6.39
Table VIII.3: Determination of piperine in different pharmaceutical additives or excipients using Method B (Compexation reaction - Prussian blue method)

<table>
<thead>
<tr>
<th>Pharmaceutical Additives</th>
<th>Piperine added (µg/ml)</th>
<th>Proposed method</th>
<th></th>
<th>Reported method</th>
<th></th>
<th>t-Value&lt;sup&gt;b&lt;/sup&gt;</th>
<th>F-Value&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Piperine recovered (µg/ml)</td>
<td>Recovered % ± RSD&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Piperine recovered (µg/ml)</td>
<td>Recovered % ± RSD&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glucose</td>
<td>5.00</td>
<td>4.99</td>
<td>99.90 ± 1.53</td>
<td>4.93</td>
<td>98.52 ± 1.19</td>
<td>1.60</td>
<td>1.65</td>
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<td></td>
<td>6.00</td>
<td>6.01</td>
<td>100.20 ± 1.18</td>
<td>6.13</td>
<td>102.10 ± 1.18</td>
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<td>1.54</td>
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<td>6.01</td>
<td>100.20 ± 0.39</td>
<td>6.08</td>
<td>101.40 ± 0.28</td>
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<td>2.68</td>
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<td>101.10 ± 1.75</td>
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<td>102.60 ± 1.54</td>
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<tr>
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<td>6.00</td>
<td>6.07</td>
<td>101.10 ± 1.51</td>
<td>6.09</td>
<td>101.50 ± 0.92</td>
<td>0.61</td>
<td>1.56</td>
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<td>4.85</td>
<td>97.00 ± 0.57</td>
<td>5.05</td>
<td>101.00 ± 0.41</td>
<td>2.10</td>
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<td>99.00 ± 0.31</td>
<td>6.01</td>
<td>100.20 ± 0.72</td>
<td>2.60</td>
<td>2.31</td>
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<td>Talc</td>
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<td>5.05</td>
<td>101.02 ± 1.23</td>
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<td>100.72 ± 1.26</td>
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<td>1.03</td>
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<tr>
<td></td>
<td>6.00</td>
<td>5.94</td>
<td>98.96 ± 1.06</td>
<td>5.96</td>
<td>99.36 ± 0.74</td>
<td>0.70</td>
<td>2.05</td>
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<td>5.00</td>
<td>4.99</td>
<td>99.8 ± 1.21</td>
<td>5.08</td>
<td>101.5 ± 0.92</td>
<td>2.52</td>
<td>1.73</td>
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<tr>
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<td>6.00</td>
<td>5.83</td>
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<td>5.91</td>
<td>98.42 ± 1.18</td>
<td>1.53</td>
<td>1.64</td>
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<tr>
<td>Microcrystallinecellulose</td>
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<td>5.07</td>
<td>101.42 ± 0.76</td>
<td>5.10</td>
<td>102.58 ± 1.08</td>
<td>1.96</td>
<td>2.01</td>
</tr>
<tr>
<td></td>
<td>6.00</td>
<td>5.98</td>
<td>99.62 ± 0.86</td>
<td>6.08</td>
<td>101.26 ± 1.08</td>
<td>2.68</td>
<td>1.57</td>
</tr>
</tbody>
</table>

<sup>a</sup> Average of five determination ± relative standard deviation; <sup>b</sup> Tabulated t-value at 95% confidence level is 2.78
<sup>c</sup> Tabulated F-value at 95% confidence level is 6.39
VIII.5. Application

To further confirm the validity and accuracy of the proposed method recovery tests were performed by standard addition method. Each test was repeated five times. The results presented in Tables VIII.2 and VIII.3 indicate very good recoveries and non-interference from commonly encountered additives and excipients that often accompany drugs in pharmaceutical preparations.

VIII.6. Conclusion

Today, extensive arrays of modern analytical techniques have been employed for nutraceutical analysis. Nevertheless, spectrophotometry will survive even in the presence of purely instrumental approaches. The proposed spectrophotometric methods provide accurate measurement for the determination of piperine in presence of pharmaceutical additives or excipients. Hence, the proposed methods using common reagents such as MBTH, iron(III) salts and potassium ferricyanide are simple, sensitive, selective and cost-effective and thus they are suited for the routine assay and evaluation of nutraceutical in preformulation and dosage forms to assure high standard of quality control. Further, value-addition to this method can be achieved if the procedure is combined with on-line or at-line system and this is currently under investigation.

Pepper finds a wide range of applications in Ayurveda. It is used as a "Rasayana" in the treatment of respiratory disorders and also as an important constituent in digestive formulations. Ayurveda uses it as an ingredient of Trikatu (a combination of three pungent herbs (black pepper, long pepper and ginger). This is a classic formula used to enhance digestion, respiration and immunity. Individually long pepper is used in correcting digestive disturbances and minor respiratory ailments. Trikatu is an important constituent in many Ayurvedic formulations. Experimental studies suggest that Trikatu increases bioavailability of the substances administered along with them. The fruits contain volatile oil, resin and alkaloids piperine and piperlongumine.

Health in focus

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Chapter VIII

Novel reactions for of piperine

References

Chapter VIII  

Novel reactions for .......... of piperine

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