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IMPLEMENTATION OF TOTAL QUALITY MANAGEMENT OF HERBAL PRODUCTS

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Highlights :

- Total quality management is a company -wide initiative designed to improve quality at all levels.
- Total quality management is having two approaches six sigma(DMADV,DMAIC) and Ishikawa.
- Natural plant-based products with phytochemical ingredients that are utilised for therapy are known as herbal remedies.
- The presence of several pollutants and residues that could affect users of herbal medications is widely documented.

Abstract:

Introduction: Total Quality Management is one of the quality management tool that used in different pharmaceutical products. Herbal remedies are naturally occurring plant-derived medications with phytochemical components utilized for therapeutic purposes. It is crucial to examine the herbal product's quality. so that total quality management is one of the tool which is used to maintain the quality.

Methods: This paper discusses about the approaches of total quality management (six sigma , Ishikawa) , how they are used to find out the adulterants and contamination in herbal products.

Result: This article consisting procedure for identifying adulteration and contamination of herbal drug products .

Conclusion: This review paper also includes the reports that are discussed on the what are adulterants and contaminations present in the herbal products and what are the analytical methods they have used for the identification of adulterants.

Index terms **: Herbal medicines, synthetic drugs, total quality management, six sigma, Ishikawa, adulterants, high performance liquid chromatography, gas chromatography.**

1.INTRODUCTION :

Total Quality Management (TQM) is a company -wide initiative designed to improve quality at all levels TQM focuses on exceeding customer expectation for quality by achieving customer expectations for quality by achieving customer-defined quality (CDF). A company must work to establish and preserve a culture of complete quality management if it wants to offer clients high-quality products and services (Bhandari SB, Baldi A.2014). TQM is an organizational strategy that prioritizes quality as a major objective and focuses more on defect prevention than defect discovery (Jain AA et al., 2022). These caused a rise in cost and time utilization because the flaw can only be found at the end of the procedure .The best tool for pharmaceutical quality management is total quality management (TQM) (Bhandari SB, Baldi A.2014). All employees must contribute to improving an organization's procedures, goods, services, and workplace culture in order for TQM to be successful (Pambreni Y et al.,2019).In every facet of life, people priorities quality. The maintenance of the quality of the herbal product is vital since pharmaceuticals used to treat human ailments are of paramount importance when it comes to quality (Lim WM et al., 2022).

1.1. THE ESSENTIAL ELEMENTS OF TQM

1 Design: Create the procedures required to conduct quality tests.

2 Do: Carry out the procedures.

3 Analyze: Keep track of, evaluate, and compare procedures, goods, and policies.

4 Act: Continue to take steps to improve the product's quality (Jain AA et al., 2022).

1.2. REQUISITE FOR IMPLEMENTATION OF TQM

1. The backing of management
2. Training and inspiration for employee
3. Thorough understanding of the process' causes and effects (Thakkar D et al., 2022).

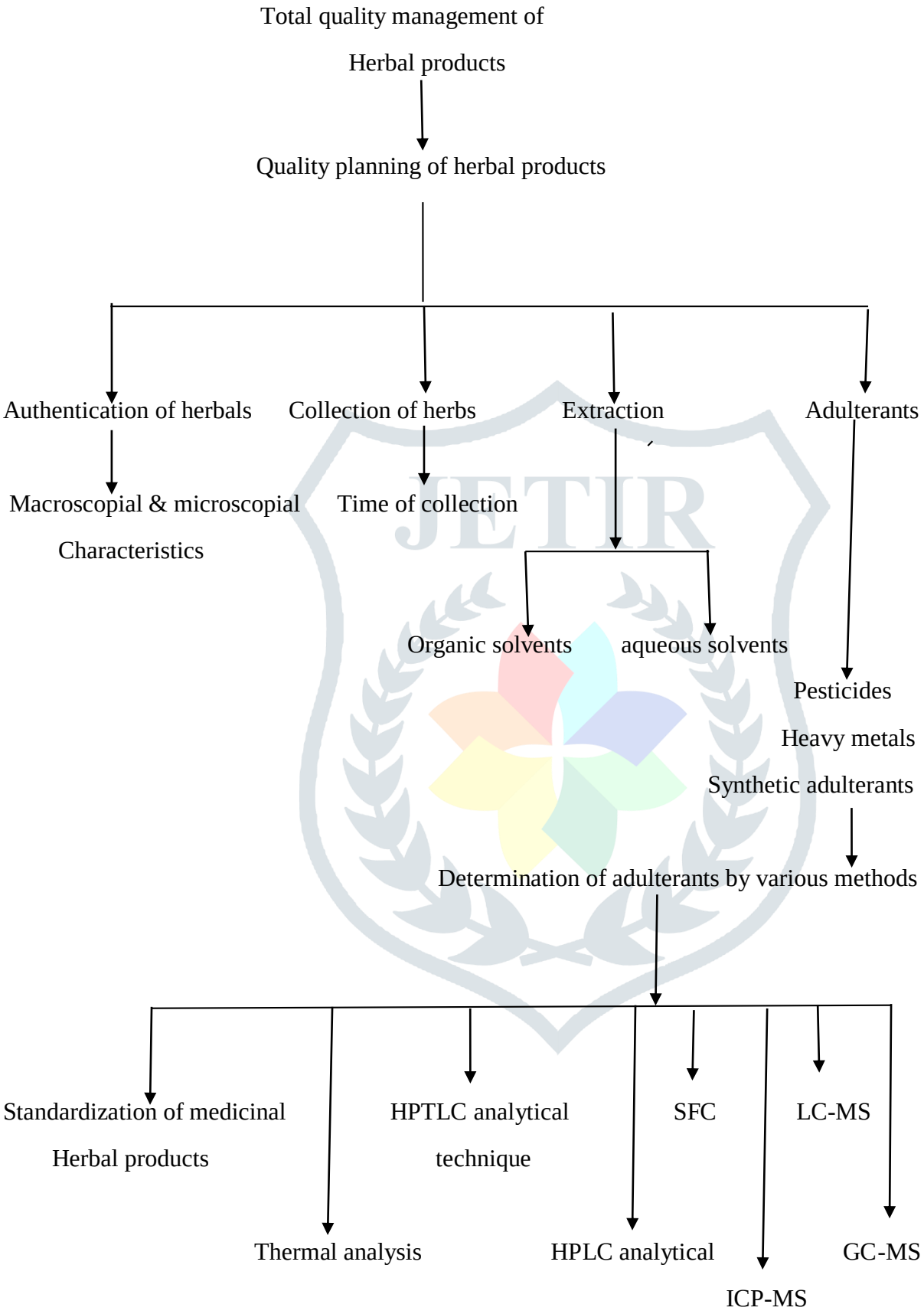

Fig : 1

- Standardization of medicinal herbs and products
- The use of thermal analysis to characterise plants and herbal products
- HPTLC analytical method for quality monitoring of herbal botanical formulation.
- HPLC analytical approach for the quality control of herbal plant formulations.

- The use of supercritical fluid chromatography (SFC) to monitor the quality of herbs
- ICP-MS (inductively coupled plasma-mass spectroscopy)
- LC-MS for the evaluation of botanical plants' quality
- GC-MS (gas chromatography-mass spectroscopy) in the quality control analysis of herbs(Balekundri A, Mannur V. 2020).

2.TOTAL QUALITY MANAGEMENT APPROACHES FOR HERBAL

2.1. Six sigma approach

2.2. Ishikawa diagram

2.1. Six sigma approach to herbal products:-

These are a group of tools or methods used to manage process quality or improve processes. By locating and eliminating the root causes of errors and reducing industrial unpredictability, the Six Sigma technique can increase the quality of process outputs (De Feo JA, Barnard W. 2003). Six sigma is a continuous improvement process that works in conjunction with lean management principles to eliminate defects. Many businesses choose six sigma to increase design and manufacturing efficiency while lowering costs (Jain AA et al., 2022).`

Six Sigma involves two methods:-

1. DMAIC
2. DMADV

DMAIC:- Define, Measure, Analyse, Improve, Control.

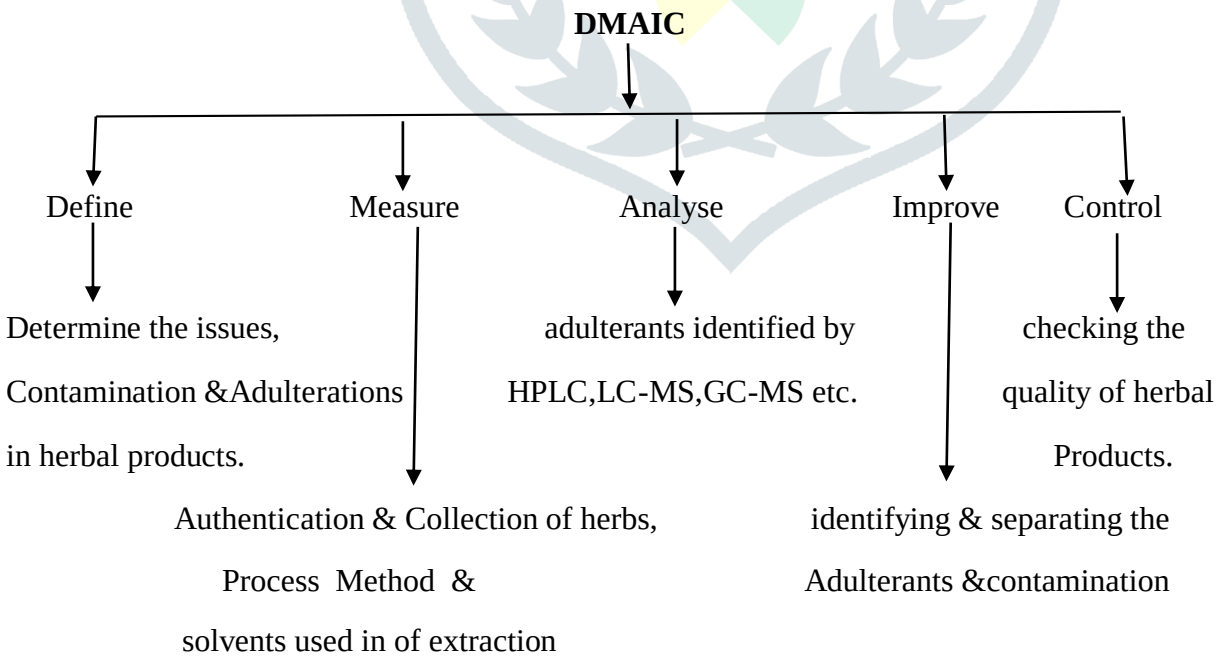

Fig: 2

DMADV:-Define, Measure, Analyse ,Design ,Verify .

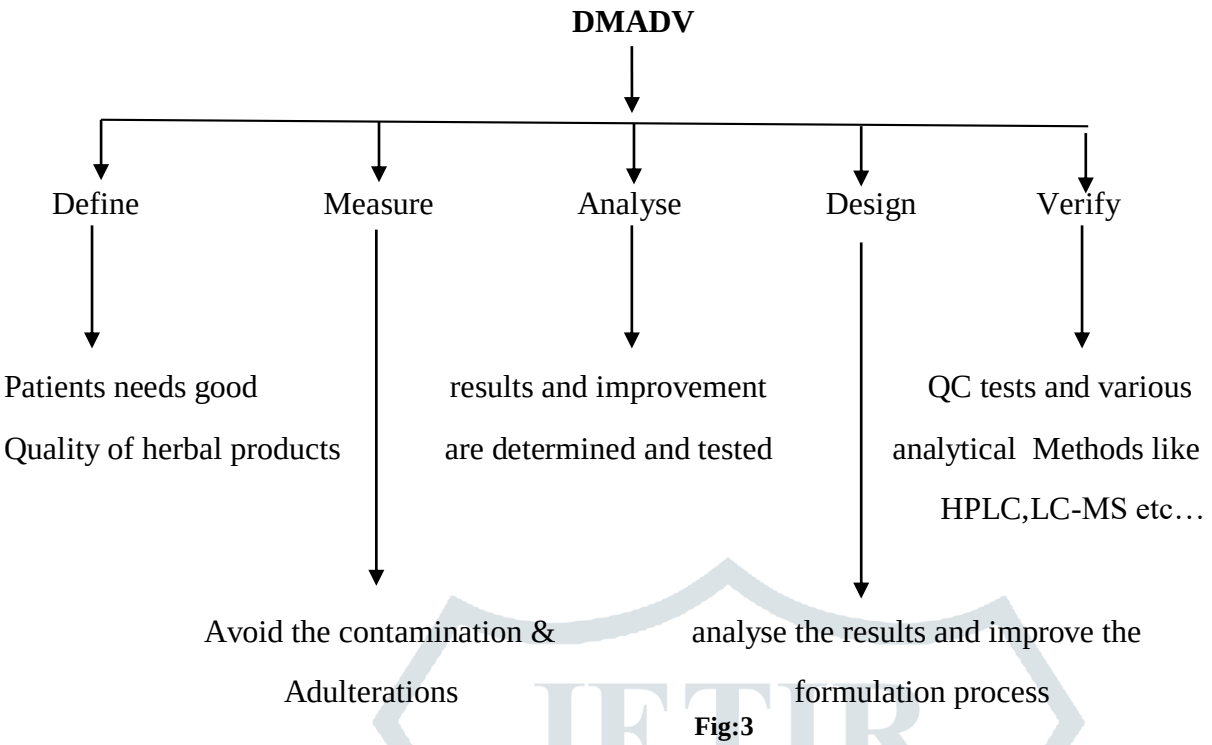

Fig:3

2.2. Ishikawa diagram for the identification of synthetic adulterants in herbal products

Using some particular analytical techniques and procedures, manufacturing process can be improved ,by using Ishikawa Diagram, Pareto analysis, Histograms etc. these diagrams considered as one of the seven basic tools for quality control. The Ishikawa Diagram is a straightforward graphical tool for analysing the relationship between a problem and all potential causes and for understanding the reasons of quality problems. An ishikawa diagram is a visual representation that shows the connections between a specific result and its causes. In this paper we focused on determining the synthetic and pesticide adulterations in the herbal products by Ishikawa diagram(Luca L et al.,2017).

3. INTRODUCTION TO HERBAL PRODUCTS

Natural plant-based products with phytochemical ingredients that are utilised for therapy or medicinal purposes are known as herbal remedies(Pratiwi R et al.,2021). Herbal remedies have a long history of use as medications and continue to meet many of the global population's health needs. Due to the considerable unpredictability of the associated chemical components, quality control and assurance still pose a challenge (Ram M et al.,2011). Plants have long been a major source of herbal remedies used to treat a variety of human ailments. Tropical nations have the highest concentration of medicinal plants, which are used to support, enhance, maintain, and restore human health worldwide Up to 80% of people in underdeveloped nations still primarily rely on herbal remedies, according to the World Health Organization (WHO), for their medical needs (Satheeshkumar N et al.,2016). In recent years, herbal medicines (HMs) have become more and more popular as a kind of treatment. Approximately 40%–50% of people in Germany, 42% of people in the USA, 48% of people in Australia, and

49% of people in France use traditional medicine. Nearly 65% of the rural population in India depends on HMs (Pamidimarri G et al., 2019).

The use of natural medicines has significantly expanded globally. Because they are made from natural ingredients, herbal products are believed to be absolutely devoid of negative effects. As a result, patients now prefer them over allopathic drugs. However, the safety of herbal products is in question given that major organ poisoning has been associated with them .been linked to the long – term use of herbal treatments (Girish P et al., 2021).The adulteration, which is more properly referred to as crude drug, initially looks to be genuine due to its morphological similarities and occasionally indistinguishable chemical composition. It involves the intentional or unintentional partial or complete replacement of a crude medicine with other chemicals that are either free or have inferior medicinal or chemical qualities (Ahmed S, Hasan MM.2015).Complex natural product extracts or fractions can be quantitatively and qualitatively analysed by combining separation processes with spectroscopic techniques. Spectroscopic detection methods are combined with high performance liquid chromatography (HPLC), liquid chromatography (LC), capillary electrophoresis (CE) or gas chromatography, to obtain structural data that enables the identification of the compounds present in a crude sample. Examples include nuclear magnetic resonance spectroscopy (NMR), photodiode arrays (PDA), UV-vis absorbance or fluorescence emission, and Fourier-transform infrared (FTIR). These methods influenced the creation of many modern hyphenated ones, including GC-MS, CE-MS, LC-NMR, and LC-MS. HPLC is the most widely used analytical separation technique for both qualitative and quantitatively identifying compounds in natural product extracts (Patel KN et al.,2010).

Adulteration

Adulteration is defined as the partial or complete replacement of an original crude medicine with another substance that has a similar appearance but differs in its chemical and therapeutic properties.

Types of adulteration

A) Replacement with subpar commercial verities

Use of many subpar commercial verities that morphologically resemble one another

Ex: Carica papaya seeds have been found in piper nigrum fruit.

B) Substitution with a medication that was made artificially

As an alternative to the original medication, synthetic chemicals are used.

Ex : artificial sugar for honey

chicory in place of coffee

C) Substitution with worn-out medications

The same plant material is combined with a medicine but the active medicinal components have already been removed.

1. substance containing volatile oil

- Foeniculum vulgare (fruit /fenel)
- Coriandrum sativum(fruit /coriander)

2. Dyestuff that contains medicines.

The residue is recolored with artificial dye in the event that colouring material is lost during fatigue.

Ex : rosamacdub (red rose petal)

Crocus sativus(stigma of flowers)

D) substitution with cheaper, more seemingly similar natural materials

A counterfeit product is unrelated to the original and may or may not contain chemical or medicinal components.

As cassia acutifolia (acutifolia) is used instead of atropa belladonna (belladonna) (senna)

E) Substitution by addition of worthless or heavy materials

Ex; large mass of stone mixed with glycyrrhiza glabra.

Lead shot mixed with pieces of papaver somniferum

F) Addition of synthetic principles

- To improve the natural character, synthetic compounds are used.
- Examples include adding benzyl benzoate to citrus oils, peru balsam citral, and lemon oil to orange oil.
- Ephedrine, chlorpheniramine, methyl testosterone, and phenacetin were the substances that were most commonly discovered.
- Prescription medications such glyburide, sildenafil, colchicine, adrenaline steroids, alprazolam, phenylbutazone, and fenfluramine have been found, according to the FDA and other investigators (Prakash O et al., 2013).

4. PESTICIDES CONTAMINATION

Pesticides are frequently employed to protect herbal plants because they are vulnerable to pests and diseases both in the field and while being stored. Pesticide contamination is a concern because of its high toxicity and long-lasting effects on the ecosystem (Łozowicka B et al.,2014).The presence of several pollutants and residues that could affect users of herbal medications is widely documented.[18] Heavy metals, pesticides, microorganisms, and mycotoxins are among the contaminants that are most commonly present in herbal materials or herbal products (Zhang J et al.,2012)crude medical plants and their products are contaminated with pesticide residue has been increasingly reported (Selvi C, Paramasivam M 2017). The growth and process of traditional herbal medicine's internationalization may be negatively impacted by the presence of pesticide residues in herbal materials.

Chemical substances called pesticides are used to manage or get rid of pests. They are classified as fungicides, rodenticides, nematocides, herbicides, insecticides, and others depending on their mode of action .(Shaban NS et al.,2016) organochlorine pesticides are frequently detected in herbal medicines, including benzene hexachlorides, dichloro-diphenyl-trichloroethane and pentachloronitrobenzene (Xue J et al., 2008). According to chemical structure, they are grouped as organochlorine pesticides [hexachlorodiphenylethanes]; organophosphorus pesticides [malathion, parathion dichlorvos]; nitrogen containing pesticides (such as atrazin and propazin); pesticides of plant origin (rotenoids and pyrethroids), etc (Shaban NS et al.,2016). Because they

break down more quickly, the compounds including organophosphorus and carbamates have been found in herbal treatments less frequently. These days, pyrethroid insecticides with great efficacy and little residue are often utilized; traces of these contemporary substances, such fenvalerate or deltamethrin, are also discovered in some herbal components (Gao T et al.,1999).

In order to detect the pesticide residues in raw medicinal plants, numerous investigations have been carried out globally. The presence of OC pesticide residues in medicinal plants has been documented frequently among the various pesticide categories (Rodrigues MV et al.,2007). High incidence of organochlorines (OCs) pesticide residues has been reported in traditional Indian, Chinese, Egyptian, and Brazilian, medicinal herbs (Selvi C, Paramasivam M 2017).Additionally frequently utilised as food, functional food, and nutritional and dietary supplements are herbal materials and medicinal plants. Therefore, patients and customers must feel secure using therapeutic plants and herbal goods. To ensure the security of herbal products, it is crucial to design a convenient quality control technique (Łozowicka B et al.,2014).

5. DETERMINATION OF SYNTHETIC ADULTERANTS IN HERBAL PRODUCTS.

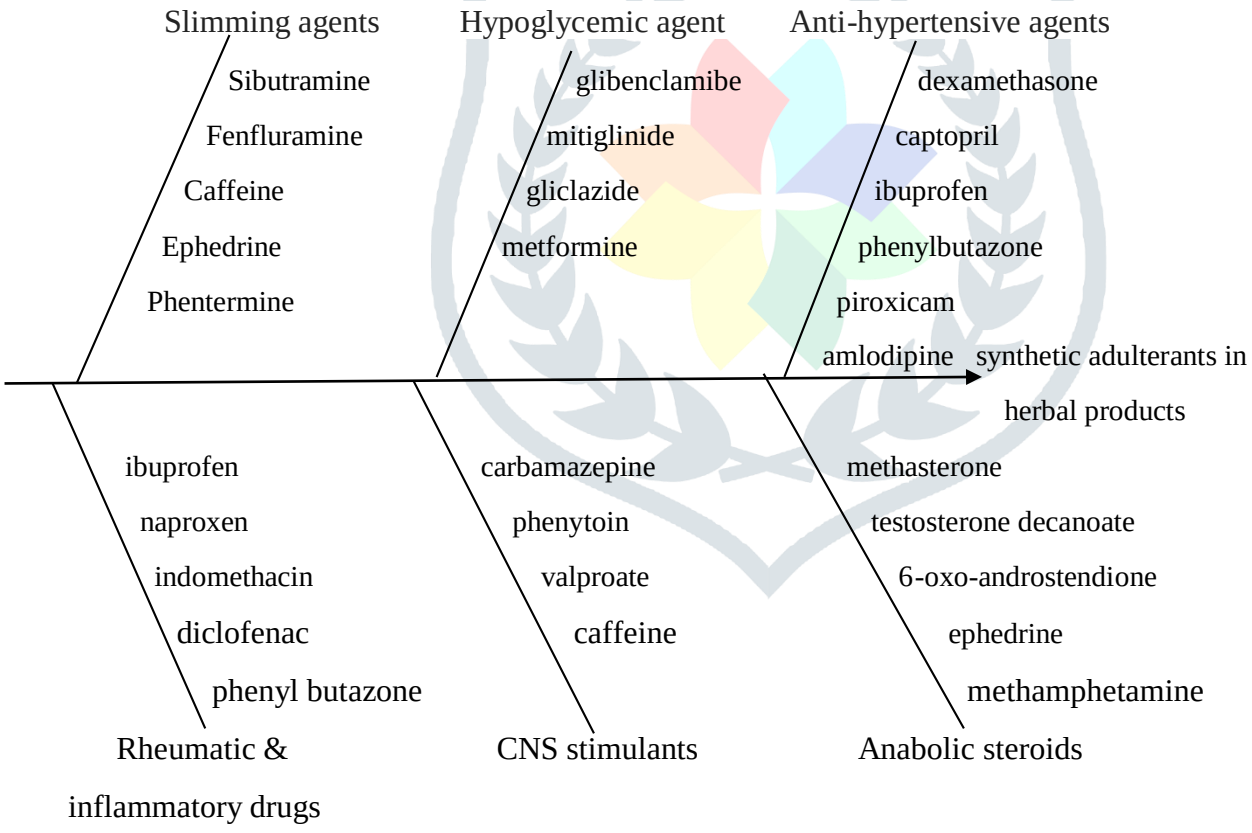

Fig 4: Determination of synthetic adulterants in herbal products.

5.1. Synthetic adulterants found in slimming herbal products

Sajad Fakari et.al 2018 did research on screening and conformation of different synthetic adulterants in slimming products. Due to the inclusion of unlawful adulterants, current research has linked the usage of nutritional

supplements containing therapeutic components to certain major health issues. Those who use such products run the risk of developing serious bodily issues like mental illness, cardiovascular disease, and liver disease. He has successfully confirms the adulteration of Phenolphthalein, sibutramine, sildenafil, fenubutrazate, protriptyline, phendimetrazine, docusate sodium, docusate potassium, fenufluramine, ephedrine. in fifteen most commonly used slimming products with different brands. For simultaneous screening and validation of adulterants, liquid chromatography-ultraviolet and LC-mass spectrometry approaches were used. Phenolphthalein, which was included in 11 of the 15 slimming products, was the most prevalent adulterant. Additionally, 5 goods included caffeine, 2 products contained phendimetrazine, and 2 products contained protriptyline (Fakhri S et al.,2018).

Acram ghasemi dastjerdi et.al 2018 conducted a study on principle component analysis of synthetic adulterants in herbal supplements advertised as weight loss drugs . He found adulterants in 61 weight loss herbal products.The products are adulterated with the synthetic adulterants like tramadol, fluoxetine, rizatriptan, venlafaxine, methadone, He analysed quantitatively using gas chromatography / mass spectrometry (Dastjerdi AG et al.,2018).

Ammar A. Jairoun et .al 2021 did a research on Adulteration of Supplements for Weight Loss by Illegal Synthetic Pharmaceutical Addition. Customers may not be aware of what they are consuming if weight reduction pills with illicit pharmaceutical medication or analogue additions are taken, which poses additional health hazards. This study is significant because it quantifies the amounts of pharmaceuticals or prescription medications that have been added unlawfully to natural weight-loss products offered in the United Arab Emirates, specifically fluoxetine, phenolphthalein, and sibutramine were identified in 137 weight loss medication it is analysed through RP-HPLC-MS/MS method for the presence of synthetic drug (Jairoun AA et al.,2021).

5.2. Synthetic hypoglycemic agents found in the anti -diabetic herbal products.

Wensheng pang et.al 2009 did research , For the purpose of detecting and structurally identifying synthetic hypoglycemia medications that have been unlawfully introduced to natural anti-diabetic herbal remedies, LC-MS-MS in MRM mode is used. He claimed that many herbal products, marketed as all-natural herbal supplements and formulations to boost hypoglycemic function, contained synthetic hypoglycemic drugs like glimepiride glipizide, glibenclamide, rosiglitazone, repaglinide, metformin, etc. These synthetic medications are frequently used for the initial treatment of type 2 diabetes mellitus. The addition of these hypoglycemic drugs to herbal preparations can cause gastrointestinal problems, skin sensitivities, and other negative side effects. The LC-MS-MS is an effective technique for identifying these synthetic medicines in herbal anti-diabetic medications, and the technology is generally applicable (Pang W et al., 2009).

Chowdury et.al 2018 did a work on Determine the existence of synthetic oral hypoglycemics in herbal anti-diabetic formulations using HPLC's determination of synthetic pharmaceuticals as adulterants in medications. As samples for the experiment, herbal anti-diabetic medications that were sold at Dhaka's local market were gathered. For the experiment, reference standards such as metformin and glimepiride were used. HPLC was used to analyse samples and standards for adulterants. Clearly identifying and measuring the chemicals contained in the samples

using the developed method was also successful (herbal anti-diabetic drugs). When 16 of the 25 samples that were examined for contamination included adulterants, 64 percent of the samples were found to be polluted (Chowdury A T 2018).

Yoe-Ray Ku a et.al 2003 did a research on Analysis of synthetic anti-diabetic drugs in adulterated traditional Chinese medicines by high-performance capillary electrophoresis. He located High-performance capillary electrophoresis (HPCE) was used to simultaneously assess four synthetic anti-diabetic medications that have been detected as adulterants in traditional Chinese medicines (TCMs), including tolbutamide , glibenclamide , chlorpropamide , and acetohexamide (Ku YR et al.,2003)

5.3. Synthetic anti-hypertensive agents found in the herbal products

N.L Zhou et.al 2010 did a research on detection of adulteration of anti-hypertension dietary supplements and traditional chines medicines with synthetic drugs using LC/MS. He developed a method for identification of 18 counterfeit anti-hypertensive medications in nutritional supplements and Traditional Chinese Medicine was accomplished using the HPLC/ESI-MS method and electrospray ionisation mass spectrometry (ESI-MS).Hydralazine, clonidine, triamterene, metoprolol, chlorthalidone, furosemide, amlodipine, nalsartan, felodipine, lisinopril, nitrendipine, hydrochlorothiozide , minoxidil, prazosin, phentolamine, indapamide, benazepril, fosinopril these are the synthetic anti hypertensive drugs. 35 Antihypertensive samples were procured from community herbal stores and markets in Hunan, China. In 35 samples 9 samples contains the Hydrochlorothiazide, Clonidine, and Triamterene. The adulterants was identified by HPLC-ESI-MS method, this method's benefits include ease of sample preparation, speed, good accuracy, and wide applicability (Lu YL et al.,2010).

Muhammad asif khan et. al 2018 analysed and quantified the toxicological effects of contaminated synthetic steroids and undeclared allopathic drugs in herbal antihypertensive preparations. He found various synthetic adulterants in anti hypertensive herbal products, synthetic adulterants like atenolol, propranolol, ACE inhibitors, i.e. captropril and furosemide and also he found synthetic steroids like betamethasone, dexamethasone, for the identification of adulterants he carried out a HPLC technique (Khan MA et al.,2018).

Akash A . Savaliya et.al 2009 studied the use of LC-MS/TOF to identify synthetic steroidal and non-steroidal anti-inflammatory medications in Indian ayurveda and herbal items. In this study, 58 AHPs were gathered from various locations in India, and a generalised technique using LC-MS/TOF was developed for the identification and confirmation of steroidal and anti-inflammatory drugs. Dexamethasone and diclofenac were discovered to be adulterants in 10 AHPs, as opposed to the one AHP that tested positive for piroxicam and the other for dexamethasone. All of the contaminated products were sold by healthcare practitioners; none of the products distributed by manufacturers or by pharmacies were affected. The study shown that steroid and anti-inflammatory medication adulteration may be quickly detected in AHPs using LC-MS/Tof based screening (Savaliya AA et al., 2009).

5.4. Synthetic Rheumatic and inflammatory drugs found as an adulterants in herbal products

Mengjiao li et.al 2017 conducted study using portable ion mobility spectrometry on the quick screening of non-steroidal anti-inflammatory medicines that were illicitly added to anti-rheumatic herbal supplements and herbal cures. He created a high performance ion mobility spectrometry with electrospray ionisation method to quickly screen for synthetic adulterants like ibuprofen, acetaminophen, naproxen, indomethacin, diclofenac sodium, that are forcibly added to anti-rheumatic natural treatments and dietary supplements. The NSAIDs in herbal supplements and treatments for rheumatoid arthritis may be found using the described method, which looks to be simple, quick, and very specific (Li M et al.,2017).

C .Y Zhang et.al 2010 conducted a study on the simultaneous detection of two glucocorticoids and five non-steroidal anti-inflammatory medications in adulterated traditional herbal medicines for the treatment of rheumatism. To detect the presence of NSAIDs and glucocorticoids in traditional herbal medicines, he developed a quick and efficient method combining UV separation with HPLC and ESI-MS detection. He discovered prednisone acetate, dexamethasone, phenylbutazone, diclofenac, indomethacin, and ibuprofen as adulterants in the traditional herbal medicines for rheumatism. This approach is straightforward, speedy, dependable, and usable (Zhang CY et al., 2010).

Aik-Jiang lau et.al 2003 did a work on analysis of adulterants in a traditional herbal medicinal products using liquid chromatography -mass spectrometry – mass spectrometry. He developed liquid chromatography -mass spectrometry -mass -spectrometry method in selected reaction monitoring SRM mode. He found synthetic rheumatic and anti-inflammatory drugs like phenylbutazone and oxyphenbutazone in traditional Indonesian herbal products. The herbal products adulterated with these synthetic drugs can be determined by LC-SRM-MS method. This analytical approach is quick, sensitive, and extremely specific. The method's accuracy, precision, linearity, LOQ, and LOD were all validated. With improved techniques for analysing adulterants in herbal medicines, their quality and safety may be better managed and regulated to ensure patient safety. The presence of synthetic medications adulterates is potentially dangerous for patients (Lau AJ et al., 2003).

5.5. Synthetic CNS drugs found as an adulterants in herbal products

A . Hemdan et.al 2018 conducted research on HPLC-UV chromatographic techniques for the identification and quantification of unregistered removed synthetic drugs in fake herbal remedies, with confirmation using HPLC-PAD and mass spectrometry. He developed a reverse phase high performance liquid chromatography (HPLC) method with ultraviolet (UV) detection for the identification of synthetic adulterator like sibutramine and phenolphthalein in weight loss products. The adulterants were confirmed using LC-photodiode array PDA and mass spectrometry. He created a method in his research to identify some prevalent synthetic adulterants in some herbal treatments sold on the market. It has been discovered that many herbal treatments contain hidden synthetic drugs that have been taken off the market due to cardiovascular problems or carcinogenicity. Both

phenolphthalein and sibutramine are contaminated when they are used with the herbal supplement slimming bomb (Hemdan A, Tawakol SM. 2018).

Marjan Khazan et.al 2014 did a research on identification and determination of synthetic pharmaceuticals as adulterants in eight common herbal weight loss supplements. In eight popular natural weight loss products that are now available on the retail market, he discovered five synthetic adulterants. He discovered caffeine and pseudoephedrine to be adulterants, along with sibutramine, phenolphthalein, phenytoin, and bumetanide in the original Super Slim, Herbal Essence, Super Slim Green Lean, and weight reduction products. By using the GC-MS technology, the contaminated synthetic ingredient was found in the herbal weight loss goods (Khazan M et al., 2014).

Etil Ariburnu et.al 2012 conducted research on the comparison of HPLC and HPTLC densitometry for the determination of sibutramine as an adulterant in natural slimming products. He developed HPLC and HPTLC procedures for the determination of synthetic adulterants after discovering illegally added synthetic sibutramine in natural slimming goods on the market. Both methods were proven to be fully functional for the routine examination of such products (Ariburnu E et al.,2012).

5.6. Synthetic anabolic steroids found in the herbal products

So-Hyun Cho et.al 2015 did a research on Determination of anabolic–androgenic steroid (AASs) adulterants in counterfeit drugs by UHPLC–MS/MS . For the purpose of identifying anabolic-androgenic steroid chemicals in fake pharmaceuticals, he created a UHPLC-MS/MS approach. The fake medications were purchased in 2014 from a Korean market. An analysis method using ultra-liquid chromatography-tandem mass spectrometry (UHPLC-MS/MS) was created, verified, and examined to evaluate the presence of 26 AASs. Nine AASs were used to adulterate nearly half of the samples. The examined samples contained testosterone 17-propionate, testosterone, boldenone, testosterone 17-valarate, 19-norandrostenedione, boldenone, nandrolone, metenolone, and methandienone (Cho SH et al.,2015).

Hans Geyer et .al 2008 did a review on Nutritional supplements cross-contaminated and faked with doping substances. According to his research, nutritional supplements often concealed illegal stimulants like caffeine, methylenedioxymethamphetamine, sibutramine, and ephedrine that were present but not declared on the labelling. In addition, a 2001–2002 research of 634 nutritional supplements purchased in 13 nations found that 15% of the nonhormonal supplements were tainted with anabolic–androgenic steroids and/or goods that were deliberately counterfeit. We use mass spectrometric methods (GC/MS, LC/MS/MS) to find new "designer" steroids in dietary supplements (Geyer H et al.,2008).

K.J.S. De Cock et.al 2000 did a research on Detection and determination of anabolic steroids in nutritional supplements. He developed a method for the determination of anabolic steroids including testosterone, 19-nor-4-androstene-3,17- dione, 4-androstene-3,17-dione and nandrolone in food supplements. He analysed by GC/MS-MS and GC/MS (De Cock KJ et al 2001).

6. DETERMINATION OF PESTICIDE RESIDUE IN HERBAL PRODUCTS

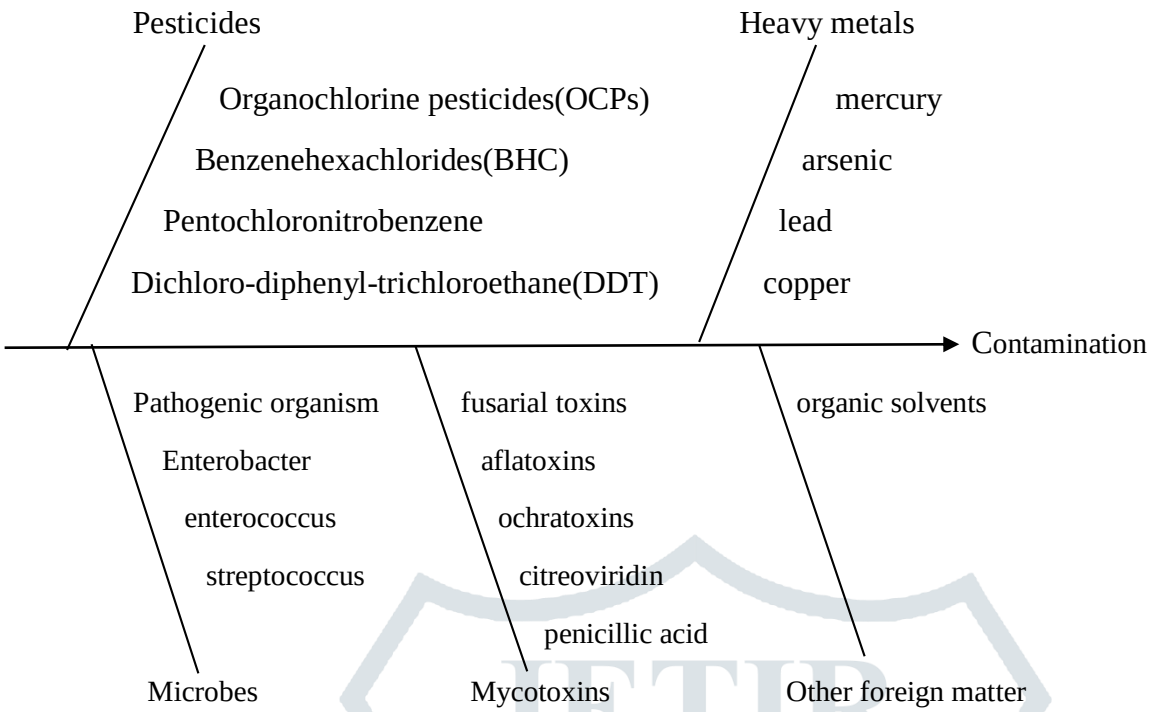

Fig 5: determination of pesticide residue in herbal products

6.1. Pesticides contamination in herbal products

Ying Wang et.al 2022 He used (HPLC-MS/MS) and (GC-MS/MS) analysis to simultaneously analyse the amounts and health risk of 168 pesticides in 1,017 samples of 10 Chinese herbal medicines (CHMs). combining chromatography and mass spectrometry (Wang Y et al.,2022).

Grazyna Kowalska et.al 2020 conducted research on the estimation of pesticide residues in a number of Polish products with plant origin using the HPLC-MS/MS technique. Using the QuEChERS approach in conjunction with HPLC-MS/MS analysis, he created a method for the assessment of pesticide residues in the examined materials. Based on this examination, 83 samples out of the 160 samples that were looked at contained pesticide residues (Kowalska G et al.,2020).

6.2. Contamination with heavy metals in herbal products

Lu Luo et.al 2021 did a research on heavy metal contaminations in herbal medicines determination, comprehensive risk assessment and solutions. He found heavy metals in 1773 samples. The maximum projected daily intake of lead , cadmium , and mercury exceeded their respective provisional tolerable daily intakes in seven, five, and four herbs, respectively. Cadmium, lead, arsenic, mercury, and copper concentrations were examined using inductively coupled plasma optical mass spectrometry. (ICP-MS). In light of the fact that it presented the largest threat in terms of anticipated daily consumption, the Hazard Index, and carcinogenic concerns (Luo L et al.,2021).

Safa Al Khatib et.al 2015 conducted study on the concentration of heavy metals in traditional herbs used often in the United Arab Emirates. The purpose of this study was to determine the amount of heavy metals present in a few traditional plants consumed in the United Arab Emirates (UAE). 81 samples of each of the seven herbs

parsley, basil , sage, oregano , mint , thyme , and chamomile were tested for the presence of cadmium, lead, copper, iron, and zinc. The samples were digested using microwaves, and atomic absorption spectrometry was used to determine the concentration of heavy metals (Dghaim R et al.,2015).

6.3. Contamination by microbes in herbal products

Danladi Abba et.al 2009 conducted research on the harmful bacteria contamination of herbal medicines sold in the city of Kaduna. The goal of this study was to determine whether powdered herbal medical preparations purchased from reputable retail locations selling herbs in the Kaduna metropolitan area were contaminated with bacteria. The amount of contamination in the herbal products was assessed using conventional techniques, such as total aerobic bacterial plate counts, measurements of some physical characteristics, isolation and characterization of specific bacterial pathogens, etc. The results showed that out of 150 herbal remedies, 70 (46.67%) had Salmonella typhi, 29 (19.33%) had Shigella spp., 88 (58.67%) had Escherichia coli, and 98 (65.33%) had staphylococcus aureus contamination (Abba D et al., 2009).

Khadija Mohamed Hassan et.al 2021 conducted study on the microbial contamination of herbal medicines sold in Kenya to treat chronic illnesses. In his investigation, he evaluated the microbiological contamination of 86 herbal remedies used to treat chronic ailments that were sold in Nairobi. The potential for bacterial and fungal growth was tested by inoculating the aqueous solutions of each herbal product onto agar. Using the streak-plate technique, discrete colonies were moved to certain media for a differential examination. There were 28 items (32.6%) that did not meet the British Pharmacopoeia (2019) standards for microbiological load. There was bile-tolerant Enterobacteriaceae contamination in 26 (30.2%) herbal items. A total of 41 bacterial isolates were obtained from the 26 herbal formulations, including 14 (34.1%) E. coli, 10 (24.4%) Salmonella species, and 17 (41.5%) unexplained bile-tolerant Enterobacteriaceae. Overall, 41 (47.7) (Hassan KM et al.,2021).

6.4. Mycotoxins contamination in herbal products

Ling Chen et.al 2020 in his study, "Occurrence and Characterization of Fungi and Mycotoxins in Contaminated Medicinal Herbs," examined the frequency of mycoflora and the level of mycotoxin contaminations in 48 contaminated samples of 13 different medicinal herbs. Aflatoxin traces were present in 70.8 percent of the plants. The majority of the mycoflora was composed of four genera: Trichoderma spp. Aspergillus spp., Rhizopus spp., and Penicillium spp., Aflatoxin, OTA, and citrinin levels in 37 cultures were checked HPLC -tandem mass spectrometry. In roughly 21.6% of cases, isolates of Aspergillus and Penicillium developed mycotoxins. One Penicillium polonicum strain that was isolated from Scutellariae radix generated citrinin. Aflatoxin synthesis genes were discovered in three Aspergillus flavus strains using multiplex PCR (Chen L et al.,2020)

Noelia Pallare´s et.al 2021 A multimycotoxin analysis of aflatoxins, zearalenone, ochratoxin A, enniatins, and beauvericin was carried out in 85 samples of medicinal plant food supplements as part of a study on the presence of mycotoxins in these products and exposure assessment. The samples were divided into 21 mixed samples and 64 samples each containing only one herbal component. The extraction was carried out with QuEChERS, and the

measurement was made with (LC-MS/MS-IT). The risk of exposure to mycotoxins was then assessed in relation to consuming dietary supplements containing medicinal plants (Pallarés N et al.,2021).

CONCLUSION :

TQM is a managerial approach used by the pharmaceutical manufacturers and also this concept is applied in the herbal product manufacturing process for the identification of adulterants and the contaminations. Major benefits of TQM involves the improvement of quality, employee participation , team work, working relationship, customer satisfaction ,employee satisfaction , productivity , communication , profitability. TQM can be applied to many fields like food industry, textile industry etc. From this review paper we can conclude that the approaches of TQM like Six sigma & Ishikawa diagram can be implemented in the identification of adulteration and contamination of herbal products.

Abbreviation: Customer defined quality (CDF), Capillary electrophoresis (CE), Electron spray ionisation mass spectrometry(ESI-MS), Fourier-transform infrared (FTIR),Gas-chromatography -mass spectrometry(GC-MS), Herbal medicines (HMs), High performance liquid chromatography(HPLC), High performance capillary electrophoresis (HPCE), Inductively coupled plasma-mass spectrometry (ICP-MS), Liquid chromatography -mass spectroscopy (LC-MS), Liquid chromatography (LC), Nuclear magnetic resonance spectroscopy (NMR), Organochlorines(OCs), Photodiode arrays(PDA), Supercritical fluid chromatography(SFC),Total quality management (TQM), Traditional chinese medicines (TCMs), Ultra- liquid chromatography-tandem mass spectrometry (UHPLC-MS/MS), United arab emirates(UAE), World health organization (WHO).

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