IJPSR (2022), Volume 13, Issue 5 (Research Article)

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 11 August 2021; received in revised form, 30 September 2021 accepted, 28 March 2022; published 01 May 2022

EVALUATION OF ADULTERATION OF HERBAL MEDICINE USED FOR TREATMENT OF ERECTILE DYSFUNCTION IN NAIROBI COUNTY, KENYA:

S. W. A. Sifuma [*1], J. W. Mwangi [1], P. C. Mutai [1], D. B. Ongarora [2] and N. M. Njuguna [3]

Department of Pharmacology and Pharmacognosy [1], Department of Pharmaceutical Chemistry [2], National Quality Control Laboratory for Drugs and Medical Devices [3], School of Pharmacy, University of Nairobi, P.O Box 19676- 00202, Nairobi, Kenya.

Keywords:

Herbal medicine, Adulteration, Adulterants, Sildenafil, Tadalafil, Vardenafil Erectile dysfunction, High-Performance Thin Layer Chromatography

Correspondence to Author:
S. W. A. Sifuma

Ph.D. Student,
Department of Pharmacology and Pharmacognosy, School of Pharmacy, University of Nairobi, P.O Box 19676- 00202, Nairobi, Kenya.

E-mail: shabansifuma@gmail.com

ABSTRACT: In the recent past, adulteration of herbal products has increased rapidly, and today it is a global problem. Synthetic Phosphodiesterase type 5 inhibitors are the main adulterants in herbal medicine used for erectile dysfunction. The present study evaluated the herbal medicines used as sex enhancers in Nairobi County, Kenya, for adulteration with Phosphodiesterase type 5 inhibitors (sildenafil, tadalafil, and vardenafil). The products were purchased from health stores in Nairobi County. Samples were screened for adulteration with sildenafil, tadalafil, and vardenafil using HPTLC. Quantification was done by integration of sample chromatograms against standard chromatograms. The samples analyzed, 33.5% were adulterated. All the adulterated samples were imported, and none of the locally manufactured samples were found adulterated. The study revealed that samples from China/Hong Kong had the largest number 14 (53.85%) of the adulterated samples. These findings were in agreement with previous studies. A number of samples (32.5%) samples studied were adulterated. Sixty percent (60%) of adulterated samples contained sildenafil, while a few samples had either tadalafil, vardenafil or the combination.

INTRODUCTION: In the herbal medicine industry, adulteration is more often than not intentional. Synthetic prescription medicines are the major adulterants. Adulteration poses health risks to patients and the general public. Synthetic Phosphodiesterase type 5 (PDE-5) inhibitors singly or in combination are the most common adulterants in herbal medicines used to treat erectile dysfunction.

QUICK RESPONSE CODE

DOI: 10.13040/IJPSR.0975-8232.13(5).2095-00

This article can be accessed online on www.ijpsr.com

DOI link: http://dx.doi.org/10.13040/IJPSR.0975-8232.13(5).2095-00

Herbal medicine for sex enhancement has been very popular due to claims of being safe with no adverse effects [1, 2]. However, adverse effects have been documented in part due to adulterants in the products [3]. In herbal medicine for sex enhancement, adulteration with PDE- 5 inhibitors is done mainly to enhance therapeutic effect [4].

There are several reported cases of adulteration of herbal medicine [5, 6]. In Saudi Arabia, adulteration of herbal medicine with tadalafil and sildenafil has been reported [7]. Dural E investigated the presence of sildenafil in herbal dietary supplements by validated HPLC method, which indicated that samples had sildenafil [8]. Assessment of common adulterants in herbal medicine for sexual enhancement in Malaysia indicated presence of

Phospho-diesterase type 5 inhibitors [9]. In Australia, the Therapeutics Goods Authority conducted post-market surveillance on herbal products used for erectile dysfunction (ED) treatment found them to contain tadalafil [10]. Search in databases in western countries, Japan, China, and Taiwan, reveal that most herbal products contained conventional drugs, and side effects were associated with adulterants contained therein [11, 12].

Furthermore, the analogs of PDE-5 inhibitors have also been reported in herbal products used as sex enhancers [13, 14]. A preliminary study suggests the presence of adulteration of herbal medicine used to treat erectile dysfunction in Nairobi County, Kenya, with Phosphodiesterase type 5 inhibitors. One study has reported adulterating herbal medicine used to treat erectile dysfunction in Nairobi County, Kenya, with Phosphodiesterase type 5 inhibitors [15].

Adulteration with Phosphodiesterase type 5 inhibitors adulterants presents serious health risks to users. Sildenafil and other PDE-5 inhibitors are known to cause adverse drug reactions such as headaches, facial flushing, dyspepsia, visual disturbances, and muscle aches. They can cause potentially severe hypotension, which can be fatal in patients using Nitrates to treat hypertension [16]. They can also interact with other drugs (drug-drug interactions and herbal-drug interactions), posing serious health risks to consumers [16]. In some case the amount of adulterant is far above the recommended dose leading to death, while in other cases the adulterant was an analogue of PDE-5 inhibitor, which poses regulatory challenge [17]. Ran *et al* documented a case of hepatotoxicity induced by adulterated "Tiger King", a Chinese herbal medicine containing sildenafil [18]. In Hong Kong, one person presented with ataxia following ingestion of sexual enhancement herbal remedy adulterated with sildenafil analogue [19]. There have been no detailed studies in Kenya to evaluate the trend of adulterants in herbal medicine used to treat erectile dysfunction. The present work reports on the adulteration of herbal medicines used to treat erectile dysfunction in Nairobi County, Kenya.

MATERIALS AND METHOD:

Sample Collection: The study was carried out in Nairobi County, Kenya. Target products in the study area were purchased from the identified healthcare stores (Pharmacies, Supermarkets, health stores, herbal kiosks, and open-air hawkers). Identification of the products was done by asking the attendants and checking the indications on the label. The samples purchased included tablets, capsules, liquids, gels, and powders. Only samples that had intact packs were purchased between July 2017 and August 2018.

Materials, Reagents, and Instrumentation: Standards of sildenafil, tadalafil, and vardenafil were obtained from TLC PharmaChem (Ontario, Canada). The methanol used was of LC grade obtained from Fisher Scientific, Loughborough, United Kingdom. Ethyl acetate was sourced from Carlo Erba, Val de Reuil, France. KSCN (98%) used was from Merck (Darmstadt, Germany). Formic acid was LC grade sourced from Fluka, St Louis, MO. Ammonia (35%) was sourced from Fisher Scientific instruments.

Screening for Adulterants and Instrumentation: Screening was done by the HPTLC method adapted from Tien *et al.* [20].

HPTLC Method, with the following Conditions: A Camag HPTLC Linomat 5 apparatus (ID QCE015 (A), with an automatic spotter and Camag TLC scanner 3 S/N 170308 (ID QCE015) (Camag, Muttenz, Switzerland), silica gel 60 glass plates, 20x20 cm were used for screening and quantification. Analysis was done at 254nm using a deuterium lamp (Lamp D2) with emission and absorption modes. Samples and standards were dissolved in methanol and methanol: ethyl acetate 40:80 was used as the mobile phase.

Standard Preparation: Fivemg of standard (sildenafil, tadalafil, and vardenafil) were each separately dissolved in 5 ml of methanol. From the solutions, 1ml was taken and diluted to 10ml with methanol. 2µl and 5µl respectively (duplicate application) were used for spotting on the TLC plates. The plates were developed in the chambers and ran in the Linomat scanner to produce the chromatogram. Chromatograms of samples and standards were compared/merged by HPTLC software.

Quantification of Adulterants: The sample and standard preparations were used to generate the

chromatograms for the quantification of adulterants. The chromatograms were stored in TLC video scan software and used to quantify adulterants using TLC software's peak area and/or peak height integration.

RESULTS: 80 samples were screened for adulteration with either sildenafil, tadalafil, vardenafil, or a combination thereof. Twenty-six (32.5%) samples were found to be adulterated **Table 1.**

TABLE 1: QUANTITY OF ADULTERANTS IN SAMPLES

S. no	Country of origin	Sample No.	Quantity of adulterant
1	China	Mis-05303/2019	Sildenafil 148.7mg/Tab, Vardenafil 0.5mg/Tab
2	USA	Mis-05304/2019	Vardenafil 3.3mg/Tab
3	China	Mis-05305/2019	Sildenafil 67mg/Tab
4	USA	Mis-05306/2019	Sildenafil 11.62mg/Sachet, Vardenafil 36.6mg/Sachet
5	USA	Mis-05308/2019	Sildenafil 71.4mg/Tab
6	China	Mis-05310/2019	Sildenafil 88.5mg/Tab
7	India	Mis-05319/2019	Vardenafil 2.4mg/capsule
8	China	Mis-05330/2019	Sildenafil 124.3mg/Tab
9	China	Mis-02537/2019	Sildenafil 127.62mg/Tab
10	China	Mis-02538/2019	Sildenafil 19.86mg/Tab, Tadalafil 24.40mg/Tab
11	China	Mis-02540/2019	Sildenafil present (Sample inadequate for quantification)
12	China	Mis-02541/2019	Sildenafil 51.90mg/Tab
13	South Africa	Mis-02544/2019	Sildenafil present (Sample inadequate for quantification)
14	China	Mis-02555/2019	Sildenafil 7.73mg/Cap
15	China	Mis-02556/2019	Sildenafil 47.26mg/Cap, Tadalafil 13.38mg/Cap
16	China	Mis-02559/2019	Sildenafil present (Sample inadequate for quantification)
17	USA	Mis-02563/2019	Tadalafil 115.52mg/Cap
18	USA	Mis-02564/2019	Sildenafil 122.01mg/Cap
19	India	Mis-02571/2019	Vardenafil 1.63mg/Cap
20	France	Mis-02578/2019	Sildenafil present (Sample inadequate for quantification) Sample inadequate
21	China	Mis-02579/2019	Sildenafil & Vardenafil present (Sample inadequate)
22	Tanzania	Mis-02582/2019	Sildenafil present (Sample inadequate for quantification) Sample inadequate
23	USA	MIS-03629/2020	Sildenafil 0.9mg/Tab
24	USA	MIS-03630/2020	Sildenafil 37.56mg/Tab
25	China	MIS-03628/2020	Sildenafil 42.91mg/Tab
26	China	MIS-03631/2020	Sildenafil 1.07mg/Tab

Only imported products comprising 32.5% of the samples were found to be adulterated. Each sample (3.85%) manufactured in Tanzania, South Africa, and France was adulterated. Two samples (7.69%) were manufactured in India, and 7 (7.69%) from the USA were adulterated. China/Hong Kong had the largest number 14 (53.85%) of the adulterated samples.

Most of the adulterated samples contained sildenafil (17 samples (65.38%). Only one sample (3.85%) was adulterated with tadalafil while 3 samples (11.54%) were adulterated with vardenafil. There were combinations of sildenafil and tadalafil (1 sample, 3.85%) and sildenafil and vardenafil (3 samples, 11.54%). Overall, sildenafil was the commonest adulterant and was found in 22 (84.62%) of the adulterated samples. Tadalafil was the least common adulterant detected in a total of 3 (11.54%) of the adulterated samples. The total number of samples from China/Hong Kong was 14, and all of them were adulterated.

There were 23 samples from the USA, out of which 7 (30.43%) were adulterated. The number of samples from India was 8; 2 (25%) were adulterated. From Tanzania, there were 6 samples, of which 1 (16.67%) was adulterated. The total number of samples from South Africa was 3, out of which 1 (33.33%) was adulterated. There were 7 samples from Europe, out of which 1 (14.29%) was adulterated.

Some samples had combinations of adulterants. The maximum daily allowable dose of sildenafil is 100mg [21], while that of tadalafil and vardenafil is 20mg [22].

DISCUSSION: This study revealed that samples from China/Hong Kong had the largest number 14 (53.85%) of adulterated samples. These findings were in agreement with previous studies. The presence of prescription medicine adulterants in Chinese herbal medicine (TCM) has been reported worldwide [23, 24, 25]. In one study, Santillo *et al.* investigated adulteration of herbal and natural sex performance enhancement dietary supplements with synthetic phosphodiesterase type 5 inhibitors. The study showed that the products were adulterated with PDE 5 inhibitors, including sildenafil and/or tadalafil. The study also showed that some samples contained more than the maximum daily allowable amount of the drug adulterant [26].

In another study, Chinese authorities collected 200 products from health market labelled as natural enhancers of sexual performance and analyzed for adulteration with synthetic phosphodiesterase type 5 inhibitors. 35% of samples were found to contain sildenafil, and the amount greatly exceeded the recommended daily allowable dose of sildenafil [27]. A Hong Kong study conducted in 2007 collected 26 herbal remedies from convenience stores revealed that 15(58%) samples were adulterated with sildenafil and its analogs [28]. In the Czech Republic, dietary supplements intended for sex enhancers were collected in a Czech market between 2009-2015 and analyzed for adulteration with sildenafil, tadalafil, vardenafil, and analogs. This study demonstrated the presence of PDE-5 inhibitors in samples [4].

There is the probable effort of manufacturers to mask the presence of PDE-5 inhibitors in sex enhancement dietary supplements [4]. In a study in Ghana, selected herbal supplements from Ghanaian market for better erectile function were evaluated for the presence of phosphodiesterase type 5 inhibitors by bioassay method. 90% of the samples showed activity indicating the presence of phosphodiesterase type 5 inhibitors. Some samples contained an amount higher than allowable daily dose of sildenafil (more than 100mg sildenafil) [29].

A study done on 80 dietary supplements intended to be introduced to herbal shops in Bushehr city, Iran, revealed that samples were adulterated with phosphodiesterase type 5 inhibitors, especially sildenafil [30].

A study conducted in the Lebanese market indicated that dietary supplements marked for sexual enhancement contained phosphodiesterase type 5 inhibitors, especially sildenafil and tadalafil. The amount of the adulterants also exceeded the maximal recommended daily allowable dose exposing the consumers to health risks[31]. Studies conducted by Tama *et al.* indicated that 48% contained Phosphodiesterase type 5 inhibitors adulterants, out of which 20% contained sildenafil and 22.5% contained tadalafil as adulterants [32]. Researchers purchased six products from the internet and health store in a Canadian study. The samples were evaluated for adulteration with undeclared Phosphodiesterase type 5 inhibitors.

Some samples were found to contain sildenafil, while others contained tadalafil [33]. One French study analyzed products from China, Taiwan, Estonia/ Spain; the study indicated that 47% of samples were adulterated, 29.41% with sildenafil, 11.76% with tadalafil, and 5.88% with vardenafil [34]. Wang *et al.* conducted an analysis of 23 illegal adulterated aphrodisiac chemical ingredients in health foods and Chinese traditional patent medicines by ultrahigh performance Liquid Chromatography coupled with quadrapole time-of-flight Mass Spectrophotometry [35]. In Kenya, preliminary studies indicated that herbal products used as sex enhancers contained sildenafil [14]. Previous reports indicate that adulterants in the form of analogs of sildenafil have been detected in herbal products marketed for erectile dysfunction [36, 37].

The maximum daily allowable dose of sildenafil is 100mg [38], while that of tadalafil and vardenafil is 20mg respectively [39, 40]; therefore a number of samples contained way above the daily allowable dose of phosphodiesterase type 5 inhibitors (highest for Sildenafil 148.7 mg/Tab) with high attendant risk to the users. These findings are in agreement with the findings in the current study. In the present study, three adulterants (sildenafil, tadalafil, and vardenafil) were investigated in the samples. The

study revealed that the samples were adulterated with sildenafil, tadalafil, and vardenafil. There is a need to study further the presence of analogs in the herbal medicine products used to treat erectile dysfunction available in Nairobi County, Kenya.

CONCLUSION: A number of samples (32.5%) of herbal medicine used to treat erectile dysfunction available in Nairobi County, Kenya, were adulterated. Sixty percent of the adulterated samples contained sildenafil, while a few contained either tadalafil, vardenafil, or the combination. Only imported samples were adulterated. The highest percentage of adulterated samples was imported from China/Hong Kong (53.9%) followed by the USA (26.9%). Two samples manufactured in India (7.7%) were adulterated. One sample each manufactured in Tanzania, France, and South A. All the adulterants in the samples were not declared on the label, posing health risks to the users. There is a need to put a policy in place to curb cases of adulteration of herbal medicinal products for the treatment of erectile dysfunction in the Kenyan market.

ACKNOWLEDGEMENT: The first author received financial support for the Pharmacy and Poisons Board research.

Declarations:

Availability of Data and Materials: The datasets used and/or analyzed during the current study are available from the corresponding author on request.

Ethical Approval and Consent to Participate: Ethical approval was obtained from the Institutional Review Committee of the University of Nairobi/ Kenyatta National Hospital.

CONFLICTS OF INTEREST: The authors declare no conflicts of interest.

REFERENCES:

1. Ekar T and Kreft S: Common risks of adulterated and mislabeled herbal preparations. Journal of Food and Chemical Toxicology 2019; 123: 288-97.
2. Kee CL, Ge X, Gilard V, Malet-Martino M and Low MY: A review of synthetic Phosphodiesterase type 5 inhibitors (PDE-5i) found as adulterants in dietary supplements. J of Pharma and Biomedical Analysis 2018; 147: 250-77.
3. Foroughi MH, Achuar M, Jokar F and Mousavi F: Identification of undeclared active Pharmaceutical Ingredients in counterfeit herbal medicines used as opioid substitution Therapy. Australian J of Forensic Sci 2017.
4. Jiru M, Stranska-Zachariasova M and Dzuman Z: Analysis of Phosphodiesterase type 5 inhibitors as possible adulterants of Botanical based dietary supplements: Extensive survey of preparations available at the Czech market. Journal of Pharmaceutical and Biomedical Analysis 2019; 164: 713- 24.
5. Assemat G, Balayssac S, Gilard V, Martinz-Froment N, Fabing I, Rodriguez F, Gennison Y, Martino R and Malet-Martino M: Isolation and Identification of ten new sildenafil derivatives in an alleged herbal supplement for sexual enhancement. Journal of Pharmaceutical and Biomedical Analysis 2020; 191: 113482.
6. Xiao S and He Y: Analysis of sildenafil in Liquor and Health Wine using surface enhanced Raman spectroscopy. International J of Molecular Sciences 2019; 20(11): 2722.
7. Hemdan A and Tawakol SM: HPLC-UV Chromatographic method for detection and quantification of undeclared withdrawn synthetic medications in counterfeit herbal medicines with confirmation by mass spectrophotometer. Chromatographer; 81: 777-83.
8. Dural E: Investigation of the presence of sildenafil in herbal dietary supplement by validated HPLC method. Turkish J of Pharmaceutical Sciences 2020; 17(1): 56-62.
9. Bujang NB, Chee CF, Heh CH, Rahman NA and Buckle MJC: Phosphodiesterase type 5 inhibitors and their analogs as adulterants of herbal and Food products: Analysis of the Malaysian market (2014-2016). Food additives and contaminants Part A 2017; 34 (7): 1101-9.
10. Lee JH, Park HN, Park OR, Kim NS, Park SK and Kang H: Screening of illegal sexual enhancement supplements and counterfeit drugs sold in the online and offline markets between 2014 and 2017. Forensic Science international 2019; 298: 10-19.
11. Ching CK, Chen SPL, Lee HHC, Lam YH, Chan SSS, Ng CWY, NCheung JWL, Chan TYCC, Lau NKC, Chang YK and Mak TWL: Adulteration of proprietary Chinese medicines and health products with undeclared drugs: experience of a tertiary toxicology laboratory in Hong Kong. British J of Clinical Pharmacolo 2018; 84: 172-78.
12. Mustafa YK, Aldewachi H, Najm R and Ammar F: Adulteration of slimming products and its detection methods. Journal of systemic review Pharmacy 2020; 11(3): 289-96.
13. Ozturk E, Akhaya E, Ozbek B and Bakirderere S: A powerful combination of quadraple isotope dilution strategy with dispersivemagnetic solid phase extraction for the accurate and precise multi-analyte determination of tadalafil,sildenafil, avanafil and vardenafil in human plasma and urine samples using LC-ESI-Tandem MS. Microchemical Journal 2020; 152: 104302.
14. Kim U, Cho HD, Kang MH, Suh JH, Eom HY, Kim J,Seo S, Kim G, Koo HR, Ha N, Song UT and Han SB: Screening of Phosphodiesterase-5 inhibitors and their analogs in dietary supplements by Liquid Chromatography-hybrid Ion Trap-Time of Flight Mass Spectrometry. Molecules 2020; 25: 2734.
15. Mwaniki M: Fake Medicines flood Country. The Nation (Nairobi) November 14, 2007, Available at: Matrix of Drug Quality Reports Affecting USAID – assisted Countries by the U.S Pharmacopeia Drug Quality and Information Program. Accessed 2007; 13.
16. Yafi FA, Sharlip ID and Becher EF: Update on the safety of Phosphodiesterase type 5 inhibitors for the treatment of Erectile Dysfunction (Review). Sexual Medicine Reviews 2018; 6(2): 242-52.
17. Zuntar I, Krivohlavek A, Kosic-Vuksic J, Granato D, Kovakevic DB and Putnik P: Pharmacological and

Toxicological health risk of food (herbal) supplements adulterated with erectile dysfunction medications. Current Opinion in food Science 2018; 24: 9-15.
18. Ran N, Alina P, Stein Y, Shapira G, Fuchs B, Berkovitz S, Hess R and Mickey ZA: A case of Liver toxicity induced by adulterated "Tiger King", a Chinese herbal medicine containing sildenafil. Current drug safety. Bentntham Science Publishers 11(2): 184-88
19. Fard HH and Akhgari M: Analytical perspectives of chemical adulterants in herbal sexual enhancer drugs. J of Pharmacy and Pharmacognosy Research 2018; 6(1): 45-53
20. Tien TKD, Grigorios T and Eike R: Simultaneous detection of three Phosphodiesterase type 5 inhibitors and their analogs in lifestyle products and screening for adulteration by HPTLC. Journal of AOAC International 98 (5): 1226-33.
21. Drugs.com: Sildenafil Dosage Guide with Precautions 2014.
22. British society of sexual medicine guidelines on the management of erectile dysfunction in men. Journal of Sex Medicine 2017; accessed 3 April.
23. Xu M, Huang B, Gao F, Zhai C, Yang Y, Li L, Wang W and Shi L: Assessment of Adulterated Traditional Chinese Medicines in China 2003–2017. Frontiers in Pharmacology 2019.
24. Santillo MF and Mapa MST: Phosphodiesterase (PDE5) inhibition assay for rapid detection of erectile dysfunction drugs and analogs in sexual enhancement products. Drugs testing and Analysis 2018; 10: 1315-22
25. Yusop AYM, Xiao L and Fu S: Suspected-targeted and non-targeted screenings of Phosphodiesterase type 5 (PDE 5) inhibitors in herbal remedies by Liquid Chromatography – Quadrapole time –of– flight Mass Spectrophotometer (LC – QTOF- MS). Drug testing and Analysis 2020.
26. Vanhee C, Tuenter E, Kamigisha M, Canfyn M, Moens G, Courselie P, Pieters L, Deconsk E and Exarchou V: Identification and Quantification methodology for the Analysis of suspected illegal Dietary supplements: Reference standard that is the Question. Journal of Forensic Toxicology & Pharmacology 2018; 7: 1.
27. Yusop AYM, Xiao L and Fu S: Determination of Phosphodiesterase 5 (PDE 5) inhibitors in instant coffee premixes using Liquid Chromatography-High-Resolution Mass Spectrometr (LC-HRMS) Talanta 2019; 204: 36-43.
28. Shi S, Wu Y, Zhao M and Cheng Q: Simultaneous analysis of 31 anti-impotence compounds potentially illegally added to herbal-based dietary supplements by Ultra-high-performance Liquid chromatography coupled with quadrapole time-of-flight Mass Spectrometry. Journal of Chromatography part B 2020; 1144: 122077.
29. Akuamoa F, Ron L, Hoogenboom AP, Astrid H, Ivonne MCMR and Toine FHB: Phosphodiesterase type 5 inhibitors in selected herbal supplements from Ghanaian market for better erectile function as tested by Bioassay. Toxicology *In-vitro* 2021; 73.
30. Hengameh HF and Akhgari M: Analytical perspectives of chemical adulterants in herbal sexual enhancer drugs. J of Pharmacy and Pharmacognosy Res 2018; 6(1): 45-53.
31. Razan S, Azza AG, Saab M and Marwa KJ: Identification and Quantification of Phosphodiesterase type 5 inhibitors as adulterants in dietary supplements for sexual enhancement in the Lebanese market. International Journal of Pharmacy and Pharmaceutical Sciences 2020; 12(3).
32. Tama AL, Musa A, Usman MA and Awwalu S: Evaluation of sildenafil as an undeclared adulterant in herbal aphrodisiac preparations by HPLC. Saudi Journal of Medical and Pharmaceutical Sciences 2020; 6(2): 168-72.
33. Reiss NFA, Silva LFG, Souza MAC, Fialho SL, Moreira CPS, Andrade MVO, Paula WX, Gloria MBA, Pianella GA and Fernandes C: UPLC for quality evaluation of genuine and illegal medicines containing sildenafil citrate and tadalafil. Journal of Chromatographic Science 2021; 59 (1): 30-39.
34. Shakour MAA, Salaam RAA, Hadad GM, Elmatty ADMA and Hameed EAA: HPLC-UV and UPLC-MS/MS method for the simultaneous analysis of sildenafil, vardenafil, tadalafil and their counterfeits dapoxetine, paroxetine, citalopram, tramadol and Yohimbine in aphrodisiac products. RSC Advances 2021; 11: 8055-64.
35. Wang XB, Zheng J, Li JJ, Yu HY, Li QY, Xu LH, Liu MJ, Xian RQ, Sun YE and Liu BJ: Simultaneous analysis of 23 illegal adulterated aphrodisiac chemical ingredients in health foods and Chinese traditional patent medicines by ultrahigh performance Liquid Chromatography coupled with quadrapole time-of-flight Mass Spectrophotometry. Journal of food and drug Analysis 2018; 26(3): 1138-53.
36. He F, Zou T, Yang J, Wang H, Deng L, Tian Y, Tan X and Shen Y: Development of a skeleton-specific antibody and Au nanoparticle-based immunochromatographic sensor for simultaneous detection of various tadalafil adulterants in health food. Food and agricultural immunology 2019; 30(1): 349-68.
37. Lee JH, Park HN, Park S, Lee YM and Kang H: Development of a specific fragment pattern – based quadrapole-Orbitrap Mass spectrometry method to screen adulterated products of Phosphodiesterase-5 inhibitors and their analogs. Journal of Science and Justice 2019; 59(4): 433-41.
38. Drugs.com: Sildenafil Dosage Guide with Precautions 2014.
39. British society of sexual medicine guidelines on the management of erectile dysfunction in men. Journal of Sex Medicine 2017.
40. Levitra: EMC 2019.

How to cite this article:
Sifuma SWA, Mwangi JW, Mutai PC, Ongarora DB and Njuguna NM: Evaluation of adulteration of herbal medicine used for treatment of erectile dysfunction in Nairobi County, Kenya. Int J Pharm Sci & Res 2022; 13(5): 2095-00. doi: 10.13040/IJPSR.0975-8232.13(5) 2095-00.