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Screening of Adulterants in Slimming Herbal Formulation by FTIR Analysis

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Herbal formulations are used worldwide during these days specifically as the remedy of some commonly occurring health problems such as diabetes, obesity and digestive disorder. As the use and demand of these herbal formulations have increased, cases of adulteration of herbal formulations with synthetic pharmaceuticals have also increased. The main reason behind the adulteration in herbal formulation with the synthetic drug is to get commercial gain by increasing effectiveness of the herbal formulation. As the use of herbal slimming formulation is on the rise in India due to increasing problem of obesity, therefore, the main aim of the present study is to analyze the herbal slimming formulations present in the Indian market for the presence of synthetic pharmaceuticals by FTIR method. Out of 20 herbal slimming formulations analysed, 7 herbal slimming samples were detected with the presence of synthetic drugs such as Modafinil, Salbutamol, Phenolphthalein and Caffeine. In our study, FTIR has proven an effective method for screening of synthetic pharmaceutical in Herbal formulations.

Keywords: Herbal drugs; adulteration; FTIR; synthetic drugs.

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1. INTRODUCTION

Nowadays people are moving towards the herbal medicines for their general health problems such as obesity due to fewer side effects in comparison with synthetic medicine and natural origin of herbal drugs [1]. A survey was conducted based on a questionnaire prepared to investigate the preferences of the public to various weight loss practices and extent of awareness about the hazardous effect of unhealthful ways to reduce weight. After interviewing 30,000 individuals (from different regions of Jordan), it was found that 74% of participants preferred dietary restriction and exercise for weight loss practice, 25% preferred pharmaceutical herbal preparations and 15% used herbal remedies given by herbalists and 12% rely on conventional drug therapy. It was reported that the most frequent herbal formulation for this purpose was diuretics and weight loss pills consist of ephedrine [1].

The phytotherapeutic formulations are globally in use for the treatment of obesity and illegal synthetic pharmaceutical were found to be present in some of these phytotherapeutic formulations, that pose a serious threat to the health of the user and continuous use of such adulterated herbal medicine may develop into adverse health problem [2,3]. According to a study conducted in Hong Kong, non-prescription slimming products were found to be adulterated with the analogue of sibutramine and fenfluramine. Due to the harmful effects of these drugs three persons were hospitalized, one of them had liver failure and one has developed acute psychosis [3]. The problem of adulteration of herbal and dietary supplements is a worldwide problem, according to literature out of 10 herbal slimming samples collected from Romania market three of them were found to be adulterated with illegal synthetic medicines [4]. Review literature on Chinese herbal medicine reported that adulterant present in herbal drugs includes corticosteroids which have a serious adverse effect on consumer health. It was also reported in the study that 24% herbal medicines are adulterated with one synthetic drug in Taiwan so strict quality control and regulatory measures are the need of the time to control this adulteration [5]. However, the sources of this adulterated herbal medicine are not only limited to the local market as it is available through internet websites also [6]. Therefore the quality and safety measures of the herbal product are a matter of concern. In India, herbal medicines are regulated by the Ministry of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH) [7] and guidelines by AYUSH should be followed strictly by manufacturers. From different kinds of literature data, it was found that various techniques have been used till now to detect the presence of the pharmaceutical drug in herbal medicines such as X-ray powder diffractometry, liquid chromatography [8], Nuclear Magnetic Resonance (NMR) [9] and High-performance thin-layer chromatography (HPTLC) [10]. The study was conducted in India to assess the prevalence of abdominal obesity and generalized obesity among 309 people in the rural area and it was found that combined obesity was 51.3% [11]. Fourier-transform infrared spectroscopy (FTIR) has many advantages like it is a non-destructive, fast and sensitive technique as it can produce the whole spectrum in single scan and process of scan takes only a few seconds. The technique depends on the absorption of specific frequency by different molecules which determines its structure and this instrument can measure all frequencies simultaneously. The sample preparation is also very easy and less time-consuming. The KBr pellet technique has its advantages like it do not interact with infrared rays and sample prepared in pellet form can be stored for a longer period than in any other form. The design of the instrument is also simple having only one moving part and gives better reliability. The overall technique is equipped with computerized data system which helps in producing more accurate and better results as it can perform a different type of data processing tasks [12]. Increased demand of herbal medicine in India and increased adulteration rate in herbal medicine in different countries as discussed above, generating the purpose of the study to detect any possible presence of synthetic pharmaceutical as an undeclared ingredient in herbal slimming formulations present in Indian Market by using a non-destructive technique FTIR.

2. MATERIALS AND METHODS

2.1 Sample Collection

Twenty samples of Herbal slimming formulations were purchased from local stores, online shopping and some open herbal samples were also obtained which did not have any ingredient list. Reference Standard of Modafinil, Caffeine, Phenolphthalein and Salbutamol was purchased from Indian Pharmacopoeia Commission, Ghaziabad, India and Pharma affiliates Pvt, Ltd, Chandigarh, India.

2.2 Procedure for FTIR Analysis

i. FTIR spectra were recorded in the wavenumber range of 4000-400 cm-1 using Potassium bromide on Perkin-Elmer FTIR spectrometer and compared with standard FTIR spectra. The KBr pellet was prepared and used for this study.
ii. Herbal slimming formulations were in the forms of dry powder, tablets or capsules. The sample was prepared by grinding them until obtaining a homogeneous powder for FTIR analysis. Total twenty samples were taken from herbal slimming formulation category.
iii. First weight the 1 mg of dried powder of herbal medicines and 500 mg of KBr. Dried powder extract was encapsulated in KBr pellet to prepare translucent sample discs. Then KBr pellet was scanned between the range of 4000 cm^{-1} -400 $cm^{-1.}$
iv. Fourier Transform Infrared Spectroscopy (FTIR), as a non-destructive technique, provides a powerful tool to identify the functional group present in the compound by interpreting annotated absorption spectrum.

3. RESULTS

3.1 FTIR Study of Herbal Slimming Formulation for the Presence of Caffeine

The standard sample of Caffeine is showing the bands for N-H stretch at frequency 3419 cm^{-1} and C=O stretch at 1661 cm^{-1}. The medium intensity band for C-N stretch occurred at wave number 1026 cm^{-1} in caffeine standard. The N-H bending appeared in a standard sample of caffeine with a weak intensity band at wave number 1431 cm-^{1}. A weak and sharp band for C=C bend at wave number 1600 cm^{-1} was found in Caffeine. The region between 3000 and 2850 cm-^{1} suggests the presence of aliphatic C-H stretch. In Caffeine spectrum, a weak sharp band at frequency 2957cm^{-1} indicates the presence of aliphatic C-H. IR spectra of herbal slimming samples S10 and S9 are almost matched with the spectra of standard Caffeine and comparison of characteristics absorption peaks of herbal samples with the standard drug is given below in Table 1.

3.2 FTIR Study of Herbal Slimming Formulation for the Presence of Modafinil

In FTIR spectra of Modafinil aliphatic (N-H) stretching appeared at wavenumber 3416 cm-^{1}. Aliphatic C-H stretch band with very weak intensity appeared at wave number 2926 cm-^{1}. Modafinil spectra showed C=O band for amide at 1686 cm-^{1}. A strong sharp band occurred at wavenumber 701 cm-^{1} for C=C bending in the standard sample and similarly IR spectra of herbal slimming samples S2 and S10 are almost matched with the spectra of standard Modafinil and comparison of characteristics absorption peaks of herbal samples with the standard drug is given below in Table 2.

3.3 FTIR Study of Herbal Slimming Formulation for the Presence of Phenolphthalein

In FTIR spectra, characteristic absorption peaks of Phenolphthalein was observed at wave number 3386 cm^{-1} for O-H stretching, at 2929 cm^{-1} for C-H stretching, at 1737 cm^{-1} for C=O, at 1093 cm^{-1} showing C-O-C stretch, at 1174 cm^{-1} C-O stretch (Phenol). IR spectra of herbal slimming samples S8 and S 12 are matched with the spectra of standard Phenolphthalein and comparison of characteristics absorption peaks of herbal samples with the standard drug is given below in Table 3.

Table 1. Comparison of absorption peaks showing different functional groups in Standard sample with test (herbal) sample

Functional group (Range in cm-^{1})	Standard caffeine(in cm-^{1})	S10 (in cm-^{1})	S9 (in cm-^{1})
C=O (amide) (1630-1680)	1661	1684,	1651
N-H bond (amide) (1550-1640)	1431	1403	1430
C-N stretch (amine)(1000-1350)	1026	1031	1027
C=C stretch (1400-1600)	1600	1619	1552
N-H stretch(secondary amine) (3300-3500)	3419	3422	3399
C-H stretch (2800-300)	2957	2926	2930

Table 2. Comparison of absorption peaks showing different functional groups in Standard sample with test (herbal) sample

Functional group (Range in cm-^{1})	Standard Modafinil (in cm-^{1})	S2 (in cm-^{1})	S10 (in cm-^{1})
Aliphatic -NH stretching(3100-3500)	3416,	3422	3426.22
Aliphatic` –CH stretching(2850-3000)	2926	2928	2926
-S=O(950-1150,)	1034	1035	1031
-C=O amide(1630-1680)	1686	1685	1684
C=C(bending))(665-730)	701	702	702
NH bend (amide)(1550-1640)	1637	1623	1619.34

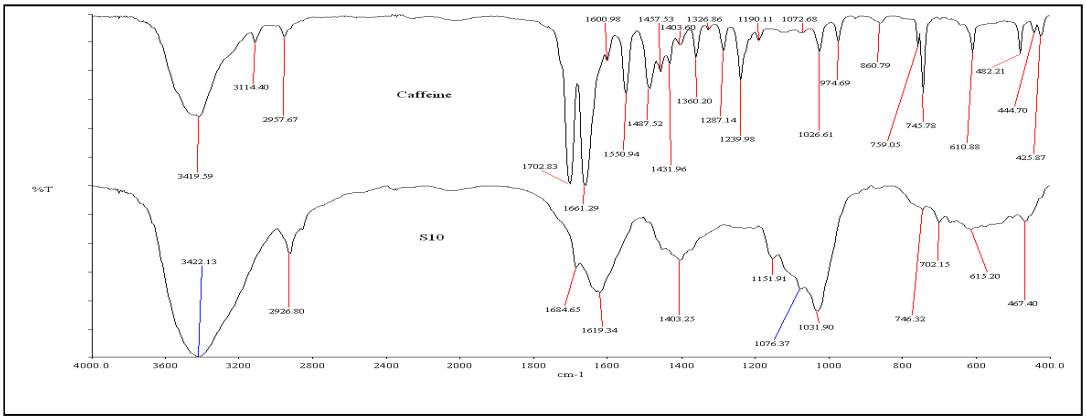

Fig. 1. FTIR overlapping spectra of standard caffeine and slimming herbal sample S10

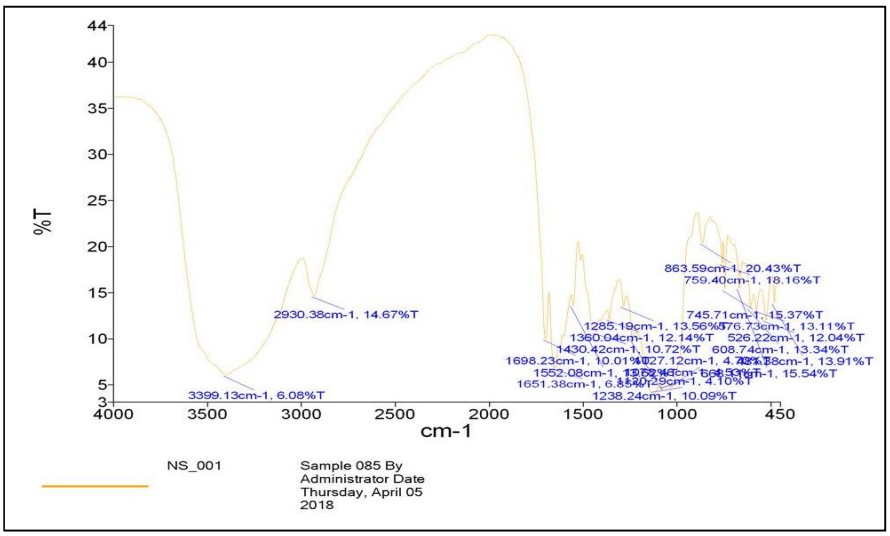

Fig. 2. FTIR spectra of slimming herbal sample S9

3.4 FTIR study of Herbal Slimming Formulation for the Presence of Salbutamol

In FTIR spectra, characteristic absorption peaks of Salbutamol was observed at 3416 cm-1 showing (O-H) stretching, at 2968 cm^{-1} showing (C-H) stretching, at 1611 cm^{-1} showing C=C stretching, at 1081 cm^{-1} for (C-OH) stretch and 616 cm^{-1} showing C=C bending. IR spectra of herbal slimming samples S1, S6 and S8 are matched with the spectra of standard Salbutamol and comparison of characteristics absorption peaks of herbal samples with the standard drug is given below in Table 4.

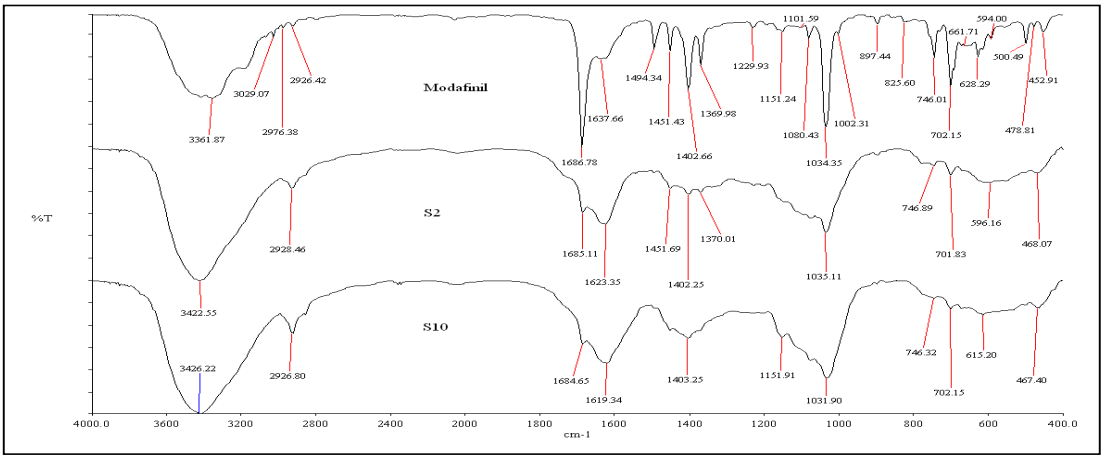

Fig. 3. FTIR overlapping spectra of standard Modafinil and slimming herbal samples S2 and S10

Table 3. Comparison of absorption peaks showing different functional groups in Standard sample with test (herbal) sample

Functional group (Range in cm-^{1})	Standard phenolphthalein (in cm-^{1})	S8 (in cm-^{1})	S12 (in cm-^{1})
O-H stretching (3200-3500)	3386	3436	3419
C-H stretching (2850-3000)	2929	2927	2928.06
C=O (1735-1750) ester \ stretching	1737	1711	1721
C-O-(1000-1150) stretch	1093	1036	1036
C-O (1260-1050) Phenol	1174	1156	1164

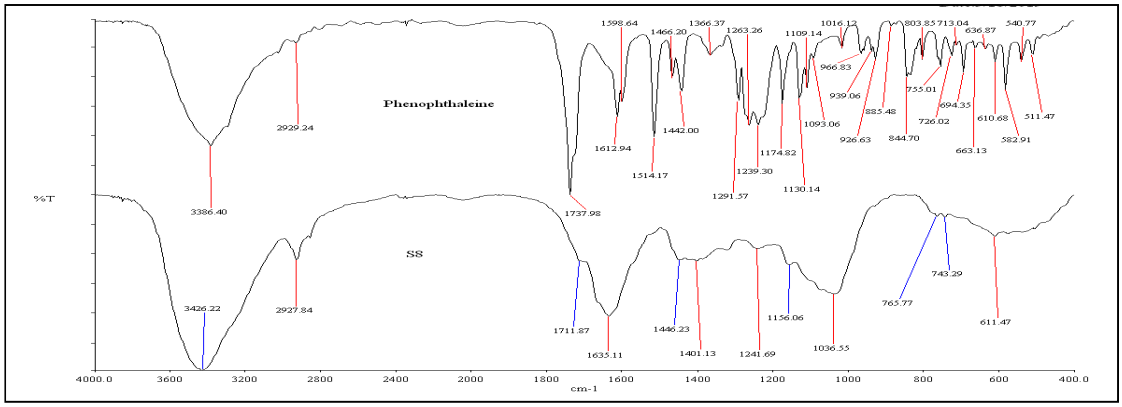

Fig. 4. FTIR overlapping spectra of standard phenolphthalein and slimming herbal samples S8 and S12

Table 4. Comparison of absorption peaks showing different functional groups in Standard sample with test (herbal) sample

Functional group (Range in cm-^{1})	Standard salbutamol (in cm-^{1})	S1 (in cm-^{1})	S6 (in cm-^{1})	S8 (in cm-^{1})
O-H stretching (3200-3400)	3416	3390.4	3404	3442
C-H stretching (2800-3000)	2968,	2930	2925	2927
C=C stretching (1600-1680)	1611,	1632,	1667	1635
C-OH stretching (1000-1260)	1081	1035	1021	1036
C=C bending (600-420)	616	606	610	611

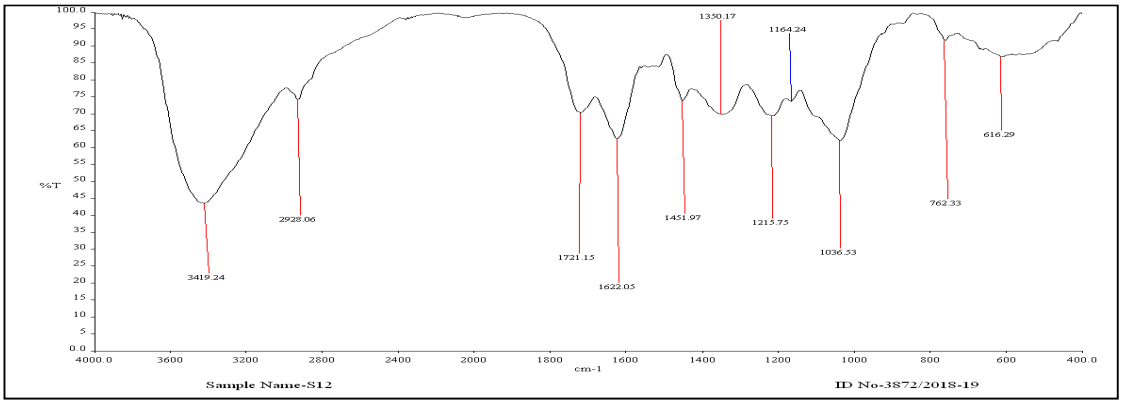

Fig. 5. FTIR spectra of slimming herbal sample S12

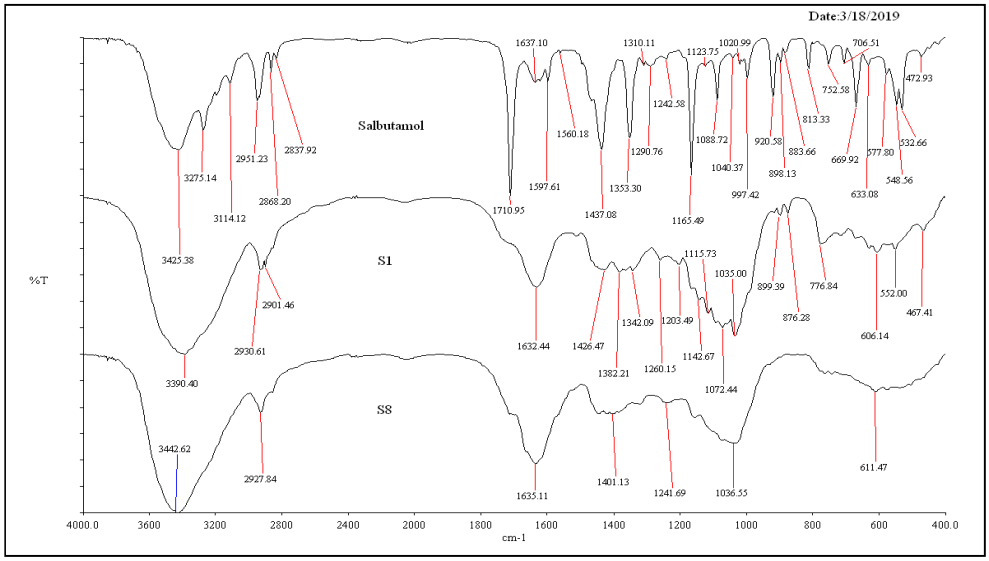

Fig. 6. FTIR overlapping spectra of standard Salbutamol and slimming herbal samples S8 and S1

4. DISCUSSION

FTIR study of 20 slimming herbal formulations taken from the Indian market, shows the presence of synthetic adulterants such as Modafinil, Salbutamol, Phenolphthalein & caffeine in 7 slimming herbal formulations. Many literatures from different countries have shown the problem of adulteration in the herbal slimming formulation such as a study of adulteration of Herbal slimming formulation has been conducted in Romania which showed the presence of Sibutramine & Fluoxetine in the herbal slimming formulation [2]. Another study of herbal slimming formulation conducted in Syria has found that these formulations are adulterated with Caffeine, Phenolphthalein, Sibutramine, Fluoxetine and Orlistat [13]. Synthetic adulterant present in the herbal formulation is the cause of concern as there can be adverse health event due to herb-drug interactions. As herbal formulation dosage is not strictly followed by the user, the amount of synthetic pharmaceutical adulterant in herbal formulation, taken by the user remains unknown not only to the user but also to the physician. Long-term use of adulterated herbal slimming formulation may result in serious illness. Phenolphthalein, found in the herbal slimming formulation in our study, was withdrawn from medicine due to carcinogenic effects [14]. Large doses of Caffeine can increase the risk of hypertension and myocardial infarction. Salbutamol as adulterant may cause side-effect of headache, muscle cramp, dry mouth and other symptoms. Salbutamol is mainly used in the treatment of

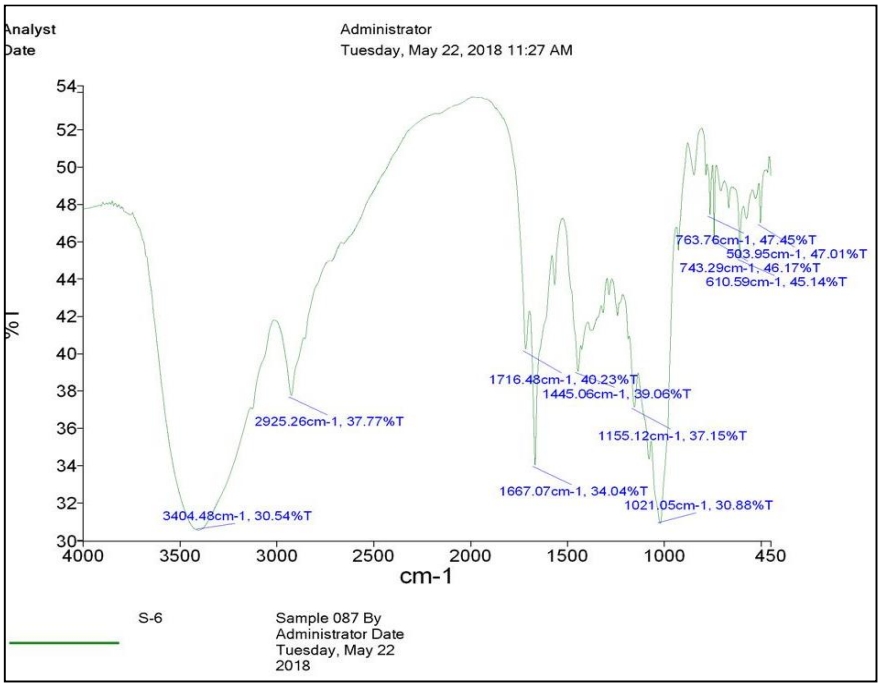

Fig. 7. FTIR spectra of slimming herbal samples S6

asthma but it also has a contribution to the weight loss process [15]. Medical tourism from western countries to south-east Asian countries has increased in recent times to herbal centers, thus users must become aware of adulteration in the herbal formulation [16].

Use of FTIR for simultaneous detection of a group of adulterants in herbal formulation provided a fast and sensitive technique with minimal sample preparation can be done easily, thus, it was preferred over another method for screening of adulterants in the herbal formulation. Other traditional methods which are laborious and time-consuming, FTIR provides an easy, effective and efficient approach for solving the problem of detecting adulteration.

5. CONCLUSION

This study concluded that the herbal products, which are containing the list of only plant extract or their parts on the label/ingredient list, may contain synthetic pharmaceutical substances. This study shows that out of 20 samples of herbal slimming formulation, seven herbal samples were detected with the presence of synthetic pharmaceuticals in which two samples were detected with Caffeine, two samples with Modafinil, three samples with Salbutamol and two samples with Phenolphthalein. Nowadays, the demand of herbal formulations has increased vastly due to high availability in India, misleading advertisements which shows that such products are 100 per cent herbal and do not have any side effects, cultural acceptability and low cost. The quality and safety of herbal drugs should be tested and strict government control and regulation of their marketing and sale are recommended.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by the personal efforts of the authors.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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