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HERITAGE

A Peer Reviewed Academic Journal of Humanities, Social Science and Science

BETHUNE COLLEGE
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BETHUNE COLLEGE
181, Bidhan Sarani, Kolkata – 700 006

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EDITORIAL

It is really memorable to write editorial for first midyear volume of the journal 'Heritage'.

Laughter is a part of human culture, even in animal world. Prof Krishna Roy in her paper 'Human Laughter : A panromic view' have reviewed the current understanding of laughter as well as physiological benefits and potential therapeutic effects to combat different ailments.

Smita Ray in her paper 'Significance of medicinal plants: the lesser utilized ones' has described how medicinal plants became a natural reserve of diverse, complex and unlimited sources of therapeutics. In this review she has explored pleothra of medicinal properties of lesser investigated plants types namely cacti, orchids, carnivorus and aquatic plants.

Priyanka Sengupta, Krishna Roy and Bulbul Thakur in their paper 'Significance of Food Security and Nutrition Security as major contributors in sustaining Health for all' have focused on the tripple burden of malnutrition. The current paper has emphasized upon food and nutrition security which act as major donator in improving overall health of human. Both of these parameters are important inputs of economic developments of many countries.

Saptarshi Mondal and Samprita Ghosh in their paper 'Indian Premier statistics : an analysis of Performers and Disappointers' have tried to study how performances of players in Indianan Premier League (IPL) in each team vary over age and whether united performance in a team gives a better run rate. They find out team score and NRR do not have exact linear relationship but on an average, they follow strong linear relationship.

Hiroj Saha in his paper 'A review of Urban Biodiversity Protection in relation with high species diversity and variety of valuable ecosystem services' has tried to emphasize on the role of crematories in biodiversity conservation has grown significantly over the last decade. Cremeteries are important green spaces in urban environments, offering nature's benefit to city residents and are valuable for urban biodiversity conservation.

Dipali Bera in her paper entitled 'Air pollution in some selected studies of India' make an attempt to analyze the level of air Pollution during 2007 to 2020 in sixteen major polluting states of India. The pollution level of the sample states are found to be less compared to all states' average except UP and MP.

In the paper "Celebrating Spectral: Exploring the essence of Carnival in Anik Dutta's 'Bhooter Bhabishyat'(2012) and 'Bhabishyoter Bhoot '(2019)", Anup Kumar Bag has tried to emphasize how Bhaktin's idea of carnival was used in the both flims. Dutta tried to fuse the essence of Bhaktinian Carnivalesque into the genere of comic horror to attribute novelty to existing flim-literary practices. The satire and comedy used in both flims attributed a sence of carnival to them and the same time decrowning of authority has been shown through the help of metaphoric devices.

Supriti Paul and Debasis Ray in their paper had established the binding of two- formyl phenolate units as unique chelating cum bridging ligands, not observed in routine synthesis from the use salicylaldehyde as stand alone ligand in the presence of the linear hexadentata N_4O_2 ligand.

Dipanwita Sur and Seemanti Ghosh in their article 'The Art and Science of Adultration' tried toexplain the ways and causes of different kinds of adultration of the authentic plant based products of economic significance. Few classical and recent methods to check the adultration have been discussed also.

Pritha Dey and Suchandra Choudhury in their paper 'Induction of Autoimmune Graves' disease as post COVID-19 complication- a short review' had highlighted how Graves' Disease had emerged as post COVID-19 complication.

We are thankful to the Department of Higher Education, Govt. of West Bengal for financial support. We convey thanks to our Printers for necessary support.

Amrita Bagchi
Samiran Ghosh

Human Laughter : A Panoramic View

Prof. Krishna Roy

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Abstract :

Laughter is a part of human culture. Human baby starts laughing as early as three months of life. This is true for all kids either normal, or quite deviated from normalcy such as deaf or blind. The ubiquitous nature of laughter raises its purposeful role in human life. Laughter is also found in animal world. Vocalizations resembling human laughter is found in several non-human species. A significant proportion of these species are primates and other mammals, which suggests that the neurological functions occurred early in the process of mammalian evolution. (1) Laughter as a mode of communication is found in over 60 species.(2) In the animal world, it serves to indicate that, an action which is being carried out, is not at all serious, for example in "fighting" or biting between foxes. It is considered as their playful nature. Laughter is considered as a normal and natural physiologic response to certain stimuli with widely acknowledged psychological benefits. This article reviews the current understanding of laughter as a physiological phenomenon with different kinds of health benefits and its potential therapeutic effects to combat different ailments.

Keywords : stress relief, immunity, gelotology, pain management.

Physiology of Laughter

Laughter can be considered as a complex emotional response to one's environment, situation, and stimuli. Scientifically, laughter may be defined as a physiological response to humor and consists of two elements: the movements of different parts of face and the sound that is emitted. These two elements occur after an order issued by the brain as an impulse and are sometimes also accompanied by movements in the extremities and trunk muscles. (3) According to Philosopher John Morreall (4) thousands of years ago, laughter could occur as a satisfactory response of relief after getting rid of a problem or situations that implied danger. Gradually, laughter would become a kind of signal as a social habit. Many researchers raised argument that laughter is related to making and strengthening human relationships. Its contagious nature is due to the innate desire of people not to be left out of the group. Morreall (5) also points out that laughter is something like a game which indicates the dominant power of one who controls or the one who produces laughter in the group. For example, employees laugh anyway, even if the boss makes jokes with little sense. Many researchers analyze laughter in different ways, however, none could determine an absolutely certain reason why each individual laughs, until came Provine, a behavioral neurobiologist at the University of Maryland in Baltimore who had spent a decade studying the reason behind laughter. According to his own word, "Laughter is a mechanism everyone has; laughter is part of universal human vocabulary. There are thousands of languages, hundreds of thousands of

dialects, but everyone speaks laughter in pretty much the same way." He also wrote, "Everyone has the capacity to laugh. Children born deaf and blind are able to laugh. Babies laugh long before they acquire speech. He had disclosed in his book, Laughter : A Scientific Investigation (6). Provine also also stated that human and other primates that roam our planet, are capable of laughing. Whenever we walk through woods listening to the odd cries and calls of the creatures that live there, those creatures may hear our laughing sounds that are just as odd and just as characteristic of our own species. In humans, it clearly serves a social function, as we see its role to provide signal to some other person with whom we wish to connect socially. In terms of evolutionary explanation, this signal of connection to stranger or familiar person, is believed to play an important role in survival. It is so basic to humans, we barely notice it unless it interferes with our pleasure or put us in annoyance. Thus it controls group behavior, as we find its contagious nature without having genuine reasons behind. This may occur due to presence of mirror neurons in humans (7) Even apes have a form of "pant-pant-pant" laughter. Laughter is primitive, an unconscious vocalization, Provine also says. "In laughter we emit sounds and express emotions that come from deep within our biologic being" Through a story, he explained how the capacity to laugh is genetically determined. The story goes like this, "One set of "giggle twins," separated at birth, was not reunited until 40 years later. Until they met each other, neither of these exceptionally happy ladies had known anyone who laughed as much as she did," Provine also reports. "Yet, both were reared by adoptive parents they described as undemonstrative and dour. These gleeful twins probably inherited some aspects of their laugh sound and pattern, readiness to laugh, and perhaps even taste in humor. "Laughter demands contexts, such as it must have social and psychological parameters (age, language, social origin, expectation of the joke and even day-month schedule, etc. The humor of the Americans usually seems acid and ironic, in relation to the English, who laugh more with self-criticism, Latinos tend to laugh at absurd associations and the use of the double meaning of words. (8) Apart from its social role, it was not generally perceived that laughter may have any particular healing effect until 1979, when Norman Cousins published a book entitled *Anatomy of an Illness*. In this book, Cousins described laughter is having analgesic effect for pain caused by his ankylosing spondylitis (9). Since that time, interest in laughter as a potential therapeutic option has grown, both in popular culture as well as in scientific research.

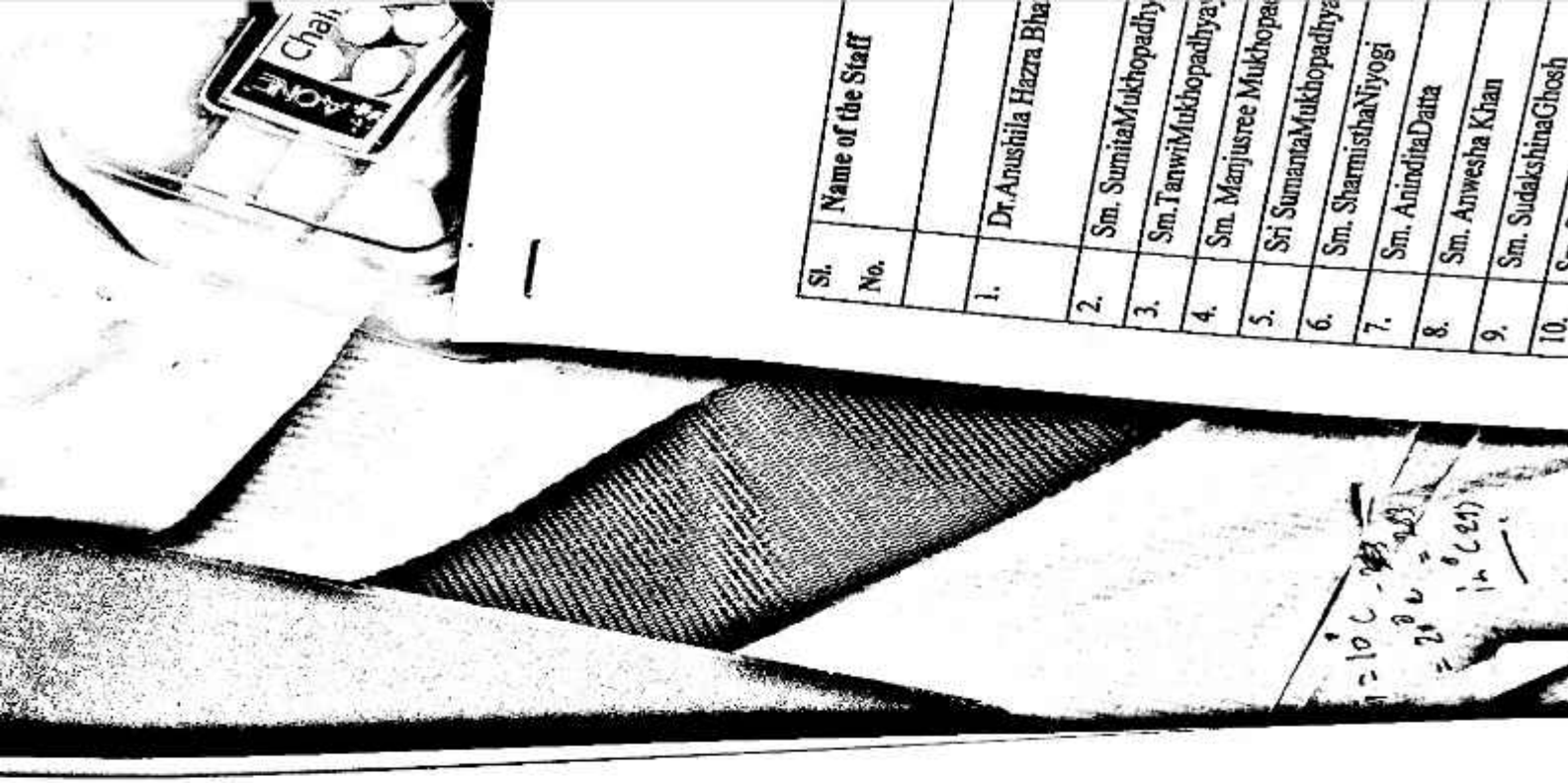
What happens in the body when we laugh?

The physiological study of laughter is called gelotology. It has been found that during laughing, fifteen facial muscles contract and the zygomaticus major muscle is constantly stimulated. The respiratory system is also active and its functioning changes because the epiglottis closes the pharynx in certain proportions, producing irregularities in the entry of air. When someone laughs for a long time and in intense situations, the tear ducts open and drop a few tears. Laughing with a cry is indeed sensational. All these changes make the face moisten and take on a reddish hue, sometimes with greater intensity and in cases even purple (10) Meanwhile, a strange sound accompanies this event. In one of his studies on the different effects of laughter in human beings, Provine (11) analyzed the sonic structure of

laughter in different people. He discovered that the sound consists of tiny notes that repeat every 210 milliseconds. This sound always has the same tonality and never by being a mixture of different tones. As an example, the laughter of some can be expressed something like "ha-ha-ha" or "ho-ho-ho" but never as "ha-ho-ha". He also points out that when listening to laughter, certain neural circuits (mirror neurons) in the brain related precisely to laughter is activated through a kind of detector and that also increases the intensity. This may explain, why laughter is contagious.

Researchers have also learned that laughter involves various regions of the brain with different effects on the body and on the psyche. Humor researcher Peter Derks traced the brainwave activity through electroencephalograph (EEG) in subjects responding to humorous material. (12) as they laughed. In every case, a regular electrical pattern was produced in the brain. If the EEG wave took a negative charge, the subject laughed. If it maintained a positive charge, there was no response, researchers said. During the experiment, researchers observed certain specific activities: such as the words and structure of the joke were analyzed on the left side of the cerebral cortex, the brain's large frontal lobe became quite active. The right hemisphere of the cortex analysed the contents of the joke. Brainwave activity then spread out to the sensory processing area of the occipital lobe of cortex. Stimulation of the motor sections evoked physical responses to the joke. So Laughter seems to affect many regions of the brain. There are different regions of the brain that are responsible for certain functions in behavior, such as the frontal lobe that is responsible for emotional responses, but in the case of laughter, something different happens. When someone laughs, the left region of the cerebral cortex analyzes all the events that may or may not produce laughter. The frontal lobe, in charge of emotional responses, increases its activity. The right brain hemisphere Laughter produces a general feeling of well-being in the body and benefits health on different levels, both physical and psychological is responsible for understanding and understanding the joke or funny fact itself and finally, the motor sections are responsible for the physical and sound response of laughter. Some experts say that this means damage to any of these regions might impair one's sense of humor or response to humor. During laughter, the limbic system of brain seems to be the central area. Research has shown that the amygdala and the hippocampus of limbic system seem to be the main areas which involve emotions. The amygdala connects with the hippocampus and the medial dorsal nucleus of the thalamus. Through these connections, the amygdala plays an important role in the mediation and control of major human activities such as friendship, love and affection, and mood. Similarly, the hypothalamus, especially its median part, is a major contributor to loud, uncontrollable laughter. Laughter thus produces a general feeling of well-being in the body and benefits health on different levels, both physical and psychological. There are still many things to discover and many aspects to analyze about laughter, for example when something is funny and especially what determines that something can cause laughter in some people while not in others?

Review of literature:



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9.	Sm. SudakshinaGhosh
10.	

Ever since the first human was born, laughing has been around and it is usually very contagious There are several theories that explain laughter. The traditional theories of laughter and humor originated in ancient times with the view that laughter is an expression of feelings of superiority over another person. This **superiority theory** was held by Plato, Aristotle, and Hobbes. Another aspect of laughter, noted by Aristotle and Cicero and neglected until Kant and Schopenhauer developed it into the **incongruity theory**, which though complicated appears widely applicable. It states that laughter is often a reaction to the perception of some incongruity. According to the third and latest traditional theory, the **relief theory** of Herbert Spencer and Freud, laughter is the venting of superfluous nervous energy (4, 13).

Sigmund Freud announced laughter as a tension releaser. Later, Philosopher, John Morreal disclosed a theory stating it is a shared expression to relieve the passing of feeling in danger. Later, in his book, Laughter : A Scientific Investigation, Robert Provine, a neuroscientist and professor of Psychlogy at the University of Maryland, Baltimore County expressed his observation in real-world laughter. Using tape recorders. He and his collaborators could capture more than a thousand "laugh episodes" in various places like shopping malls, cocktail parties, class reunions and also in bars .Moreover. He along with his student volunteers noted in a "laugh log" the circumstances around every time they tittered, chuckled, or guffawed. The results were much surprising. Firstly, less than 20 percent of the real-world laughter incidents were in response to some funny incidents. Secondly, in most of the cases, people were found to giggle or chuckle even at simple statements such as "I'll see you guys later," "I see your point," etc. Thirdly, in all of these cases, the person who initiated the laugh-provoking statement was 46 percent more likely to be the one chuckling than the person listening. Fourthly, while laughter may erupt at any point in response to something funny, but in only eight of the 1,200 laugh episodes Provine cataloged that laughter is interrupted at somebody's saying. But at, 99.9 percent of the time, laughter occurred in tidy, natural breaks in the conversation, punctuating the speech like a period or exclamation point.

Provine also discovered that we come across laughter in our everyday lives, mostly not in response to anything resembling jokes. Instead, it occurs in conversations that, out of context, do not seem funny at all. (42) Therefore, Provine and other researcher's discoveries suggest that laughter at the core level, is a form of of communication (43), inherently social and not just a by product of finding something funny. In fact, when Provine went through the laugh logs he collected, found his participants were 30 times more likely to laugh in the presence of others than when they were alone. In a few isolated instances of laughter, nearly all occurred in response to TV shows or other media. It denotes, electronic device, proxies for other people. This odd and powerful vocal mannerism of laughter seems to have an innate need to share funny matters with others. If we go for Evolutionary theory of this body response, we will come across various possible explanations. Of these, the most significant theory was put forward in a 2005 *Quarterly Review of Biology* article by an undergraduate student Matthew Gervais and his adviser, evolutionary biologist David Sloan Wilson. The theory is again based on a study by 19th-century French physician named Guillaume Duchenne, who went around zapping people's faces with electrodes. He worked at an old woman's hospice, and

so had access to a lot of prone bodies. Perhaps he was charming in appearance. According to articles on Duchenne, all the ladies wanted to be electrocuted by the "little old man with his mischief box." After applying the prongs of his box to people's faces, Duchenne evoked one kind of smiling, voluntary in nature with the type of expression exhibited at the time when we grin to be polite. He discovered this mannerism, involves the face's zygomatic major muscles, raising the corners of the mouth. But Duchenne also discovered a second variety of smiling and laughing, which occurs when we find something truly entertaining or funny. At this time, expression was more complex, utilizing both the zygomatic major muscles and the orbicularis oculi muscles that form crow's feet around your eyes. This is the reason for the old saying that a real smile is in the eyes. With the application of electrodes, Duchenne was never able to reproduce this second form of exsmile pression— now known as a Duchenne smile or Duchenne laughter. He rather considered that this kind of smile is possible only put by the sweet emotion of the soul. Duchennes's discovery was brought to the notice of people by Gervias and Wilson, after more than a century, indicating evolution of laughter at two different points of human development. The first event was triggered in response to funny matters, sometimes between 2 million to 4 million years ago, In fact, it appeared even before emergence of language, just to make others feel or provide a signal that no danger is lying ahead, basic demands are satisfied and everything seems fine. For primates, after play fighting, there is an outburst of breathy panting. Gervias made the inference that laughter made a signal for certain non serious novelty, and associated others may join this event cognitively, emotionally and socially. Accordingly, these professors from the University of Binghamton consider that laughter originated seven million years ago, as a result of with the gasping of hominids when playing with others.

Gervias and Wilson next theorized (14) that long long years after, sometime in the hundreds of thousands of years after, the non-Duchenne sort, or other sort of laughter, independent of contents of humour, emerged. With the advent of human development, cognitively and behaviorally, people learned and tried to mimic the spontaneous behavior of laughter, just to take the advantage of its effects. But they were not able to produce the exact eye-muscle movements of real laughter and smiling. This way, mimicked laughter was practiced for beneficial purposes. Thus Gervais and Wilson put it in their paper, "non-Duchenne laughter came to occur in aggressive, nervous, or hierarchical contexts, functioning to signal, to appease, to manipulate, to deride, or to subvert."Another interesting fact is that Bipedal locomotion in human is anticipated as one of the causes for more vocalization and laughter (44)

Basic evolution of laughter in humans.

It is often said laughter has its origin from non human primates or other mammals. To examine this view, scientists carried out experiments with induced laughter such as tickling. They studied the acoustics of tickle-induced vocalizations from infant and juvenile orangutans, gorillas, chimpanzees, and baboons, as well as tickle-induced laughter produced by human infants. Character states of the resulting acoustic data were then coded and further

evaluated submitted for quantitative phylogenetic analysis. Acoustic outcomes revealed both important similarities and differences among the five species. Moreover, Furthermore, phylogenetic trees reconstructed from the acoustic data matched the well-established trees based on comparative genetics. These results provide strong evidence that tickling-induced laughter is homologous in great apes and humans and support the more general postulation of phylogenetic continuity from nonhuman displays to human emotional expressions. (45)

There exists another theory, which takes the person-to-person connection provided by laughter a step further, is that laughter may be a supplement for the act of grooming each other. Grooming one another is a behavior seen in primates with trust, investment of time and development of friensship. With the increase of community, it becomes difficult to groom one another to establish friendship bond and laughter may be a good substitute as it can be done in a larger group with a more immediate impression. (15)

Every person has his/her own personal signature in laughter as we call "laugh Print". It may be snorting, cackling chortling or a wild, weird little giggling. Laughter in the human brain as a social response appears after the third month of life, never to disappear. A study from the University of Ontario reports that adults laugh an average of 18 times a day, children tend to laugh three to five times more. The phonetics of laughter is universal, in all cultures the same language of a laugh or a laugh is accepted. (8)

Types of laughter:

Laughter is characterized a physical reaction involving a distinct repetitive vocal sound, certain facial expressions, and contraction of various muscle groups. One study has indicated five separate types of laughter such as genuine ("spontaneous"), self-induced ("simulated"), stimulated (eg., tickling), induced (i.e., via drugs), and pathological. (16) Pathological laughter is different, due to a disorder of emotional expression mediated by damage of pathways in the cortex and brainstem. This is called laugh attack or Pseudobulbar affect where the person experiences uncontrolled laughter, cry or get upset without having any cause (17) On the contrary fake laughing releases endorphins since the brain interprets it by the position of the muscles of the face. Endorphins make us feel happier and less stressed.

Laughter can also be classified as **Etiquette Laughter** which could have developed in our ancestors before full speech, and the sound denotes a way to communicate and show agreement. It may be **Contagious laughter.** According to Provine, contagious laughter raises the possibility that humans have laugh detectors. In other words, people are made to respond with laughter on hearing laughter itself, much like the mystery of spreading a yawn (11). It may be a separate type called **Nervous laughter** which is not laughter at all but a defense mechanism in hostile situation. (18)

Apart from types of laughter, the ways of laughing may vary from giggles to guffaws and from chuckles to cackles. It appears that we humans laugh for many reasons, some of them

may be odd. Laughter seen after tickling or tickling laughter demands special attention. As per the opinion of neurobiologists and evolutionary biologists, we laugh when we are tickled just because hypothalamus and anterior cingulated cortex, the part of the brain tells us to laugh if exposed to a light touch. It is also the same part that tells us to expect a painful sensation. Thus Laughing when tickled in our sensitive spots (under the arms, near the throat and under our feet) could act as a defensive mechanism. It is anticipated that we have evolved to send this signal out to show our response to overcome or to dispel a tense situation as a defense mechanism. Gorillas or rats both laugh like us when they are tickled. But we cannot hear the giggle of rats at 50kHz, which is out of our audio range. (19)

There are also sexual differences in laughter as Provine has studied male/female laughter patterns. In one occasion, he carried out study of humans in their natural habitat of shopping malls, city sidewalks, and the university student union, involving about 1,200 laugh episodes. And he found that Speakers laugh more (46%) than their audiences. The effect was even more striking when he saw females were while talking laughed 126% more often than the people they were talking to. The socio biological aspect of laughing was striking, he admitted. People were found to laugh about 30 times more when they were around others than when they were in solitary situation.

The benefits of laughter :

It is commonly accepted that laughter exerts some psychological benefits, such as reduction of depression, anxiety, and stress (20, 21, 22) But studies show, it has some small but quantifiable positive physiological benefits. Moreover, literature on laughter depicts different effects based on the type of laughter studied either spontaneous or self-induced. (3)
Probably Laughter works as a reappraisal technique, reducing the limbic response associated with "fight-or-flight" reactions. In other words, when feeling stressed the physiological act of laughter make us tension free. It is often said, laughter is the best medicine. This saying "laughter is the best medicine" is believed to have originated — albeit now in a snappier form —from **Proverbs 17.22 of the King James Bible**. But how it exerts its strong medicinal value? According to the Mayo Clinic, (23) there are multitude health benefits of laughter. It may increase our oxygen intake, which eventually can stimulate our heart, lungs, and muscles. It further releases the endogenous feel good hormone endorphins, to make us feel happy and even relieve pain or stress. The associated act of changing our heart rate and blood pressure through laughter is also ultimately calming and tension-relieving. Even our immune system response may enhance through the release of stress-and illness-reducing neuropeptides. Laughter also signals cooperation, a key aspect of human survival, and promotes a healthier body. By seeking out more opportunities for laughter, we can improve our emotional health, strengthen our relationships, find greater happiness, keep appositive optimistic outlook in difficult situations —and even add years to our life. It may even help us to live longer. A study in Norway found that people with a strong sense of humor outlived those who do not laugh as much. The difference was particularly notable for those battling cancer. (47) But how does it exert its action ?

a. Laughter may reducing stress, anxiety, and depression : It has been shown to exert stress-reducing effects by suppressing the bioactivities of some neurohormones epinephrine, cortisol, and 3,4-dihydrophenylacetic acid (a major dopamine catabolite) (24,25) Reduced activities, of norepinephrine, serotonin, and dopamine are linked to depression, and laughter is shown to enhance dopamine and serotonin activities (Yim et al l2016). Serotonin is the same brain chemical affected by the most common types of antidepressants, SSRIs. But effective duration as antidepressant is not known. Laughter therapy may be effectively used for reducing short-term and long-term stresses and thus to improve significantly the quality of life (26) Moreover, Laughing eliminates stress hormone cortisol from our blood stream and stimulates release of chemicals in the brain: dopamine, oxytocin and endorphins. Oxytocin, the empathy hormone and the bonding chemical creates a sense of relatedness. Endorphins on the other hand, triggers the feelings of pleasure, helps to endure pain sensation. (27)

b. Laughter and Pain Management : Laughter may decrease our pain sensation by facilitating the synthesis of natural painkillers. Moreover, it has been found to enhance the tolerance of pain. (27, 28)

c. Laughter is central to relationships : A study by American scientists indicated frequency of laughing in women is more than men (126%) , but men seem to instigate laughter much more than women. Couples who laugh together report having higher quality of relationship. (29) In the northeastern corner of Tanzania, on Jan. 30, 1962, three school girls started giggling in a religious boarding school classroom. They could not stop laughing and soon it became a very strange epidemic, spreading to their classmates. The laughing attacks lasted from a few minutes up to a few hours. Interestingly, one poor girl reportedly experienced symptoms for 16 straight days. The victims were so much affected that they could not focus on their schoolwork, and if being refrained by others, they tried to attack them. Gradually when 95 students out of 159 pupils of the school had come down with this laughing disease, the school authority was compelled to shut down the school. The students returned to their villages, taking the disease (*omuneepo*) with them. Gradually, it was found the disease to spread from person to person, school to school, village to village. The villagers were much afraid as the education of the children was interfered. It was reported by noted local medical officers in a 1963 report in the *Central* African Journal of Medicine. (46) The reason behind it was not clear. Around a thousand people were affected and after two months the epidemic died down. Later, researchers went to the particular village in Tanzania, half a century after to trace spread of omuneepos across the region, took interview with the students, teachers, and local medical experts having first hand experiences. They came to know that there was nothing funny at all about the situation at the time. The religious boarding school where the laughter began was marked by strict rules, windowless dorms, and devilishly uncomfortably chairs designed to promote correct posture. Investigators found similar conditions at other locations where the *omuneepo* later erupted : Serious overcrowding, poor food quality. "It's a form of complaint," Kroeber Rugliyama, a longtime local psychiatrist said of the mysterious laughter. "They had no alternative form of expression." (48)

d. Laughter stimulates the immune System : It stimulates body immunity by decreasing stress hormones and increasing the immune cells along with the level of antibodies. (30, 31, 32)

e. Laughter evokes Euphoria : By promoting release of Body's natural feel good hormones endorphins laughter creates overall sense of well being. Researchers from Finland and the United Kingdom found that social laughter triggers the release of endorphins, from brain regions responsible for arousal and emotion. Endorphins interact with opioid receptors in the brain to help relieve pain and trigger feelings of pleasure. Their study revealed that people with more opioid receptors, are gifted with brain regions associated with the processing of emotions, the more they engage in social laughter. Highly addictive opioid drugs, e.g. heroin, also binds with these receptors, suggests how laughter evokes euphoria. "The relationship between opioid receptor density and laughter rate also suggests that [the] opioid system may underlie individual differences in sociability." "Our results highlight that endorphin release induced by social laughter may be an important pathway that supports formation, reinforcement, and maintenance of social bonds between humans," says study co-author Prof. Lauri Nummenmaa, of the Turku PET Centre at the University of Turku in Finland. The researchers recently reported their results. (33) For the study, Prof. Nummenmaa and colleagues enrolled 12 healthy men to their study. Participants were injected with a radioactive compound that adheres to opioid receptors in the brain. Using positron emission tomography (PET) imaging, the researchers were then able to monitor the release of endorphins and other peptides that bind to opioid rectors. Participants underwent PET scans twice. The first scan was conducted after each participant spent 30 minutes alone in a room, and once after they spent 30 minutes watching laughter-inducing video clips of their close friends. The researchers found that the social laughter condition led to a significant increase in endorphin release in the thalamus, caudate nucleus, and anterior insula regions of the brain. These are brain regions that play a role in arousal and emotional awareness. Additionally, the team found that participants with a greater number of opioid receptors in the cingulate and orbitofrontal cortices of the brain were more likely to laugh in response to their friends' video clips, The cingulate cortex is involved in the processing and formation of emotions, while the orbit o frontal cortex is involved in a number of emotion-related processes. Endorphins also promote the feelings of togetherness. Prof. Robin Dunbar, of the University of Oxford in the U.K., and the of co-author of the study adds that the results highlight the importance of vocal communication in social bonding. "Other primates maintain social contacts by mutual grooming, which also induces endorphin release. This is however very time-consuming. Because social laughter leads to similar chemical response in the brain, this allows significant expansion of human social networks: laughter is highly contagious, and the endorphin response may thus easily spread through large groups that laugh together."

f. Laughter and social connection : Just like small conversation, laughter play a crucial role in social bonding, nurtures friendship. In fact, most laughter is centered around playful situations. Our daily experiences may have noticed that we laugh much in a group than when being alone. Studies on this issue have shown young children between the ages of 2.5 and 4 were found to be eight times more likely to laugh at a cartoon when they watched it with

another child even though they were just as likely to report that the cartoon was funny whether alone or not. For adults, in a study involving 24 different societies with 966 participants, scientists played short sound bites of pairs of people laughing together. In some cases, the pair were close friends, in others, the pair were strangers. Participants in the study were asked to listen to the simultaneous laughter and to determine their level of friendship shared by the laughers. Using only the sound of the laughter as cues, they could confidently express the duration of friendship of the participants. These results suggest not only the link between true laughter and durable friendship but also the transparency of laughter, while genuine or pretentious laugh at a joke. (Detecting affiliation in co-laughter across 24 societies. (34) Effective use of laughter to reduce long term or short term stresses can significantly improve the quality of life (35)

Laughter can be used as a non invasive, cost effective and easily implementable therapeutic measure to reduce the intensity of many mental illnesses (36)

g. It protects the heart by improving the function of blood vessels and increasing blood flow, which may protect us against a heart attack and other cardiovascular problems. Studies have shown that laughter has an anti-inflammatory effect that protects blood vessels and heart muscles from the damaging effects of cardiovascular disease. (37, 38) How this happens is not entirely understood, but it seems related to lessening the body's stress response, which is directly linked to increased inflammation. Regular, hearty laughter should probably be part of every heart disease prevention program

h. It burns calories : Selective study has found that laughing for 10 to 15 minutes a day can burn approximately 40 calories— which could be enough to lose three or four pounds over the course of a year. (39)

i. Laughter fosters brain connectivity : Not all laughter is the same, One study has found differences in how we perceive, for example, joyous laughter versus taunting laughter versus tickling laughter, each of which activates connections between different brain regions laughter fosters rigorous brain-region connectivity that kicks in when we hear a laugh, as our brains work to decipher what sort of communication is coming through. (40)

Is Laughter really the best medicine ?

Many researchers claim that laughter carries health benefits, as it represents all the positive emotions that offset hostility and eventually exert positive effects on the immune system.

But contrary to the health activists laughter researcher Provine holds different views since most of the researches in this area is very limited. However, the therapeutic value of laughter was popularized by Norman Cousins (in his 1976 article, published in *The New England Journal of Medicine*,) and the idea was expanded into a book where Cousins, describes his affliction with a painful and life-threatening degenerative disease (ankylosing spondylitis) and his successful self-treatment with vitamin C. But Provine admits, though laughter may exert certain health benefits, but it is indeed a very violent activity. According to him,

"Laughter increases your heart rate, but would similar changes be produced by yelling or singing? There may be something unique to laughter, but that research hasn't been done yet."

On the contrary, Margaret Stuber, Ph.D., Professor of Psychiatry and biobehavioral sciences at UCLA. (and also the co-director of the UCLA Jonsson Cancer Center's Rx Laughter, a nonprofit project dedicated to helping the ill via humor and to supporting more scientific research on laughter), has found that when children watched funny videos -- while their hands were in ice water -- they could tolerate pain better. She also found children who laughed more, assessed the experience as less unpleasant. And they also had lower levels of the stress hormone cortisol. Stuber suggests, parents can teach their kids to see the funny side of life. This therapy may change the vision of life. She has initiated an experiment where puzzle pieces are put together to the children, just to discover them the funny sides of things and also to learn about a situation as non-threatening or not embarrassing. (Webmed report). In one of her studies, Stuber found and disclosed to webmed that people who are able to laugh -- rather than being embarrassed or angry in certain situations -- tend to have fewer heart attacks and better blood pressure (41). According to her, more research work on the effects of laughter, are coming out.

Another a psychotherapist, Stephan Wischerth who leads the New York City's Laughter Club, tells WebMD, "Laughing makes people laugh,". "I find that we really have lot of laughs just frozen inside our chest, just dying to get out. I give people permission to laugh out loud, be silly, get rid of stress. They discover for themselves how to take life a little less seriously. People feel like they're constantly under barrage. Why not joke about it?" "The contagious quality inherent in laughter – that's what helps bolster them". In his clinic, among those who attended were someone with Stage 4 Cancer, another person with a degenerative nerve disease, i.e. people who are really stressed out.

Still another Laughter Club leader at the Getting Well Campus in Orlando, Kim McIntyre says even in forced laughters, people experience beneficial effects as part of a mind/body/wellness program. Efforts must be exerted to stimulate the inner child that too often gets lost as we age. She also told Webmed, "Ninety percent of the time, when we start out with forced laughter, people start laughing,". "Pretty soon, there's an overwhelming amount of genuine laughter. Your ear hears it and you start laughing."

Conclusion:

Laughter can be considered as a human asset. It is a well known fact that laughter can have deep and long-lasting psychological effects. Only recently we are gathering knowledge of the physiologic effects of laughter. Currently, more research is indicating that the physical act of laughing, even without humor, is linked to chemical changes in the body that potentially reduce stress and increase pain tolerance. Moreover, laughter is nowadays being used as therapeutic measure for combating many kinds of aliments. However, the effects of laughter on the neuro endocrine, and immune systems are needed to be objectively studied to define the underlying molecular regulation of psychosocial behaviors. Nowadays, laughter therapy which includes laughter exercises, clowns, and comedy movies, books, games, and puzzles is being used to help relieve pain and stress and improve a person's sense of well-being. It is also used sometimes to help people cope with a serious disease, such as cancer.

References :

1. Panksepp, J. (2000). The riddle of laughter neural and psychoevolutionary underpinnings of joy. Current Directions in Psychological Science. 9 (6):183–186. doi: 10.1111/1467-8721. 00090. S2CID 145577390.
2. Johnson, Doug (17th May 2021) "From apes to birds, there are 65 animal species that "laugh"". Ars Technica. Retrieved 20 May 2021 .
3. Louie ,D., Brook, K., Frates, E.(2016)The Laughter Prescription: A Tool for Lifestyle Medicine, , Am J Lifestyle Med. 2016 Jul-Aug; 10(4): 262–267. Published online 2016 Jun 23. doi: 10.1177/15598276145502.
4. Morreall , J. (ed) (1986) The Philosophy of Laughter and Humor, State University of New York Press
5. Morreall , J.(1982)A New Theory of Laughter *in* Philosophical Studies: An International Journal for Philosophy in the Analytic Tradition, 42(2): 243-254 , Published by: Springer, https://www.jstor.org/stable/i395993
6. Provine , R R. (2000) Laughter: A Scientific Investigation. University of Maryland, Baltimore County
7. Provine, R R (2007). Neglected Mirror-Like Behavior: Contagious Yawning and Laughing, Observer, September.
8. Jeanie Lerche Davis, Why do we laugh? No laughingmatter,https:// www.webmed.com/ jeanie –lerche-davis.
9. Cousins, N. (1979) *An Anatomy of an Illness*. New York, NY: WW Norton.
10. Marshall, B. How laughter works, House stuff works, https:// science.housestuffsworks.com, accessed on 12.06.22
11. Provine, R R (1996)Laughter, American Scientist, 84: 38-47
12. Derks, P., Gillikin, L. S., Bartolome-Rull, D. S., & Bogart, E. H. (1997). Laughter and electroencephalographic activity. *Humor: International Journal of Humor Research, 10(3), 285–300. https://doi.org/10.1515/humr.1997.10.3.285*
13. Baber, H., Donnelly, J., & Morreall, J. (1984, December). Taking Laughter Seriously. Retrieved January 26, 2021, from ResearchGate https://www. researchgate.net/ publication/ 324303385 _Taking_Laughter_Seriously/
14. Gervais, M. & Wilson, D. S.. (2006). The evolution and functions of laughter and humor: A synthetic approach. The Quarterly review of biology. 80(4). 395-430. 10.1086/498281
15. Stierwalt, S. (2020) Why do we laugh, Scientific American February 9, 2020, https:// www.scientificamerican.com/sabrina- stierwalt
16. Mora-Ripoll R.(2010) The therapeutic value of laughter in medicine. *Altern Ther Health Med.*;16(6): 56-64.
17. Parvizi J, Anderson SW, Martin CO, Damasio H, Damasio AR.(2001) Pathological laughter and crying: a link to the cerebellum. *Brain.*; 124(pt 9): 1708-1719
18. Ramachandran, V.S.(2005) *A Brief Tour of Human Consciousness:* From Impostor Poodles to Purple Numbers , PLUME, ISBN 0131872788
19. Why do we laugh when we are tickled? - BBC Future, https://www.bbc.com › future › article › 20140131-why-.. accessed on 12 th june 2022.
20. Foley E, Matheis R, Schaefer C. (2002) Effect of forced laughter on mood. *Psychol Rep.*;90(1):184.

21. Kuiper NA, Martin RA.(1998) . Laughter and stress in daily life: relation to positive and negative affect. *Motiv Emot.*; 22:133-153.

22. Szabo A, Ainsworth SE, Danks PK. (2005) Experimental comparison of the psychological benefits of acrobic exercise, humor, and music. *Humor.*; 18:235-246

23. Stress management. https://www.mayoclinic.org/healthy-lifestyle/stress-management/in-depth/ stress-relief / art-20044456.

24. Berk L.S., Tan S.A., Fry W.F., Napier B.J., Lee J.W., Hubbard R.W., Lewis J.E., Eby W.C. (1989) Neuro endocrine and stress hormone changes during mirthful laughter. *Am. J. Med. Sci.* 298:390–396.

25. Yim J. (2016). Therapeutic benefits of laughter in mental health: a theoretical review. *Tohoku J. Exp. Med.*; 239:243–249.

26. Zhao J., Yin H., Zhang G., Li G., Shang B., Wang C., Chen L.(2019). A meta-analysis of randomized controlled trials of laughter and humour interventions on depression, anxiety and sleep quality in adults. *J. Adv. Nurs*; 75:2435–2448.

27. Dunbar R. I. M., Baron Rebecca, Frangou Anna, Pearce Eiluned, van Leeuwen Edwin J. C., Stow Julie, and van Vugt Mark, (2012) , Social laughter is correlated with an elevated pain threshold. *Proc. R. Soc. B.*2791161–1167

28. Lapierre S.S., Baker B. D., Tanaka H. (2019). Effects of mirthful laughter on pain tolerance: a randomized controlled investigation. J. Bodyw. Mov. Ther.; 23:733–738.

29. Laura ,E., Aura, E., Kurtz, S.B., Algoe (2015) Journal of International association for relationship research, Putting laughter in context: Shared laughter as behavioral indicator of relationship well-being, 22(4): 573-90.

30. Bennett MP, Zeller JM, Rosenberg L, McCann J.(2003). The effect of mirthful laughter on stress and natural killer cell activity. *Altern Ther Health Med.*;9(2):38-45.

31. Takahashi K, Iwase M, Yamashita K, et al.(2001). The elevation of natural killer cell activity induced by laughter in a crossover-designed study. *Int J Mol Med.*;8:645-650

32. When laughing, the body produces more gamma interfection T-cells and disease fighting cellsboosts the immune system. http://serendip.brynmawr.edu/exchange/node/2054.

33. Sandra M, Lauri T, Robin I. Dunbar, T. Karjalainen, Jussi, H., Eveliina A., Riitta H, Iiro, P. Jääskeläinen, Mikko S and Lauri Nummenmaa. (2017). Social Laughter Triggers Endogenous Opioid Release in Humans, Journal of Neuroscience, 37 (25) 6125-6131; DOI: https://doi.org/10.1523 /JNEUROSCI.0688-16.2017

34. Gregory A. Bryant , Daniel M. T. Fessler, Riccardo Fusaroli, Y. Zhou. (2016) PNAS, 113 (17) 4682-4687, https://doi.org/10.1073/pnas.1524993113]

35. Zhao J., Yin H., Zhang G., Li G., Shang B., Wang C., Chen L (2019). A meta-analysis of randomized controlled trials of laughter and humour interventions on depression, anxiety and sleep quality in adults. *J. Adv. Nurs.*; 75:2435–2448.

36. Van Der Wal C.N., Kok R.N.(2019) Laughter-inducing therapies: systematic review and meta-analysis. *Soc. Sci. Med.*; 232:473–488.

37. Boone T, Hansen S, Erlandson A.(2000). Cardiovascular responses to laughter: a pilot project. *Appl Nurs Res.* 2000; 13:204-208.

38. McMahon C, Mahmud A, Feely J. (2005). Taking blood pressure— no laughing matter! *Blood Press Monit.*; 10:109-110.

39. Buchowski , M S., Majchrzak, K M., Blomquist, K., Chen, K Y., Byrne, DW., Bachorowski, J-A. (2007). Energy expenditure of genuine laughter, Int J Obes (Lond) 31(1): 131-7. doi: 10.1038 /sj.ijo.0803353.

40. Wildgruber D, Szameitat D P, Ethofer T, Brück C, Alter K, et al. (2013) Different Types of Laughter Modulate Connectivity within Distinct Parts of the Laughter Perception Network. PLOS ONE 8(5): e63441. https://doi.org/10.1371/journal.pone.0063441.

41. https://www.mayoclinic.org / healthy-lifestyle / stress-management / in-depth / stress-relief / art20044456

42. Provine, R (2016) laughter as a scientific Problem: an adventure in sidewalk neuroscience., Journal of Comparative Neurology. 524:1552-1539.

43. Ginzburg, J., Mazzocconi, C., Tian, Y(2020). Laughter as language., Glossa: a journal of general linguistics 5(1): 104. 1–51.

44. Provine, R. (2017). Laughter as an approach to vocal evolution: The bipedal theory. Psychonomic Bulletin & Review, 24: 238-244

45. Davilla, Ross, M., Owren, M.J., Zimmermann, E. (2009). Reconstructing the evolution of laughter in great apes and humans. Curr Biol. 2009 Jul 14;19 (13): 1106-11. doi: 10.1016/j.cub.2009.05.028. Epub 2009 Jun 4.PMID: 19500987.

46. Rankin, A.M., Philip, P.J. (1963). An Epidemic of laughing in the Bukoba district of Tanganyika The Central African Journal of Medicine. (167-170). *Transcultural Psychiatric Research Review and Newsletter*. 1965;2(2):128-128. doi:10.1177/136346156500200218

47. International Moment of Laughter day-April 14 | McGregor, https://mcgregoramasa.org › 2021 March 25.

48. Mcgraw, P and Warner J.(2014), Why do humans laugh? The evolutionary biology of laughter. SLATE, MARCH 25, 201411:41 PM, Accessed on 12.06.22

Significance of medicinal plants: the lesser utilized ones

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Abstract

Natural reserve of medicinal plants is a diverse, complex and unlimited source of therapeutics. They have supported human health since ancient times and a vast majority of the global population is currently inclined towards herbal preparations owing to their efficacy, cost efficiency and minimal side effects. As with any other field of science, development of state of art research facilities have optimized the identification of therapeutic principles, facilitated effective extraction and quantification procedures, helped in determining the medicinal potency and contributed immensely towards herbal drug development. During the course of time we have either lost track or neglected many plants that have ethnobotanical significance resulting in research and exploitation of selected plant species only. This has not only resulted in biodiversity imbalance but has restricted the utilization of the full potential of medicinal plants. The aim of this review is to draw attention to the wide plethora of medicinal properties of lesser investigated plant types namely mushrooms, cacti, orchids, carnivorous and aquatic plants. It briefly touches upon the recent trends in medicinal plant research which when applied to these lesser known plants can be of immense benefit to pharmacognosy and medical science.

Keywords

Medicinal plants, Mushrooms, Cactui, Orchids, Carnivorous plants, Aquatic plants, secondary metabolites

Introduction

The rising demand for pharmaceuticals and nutraceuticals is paralleled by an upsurge in developing natural products for the prevention and treatment of human ailments and the focus has been particularly on secondary metabolites. Increased medicinal plant research is evident from the rise in number of publications from 4,686 in 2008 to 14,884 in 2018 (1). The secondary metabolites are specialized biochemical compounds which play no apparent role in plant growth, enlargement, and reproduction but help them in combating stress conditions and adaptation (2, 3). The diverse array of secondary metabolites effective in biotic and abiotic stress tolerance includes alkaloids, terpenoids, glycosides, flavonoids, quinones, coumarins, polyketides, steroids, glycosides, volatile oils, resins, tannins, cyanogenic glycosides, etc (4). Secondary metabolites do not engage in any precise role in the internal organization of the producers but help in defense mechanisms and their investigation could result in the identification of new signalling molecules (5, 6, 7, 8). Sophisticated analytical approaches, innovative techniques and bioinformatics coupled with R&D investments enhance the optimal utilisation of various medicinally important compounds. The herbal drug industry is facing challenges such as mass exploitation leading to biodiversity extinction, slow multiplication rate, low bioavailability, tissue specific distribution, geographical and seasonal variation in metabolite content and continuous reduction in land availability. *De*

novo synthesis of chemical analogues is expensive, laborious and largely inaccurate (9). Furthermore major focus on exploitation of plant resources for therapeutic principles has been restricted to certain genera while a plethora of plants remains unexplored. Keeping these disadvantages in mind, the need of the hour is to widen our search for secondary metabolites from unconventional sources. The current review aims to highlight the plants whose medicinal properties though reported or used in traditional and ethnobotanical practices, are not utilized in mainstream formulations. Case study of mushrooms cacti, orchids, carnivorous and aquatic plants have been dealt with herein. While cacti and orchids are cultivated for ornamental purposes, carnivorous and aquatic plants are left to grow in the wild. An amalgamation of ethnobotanical knowledge and precise instrumentation can help in sustainable use of plants to combat human diseases.

Case study 1: Mushrooms

Mushrooms are a group of organisms belonging to the families Ascomycetes and Basidiomycetes of the kingdom Fungi, the fruiting body being mostly epigeal but sometimes hypogeal in nature (10). Mushrooms possess a variety of medicinal properties due to the presence of their active constituents such as polysaccharides, dietary fibers, selenium oligosaccharides, triterpenoids, peptides, proteins, alcohol, phenols, amino acids and mineral elements (11). In China since 100 A.D. mushrooms are used as medicine (12) but in the developing countries wild edible macro-fungi have often been ignored.

Medicinal properties of bioactive compounds from mushrooms

Mushrooms are known to possess medicinal properties that provide benefits against a large number of diseases for instance antimicrobial, antioxidant, anticancer, immune system enhancer, antiviral, anti-hyperlipidemia, radical scavenger, anti-parasitic and anti-inflammatory (13). Researchers have focused on antimicrobial, antioxidant, prebiotic and anti-inflammatory properties. The medicinal uses of bioactive compounds from mushrooms are given in table 1.

Case study 2: Cacti

Theophrastus used the term Cactus, derived from an ancient Greek word ‘kaktos’, to demarcate the spiny plants (14). It consists approximately of 1,600 species in 130 genera subdivided in the three subfamilies Pereskioideae, Opuntioideae and Cactoideae (15). Cactus, also referred to as ‘new world plants’ is popular as no maintenance wild/ornamental plants belonging to the family Cactaceae and has great economic value (14). Bioactive compounds from cacti are under investigation owing to the proven anti-cancerous, antioxidant, antiviral anti-inflammatory, anti-diabetic, anti-hyperlipidemic and hypercholesterolemic effect.

Medicinal use of bioactive compounds

Anti-cancerous effects: Recent studies indicate remarkable anticancer activities in the extract of cactus pear. It is also found that cacti prevent the proliferation of *in vitro* cervical, ovarian and bladder cancer cell lines and inhibits the growth of cancerous cells in the mice

ovarian culture model *in vivo* (16). The chemo preventative and anticancer activities of crude extracts from plants are comparable to the synthetic Retinoid N-(4-Hydroxyphrenyl) retinamide (4-HPR) which is used in ovarian cancer (16, 17).

Antioxidant effects: The antioxidative property of cactus cures many beneficial health effects (18). The antioxidants such as polyphenolics are cardio protective, anticancerous, antiviral and anti-allergenic (19). These polyphenolics of cactus increases the intracellular calcium ions in endoplasmic reticulum and this perturbs the expression of interleukin 2 which is associated with human T cells (20).

Anti-inflammatory effects: Genus *Opuntia* has been used for its analgesic and anti-inflammatory effect. The fruit extract of *Opuntia dillenii* (21) and the lyophilized cladode has known anti-inflammatory effect. The phytosterols of fruit and stem extract are used in this. The component of stem extract Betasitosterol also has anti-inflammatory effect. With the help of the fruit and stem extracts the gastric lesions in mice were reduced remarkably (22). Remarkable anti-inflammatory effects of indicaxanthin have recently been demonstrated in an animal model of acute inflammation (23).

Case study 3: Orchids

The meaning of the word –orchid‖ (Orchis in Greek) is testicles and Theophrastus first coined the term according to the plant anatomy. Orchids are the most beautiful group of plants belonging to the largest family of angiosperms Orchidaceae (24, 25) and consists more than 25,000 species distributed around the globe from tropics to high alpine (26) except the deadly hot desserts and extremely cold Antarctic area (27).They are important aesthetically, medicinally and also regarded as ecological indicators (28). Besides their economic importance, orchids are also used as herbal medicine and food by different cultures and tribes in the different parts of world (29, 30). However, orchid cultivation is rare for medicinal use (31). Orchids synthesize biochemically active secondary metabolites of different chemical types (32). They have been used variously in different diseases as anti-convulsive, anti-rheumatic, anti-viral, anti-carcinogenic, anti-inflammatory, diuretic, neuroprotective, hypoglycemic, anti-aging, wound healing, antitumor, antimicrobial and many other activities. From different genera of orchids a wide range of important phytochemicals are isolated such as alkaloids, flavonoids, stilebnoids, anthocyanins, triterpedoids, orchinol, hircinol, cypripedin, bibenzyl derivatives, phenanthrenes, jibantine, nidemin and loroglossin which are present in leaves, pseudo bulbs, roots, flowers or in the entire plant. Therapeutic uses of medicinal orchids are mentioned in table 2.

Conservation status of Orchids

The family Orchidaceae account for nearly 8% of angiosperm species diversity with five subfamilies (Apostasioideae, Cypripedioideae, Vanilloidea, Orchidoideae, and Epidendroideae) (24, 25). Major threats include habitat destruction, illegal harvesting and

due to their complex life histories, orchids are thought to be particularly vulnerable to the effects of global climate change (33). All species of subfamily Cypripedioideae (slipper orchids) were assessed for the Global Red List in a recent project, and due to a combination of habitat degradation and in some cases, ruthless harvesting, nearly 90% of species were assessed and reported to be threatened (34).

Case study 4: Carnivorous plants

There are approximately 700 identified species of carnivorous plants divided in 15 genera and 9 families (35). They are distributed in Canadian arctic, Scandinvia, Greenland, Malaysia, Australia, Brazil, India etc. but not found in Antarctica (36). In India, a total of five genera of carnivorous plants are reported with 44 species; viz. *Utricularia* (38 species), *Drosera* (3 species), *Nepenthes* (1 species), *Pinguicula* (1 species), and *Aldrovanda* (1 species) (37, 38, 39).

Ethnobotanical medicinal value of carnivorous plants

Insectivorous plant species show unique ethnobotanical values. *Drosera burmunnii* is reported to be used for curing loss of memory and against cough (40) while the whole plant paste is used to cure blood dysentery (41) and against stomach problems (42). *Nepenthes* species have been used in traditional medicines against many diseases. It has been reported that Northeast Indian herbalist prescribed the fluid from an unopened pitcher of *Nepenthes khasiana* is used to treat of diabetes mellitus, night blindness, conjunctivitis, ear troubles and gynecological problems (37, 43). It is reported that this plant is also used for the treatment of urinary problems, itching of the eye, night blindness, wound (37, 45). The powder of *N. khasiana* pitcher is used to treat cholera and fine paste used to treat leprosy (44). *Nepenthes ampullaria* and *N. gracilis* are the two most common species used in folk medicine, where the liquid of an unopened pitcher are administered to regulate the menstrual cycle, ease child birth, relieve asthma, treat eye inflammation, and act as a stamina booster (46). The root of *Nepenthes* is used in the treatment of bed-wetting dysentery and stomachache (47). In Vietnam, *Nepenthes mirabilis* is used in the treatment of gastric ulcer, jaundice, high blood pressure, uterine stones, and hepatitis by traditional medical practitioner (48). In Malaysia the blended leaves of some *Nepenthes spp.* have been used as an astringent and the decoction of stem of *N. ampullaria* has been consumed to treat malaria (50, 51). *Utricularia reticulata*is administered against urinary problems by tribal people (52).

Pharmacological uses of Carnivorous plants

The ethnomedicinal values of insectivorous / carnivorous plants indicate that plant parts possess antibacterial and antifungal potentials. Trap fluid of *Nepenthes* species inhibit the growth of bacteria (53). Bhau et al. (54) reported the leaf extracts of *Nepenthes khasiana* shows antimicrobial activity of against *Escherichia coli*, *Candida albicans* and *Aspergillus niger*. Antibacterial activity of *Nepenthes* species against *Escherichia coli*, *Salmonella enterica* and *Staphylococcus aureus* has been reported (55).

Antioxidant effects: The methanolic leaf extract of *N. khasiana* displayed strong antioxidant properties in 2, 2-diphenyl-1-picrylhydrazyl (DPPH), superoxide anion, and hydroxyl radical scavenging activity (44). Thanh et al. (48) reported that *Nephenthes* contain a flavonoid which is responsible for anti-oxidant activity. *Nepenthes* plant extracts have antioxidant activity (46) Antioxidant properties of the pure compounds isolated from branches and leaves of *N. mirabilis* were studied for their peroxyl radical scavenging and reducing capabilities. Compounds such as nepenthones F, droserone, nepenthone C, cisisoshinanolone, quercetin, quercetin 3-O-β-D-glucuronide, quercitrin, kaempferol-3-O-α-L-rhamnoside, and (-)-epicatechin were found to exhibited strong peroxyl radical scavenging activities in a dosedependent manner at 1.0 and 10.0 μM concentrations (48). Choosawad et al. (56) reported the antioxidant activity of *Utricularia aurea*.

Antidiabetic effects: A study was conducted on the hypolipidemic and hypoglycemic potential of *N. khasiana* extract in insulin resistance and dexamethasone-induced hyperlipidemia in laboratory rats. At a dosage level of 250 and 500 mg/kg, methanolic extract of *N. khasiana* pitcher actively prevented the increase in the level of cholesterol, glucose, triglyceride, low density lipoprotein with progressive decreased in both high-density lipoprotein, and body weight triggered by dexamethasone on tested rats (43). Hypoglycemic property of methanolic leaf extract of *N. bicalcarata* was reported in the alloxan diabetic induced rats. A dose of 300 mg/kg body weight showed a significant decrease in blood glucose level in a time-dependent manner (46).

Anti-inflammatory effects: Some compounds isolated from branches and leaves methanolic extract of *N. mirabilis* showed anti-inflammatory activities. 2-methoxy -7-methyljuglone inhibited the production of interleukin (IL-12) p40, IL-6, and tumor necrosis factor (TNF-α). The active compound, nepenthoside B exhibited strong inhibition of IL-12 p40, and IL-6 production. Likewise, the inhibition of IL- 12 p40 by naphthalene derivatives (nepenthoside A, nepenthoside B, nepenthone C, nepenthone F, nepenthone G, cis-isoshinanolone, droserone, 2-methoxy-7-methyljuglone, and plumbagin), phenolic compounds [(–)-heimiol A, 4-hydroxy-2,6-dimethoxyphenyl 6`- O- vanilloyl-β-D-glucopyranoside, koaburaside, leonuriside A, and syringaresinol], lupeone, and flavonoids (quercetin, (–)-epicatechin, quercetin 3-O-β-D- and glucuronide) was more effective than positive control. However, these bioactive compounds showed no or little inhibitory properties on TNF-α production in lipopolysaccharides stimulated bone marrow-derived dendritic cells (57). Some insectivorous plants of India and their uses and their co-relation with bioactive compounds for future drug development to fight against antimicrobial resistance have been enlisted by Kumar (58).

Case study 5: Aquatic plants

Aquatic plants have many unique biological features and are potential for their agricultural, nutraceutical and medicinal importance. Many plant species under aquatic origin were reported to have valuable folklore utilization in traditional medicine (59). Aquatic and wetland angiosperms are very remarkable forms of plant life and they provide livelihoods for the millions of people who live within and around them. Economically a large number of

aquatic plants are useful for their medicinal as well as food value to the human being. Man utilized the plant parts like rhizome, roots, fruits, leaves, etc. in various ways and also for the treatment of various ailments (60, 61, 62).

Ethnobotacinal uses of aquatic plants:

Many plant species under aquatic origin were reported to have valuable folklore utilization in traditional medicine (59). *Pistia stratiotes* and *Eichhornia crassipes* are medicinal plants known from the ancient system of Indian medicine and used in Ayurveda. *Nymphaea caerulea* is used in traditional medicine to treat diabetics, cardiotonic for palpitation of heart, and liver disorders (63, 64).

Pharmacological uses of aquatic plants:

Aquatic plants produce a variety of compounds such as flavones, flavonoids, flavonols, phenolic polyphenols, quinones, tannins, coumarins, terpenoids, essential oils, alkaloids, lectins, and polypeptides (65). These substances are used for developing new antimicrobial, antiviral anti-angiogenesis, and anticancerous drugs (66, 67, 68).

Anti-convulsing activity: Herbal drugs have been used in various traditional medicines for the treatment and management of epilepsy, due to the avoidance of associated side effects and dependency development which was caused by prolonged use of other prescribed synthetic drugs (69). *N. indica* and *N. macrospermum* showed anticonvulsant activities and possess the same mechanism as benzodiazepines, phenobarbitone, felbamate, etc., by inducing the delayed onset and discontinuation of seizures and the rapid recovery without any toxicity report after consumption. *N. indica* is known to be effective against petitmal and grandmal type of epilepsy, which is confirmed by investigating the anticonvulsant effect using aqueous and alcohol extract of their roots and rhizomes by maximum electroshock convulsion and pentylenetetrazole induced convulsion methods in Swiss albino mice (70). *N. macrospermum* was also reported to be effective against the petitmal type of epilepsy and it was found that the alcohol extract of *N. macrospermum* at doses of 500 mg/kg and 750 mg/kg bodyweight, extremely diminished the severity and increased the latency of convulsions in the pentylenetetrazole induced seizure model (71).

Sedative activity: Antiepileptics are generally consumed with other anxiolytic drugs. As majority of antiepileptic drugs have to be consumed constantly, concomitant administration of other drugs induces the risk of drug interaction. By considering these factors, researchers are now interested in compounds from plant origin for developing anxiolytic drugs with minor side effects. *N. macrospermum* is considered as the potential source of such traditional drugs formulation, e.g. Tagara. It has antiepileptic properties and was found to provide sedative effect investigated by a significant reduction in locomotor activity in Swiss albino mice which was studied by using an actophotometer. The alcohol extract of *N. macrospermum* up to a dose of 750 mg/kg body weight caused central nervous system depression which was indicated by a reduction in locomotor activity without inducing any toxicity, therefore it is reported that it has no acquired side effect (71, 72).

Antioxidant activity: Medicinal plants have always been recognized as a potential source of natural antioxidants from an ancient period of times. Among Nymphoides species, *N. hydrophylla* and *N. indica* are reported to have antioxidant property. *N. indica* is claimed to possess moderate antioxidant activity. Recent study indicated that the ethyl acetate extract of *N. indica* leaf fractions presented better antioxidant potential determined by 2, 2-diphenyl-1-picrylhydrazyl (DPPH) scavenging activity. It can be suggested that the ethanolic extract of *N. hydrophylla* has significant antioxidant activity compared to other extracts (73). The comparative study of the ethanolic and aqueous extract of *N. hydrophylla* were performed in another study, where it was found that the ethanolic extract exhibited higher antioxidant activities than the aqueous extract in the anti-lipid peroxidation, reducing power, metal chelation, and 2, 2-azino-bis (3-ethylbenthiazoline-6-sulfonic acid) or ABTS radical scavenging assays, whereas the aqueous extract possessed more potent activity in the superoxide and DPPH radical scavenging assays (74). The crude methanolic extract of *N. hydrophylla* was also examined in another study for possible antioxidant activity, where the total phenolic content in leaves of *N. hydrophylla* extract was found to be 12.5 mg of gallic acid equivalent (GAE)/g of extract indicating the moderate antioxidant activity (73). Chung et al. (75) isolated and tested the anti-Inflammatory and antioxidant components from the plant which showed significant activity from *Hygroryza aristate*. Leaves of *Glinus oppositifoilus* show antipyretic property (76).

Hepatoprotective activity: Plant extract having antioxidant activities also leads to the inhibition of oxidative damage to a targeted tissue. Considering such antioxidant potential, the *in vivo* hepatoprotective effect of *N. hydrophylla* was measured against the carbon tetrachloride (CCl_4) induced liver injury in albino rats. It was demonstrated that the ethanolic whole plant extract of *N. hydrophylla* reduced the increased levels of biochemical parameters, like serum glutamate pyruvate transaminase, serum glutamate oxaloacetate transaminase, alkaline phosphatase and bilirubin, etc. As indicated in CCl_4 induced hepatotoxicity and following histopathological studies, it was reported that the ethanolic extract of *N. hydrophylla* produced impressive hepatoprotective activity without any necrosis and sinusoidal dilatations resembling to the standard _Silymarin' group. Simultaneous treatment of ethanolic extract with CCl_4 was found to produce lower hepatic damage in contrast to the animals treated with CCl_4 alone which caused hepatotoxicities, like macro and micro vesicular fatty infiltration, necrosis, sinusoidal dilatation and congestion of central vein etc. It was suggested that the possible mechanism of such hepatoprotective action exhibited by *N. hydrophylla* could be the lipid peroxidation inhibition and free radicals scavenging effects (74).

Cytotoxic activity: Cytotoxic screening of plants is the preliminary method that seems to be capable of detecting natural anti-carcinogenic agents present in crude extracts. According to the literature, the leaf of *N. hydrophylla* was found to be cytotoxic which was investigated by using brine shrimp lethality bioassay, where the result showed that the crude methanolic extract of leaves of *N. hydrophylla* had significant cytotoxic activity. Through performing this general bioassay, it can be considered that such valuable species of Nymphoides genus can be the potential source of anticancer compounds (77, 78). Sulphated polysaccharide

compounds isolated from *Alternanther aphiloxeroides* show significant *in vitro* anti-HIV activity (79). *Cyathocline purpurea* contains sesquiterpene lactones which show anticancer activity (80).

Antitumor activity: Most antitumor drugs are generally encountered through plant derived compounds or their derivatives. Currently, few Nymphoides species are accounted for its antitumor activity. Among them, *N. peltata*, the common wetland plant, exhibited significant antitumor activity. Based on the phytochemical study, the proposed antitumor effect of *N. peltata* extract is thought to be due to the presence of the four major antitumor constituents, i.e. ephedrine, ephedradine C, 4-hydroxycoumarin and delta-1- dihydrotanshinone (81). The aqueous extract of *N. indica* was also reported to have higher anti-proliferative activity on HeLa cell line (82).

Antimicrobial activity: Aquatic medicinal plants have always been considered as potential sources for investigating antimicrobial properties which are intended for new drug development (83). The antimicrobial effects of such aquatic *N. indica* species were reported to be carried out through *in vitro* antimicrobial assay in an integrated screening panel. In this study, it was observed that the n-hexane fraction of *N. indica* leaf extract showed the highest levels of antimicrobial and antifungal activities against *Staphylococcus aureus* and *Microsporum canis*, and it was claimed that the isolated lipophilic constituents from that n-hexane fraction showed moderate antimicrobial activities among which the isolated compound, azelaic acid was highly active against *Staphylococcus aureus*. The 90% methanolic fraction of *N. indica* extract was also found to be active against *Staphylococcus aureus* (73). The extracts of *Acorus calamus* have been found to possess an antibacterial activity. Bhuvaneswari and Balasundaram (84) reported that the BetaAsarone fraction of the rhizome has stronger antibacterial activity. Su et al. (85) reported the potent antiproliferative effect of *C. minima* on nasopharyngeal carcinoma cells.

Antiparasitic effect: There are numerous medicinal plants known to be used as potent antiparasitic agent which are still under investigation for the development of novel antiparasitic drug. Nymphoides species are reported to have various antiparasitic properties, like antiprotozoal, antimalarial and anthelmintic, etc. An experiment reported that the isolated lipophilic constituents and the flavonoid i.e. 3, 7-DiO-methyl quercetin-4'-O-β-glucoside from *N. indica* leaf extract showed antiprotozoal activities against *Trypanosoma brucei*, *Leishmania infantum* and *Trypanosoma cruzi*. Azelaic acid, the lipophilic compound isolated from *N. indica* leaf extract also showed weak antiplasmodial activity against *Plasmodium falciparum* K1 (73). The crude methanolic leaf extracts of *N. hydrophylla* is reported to exhibit significant anthelmintic property against *Pheritima posthuma* earthworm in a dose-dependent manner, where the results were expressed in terms of time for paralysis and time for death of worms (77).

Overview of techniques involved in herbal drug formulation

Screening for herbal decoction can be done by randomised method or by selecting plants known to be effective against diseases. Standardisation of therapeutic metabolites from

crude cellular extracts forms the preliminary step of drug preparation. The development of chromatographic and spectroscopic techniques has given a huge boost to medicinal plant research. However, these classical techniques are often challenged with problems of reproducibility and quality assurance. Hence modern throughput techniques like microwave-assisted extraction, pressurized liquid extraction, and several others and study of metabolite pharmaco-dynamics are being targeted (86, 87). Research based on pharmacopoeial guidelines have seen the application of sophisticated instrumentations such as HPLC, HPTLC, GC, Supercritical Fluid Chromatography, Near-Infrared Spectroscopy, NMR, MALDI-MS and a combination of analytical techniques with metabolomic analysis. Understanding the immensely diversified secondary metabolites occurring in nature, preparation of molecular models and chemical analogues and well assessed clinical trials are hugely facilitated by multivariate analysis software – the domain of metabolomics.

Conclusion and Future prospects

History has witnessed a dependence on therapeutic plants by humans since time immemorial. Simultaneously development has occurred in herbal drug preparation ranging from organoleptic analysis to modern day advanced instrumental techniques. The aim is to develop effective and adulterant free high quality herbal medicines. Plants such as *Catharanthus, Ocimum, Rauvolfia, Tylophora, Podophyllum, Artemisia, Withania, Nicotiana, Bacopa, Aloe* are few of the ones which have received the attention resulting in their exploitation and near to extinct condition. Nature has gifted us with a plethora of medicinal plants many of which are either unexplored or even though used traditionally are now largely forgotten. Many varieties of medicinally important plants including cacti and aquatic ones have simple growth requirements. Orchids once cultivated can serve the dual purpose of aesthetics and therapeutics while carnivorous plants have received minimal focus. This review has presented a comprehensive report of medicinal properties of the above mentioned group of plants while touching upon the trends in analytical research. The future beholds immense possibilities in this field. Nanoparticle mediated herbal drug formulation and deliveries, detection of adulteration based on DNA barcoding, online search engine optimization are few such instances. The best practices focus on economizing cost and time while effectively and sustainably exploiting the treasure of medicinal plants.

References :

1. Fitzgerald, M., Heinrich, M., Booker, A (2020). Medicinal plant analysis: a historical and regional discussion of emergent complex techniques. *Frontiers in Pharmacology*, 10, 1480.
2. Kurashov, E. A., Krylova, J. V., Mitrukova, G. G., Chernova, A. M. (2014). Low molecular-weight metabolites of aquatic macrophytes growing on the territory of Russia and their role in hydroecosystems. *Contemporary Problems in Ecology*, 7, 433-448.
3. Li, Y. X., Pan, Y. G., He, F. P., Yuan, M. Q., Li, S. B. (2016). Pathway analysis and metabolites identification by metabolomics of etiolation substrate from fresh-cut Chinese water chestnut (*Eleocharis tuberosa*). *Molecules* 21, 1648.
4. Halder, M., Jha, S. (2020) Morphogenesis, genetic stability, and secondary metabolite production in untransformed and transformed cultures. In: Ramawat K, Ekiert H, Goyal S (eds) Plant cell and tissue differentiation and secondary metabolites. Reference Series in Phytochemistry. Springer, Chambridge.

5. Pagare, S., Bhatia, M., Tripathi, N., Pagare, S., Bansal, Y. K. (2015). Secondary metabolites of plants and their role: overview. *Current Trends in Biotechnological Pharmacy*, 9, 293-304.
6. Liebelt, D. J., Jordan, J. T., Doherty, C. J. (2019). Only a matter of time: The impact of daily and seasonal rhythms on phytochemicals. *Phytochemical Review*, 18, 1409-1433.
7. War, A. R., Paulraj, M. G., Ahmad, T., Buhroo, A. A., Hussain, B., Ignacimuthu, S. (2012). Mechanisms of plant defense against insect herbivores. Plant Signalling Behaviour, 7, 1306 - 1320.
8. Bartwal, A., Mall, R., Lohani, P., Guru, S. K., Arora, S. (2013). Role of secondary metabolites and brassinosteroids in plant defense against environmental stresses. *Journal of Plant Growth Regulation*, 32, 216-232.
9. Nandagopal, K., Halder, M., Dash, B., Nayak, S., Jha, S. (2018). Biotechnological approaches f or production of anti-cancerous compounds resveratrol, podophyllotoxin and zerumbone. *Current Medical Chemistry*, 25, 4693–4717.
10. Rathore, H., Prasad, S., Kapri, M., Tiwari, A., & Sharma, S. (2019). Medicinal importance of mushroom mycelium: Mechanisms and applications. *Journal of Functional Foods*, 56, 182–193.
11. Wani, B.A., Bodha R. H., Wani A. H. (2010) Nutritional and medicinal importance of mushrooms. *Journal of Medicinal Plant Research*, 4(24), 2598-2260.
12. Gunde, C. N., (1999) Medicinal value of the Genus *Pleurotus* (Fr.) P. Karst. (Agaricales s.l., Basidiomycetes. *International Journal of Medicinal Mushrooms*, 1, 69-80.
13. Wasser S. P. (2017). Medicinal mushrooms in human clinical studies. part i. anticancer, oncoimmunological, and immunomodulatory activities: a review. *International Journal of Medicinal Mushrooms*, 19(4), 279–317.
14. Shetty, A. A.; Rana, M. K. and Preetham, S. P. (2012). Cactus: A medicinal food. *Journal of Food Science and Technology*, 49(5):530-536
15. Wallace, Gibson A. C. (2002). Evolution and systematics. In: Cacti: Biology and Uses. Eds: Nobel PS, University of California Press Berkeley-Los Angeles-London, 1-21.
16. Camacho-Chab, J., Lango-Reynoso, F., Castañeda-Chávez, M., Galaviz-Villa, I., Hinojosa Garro, D. and Ortega-Morales, B. (2016). Implications of extracellular polymeric substance matrices of microbial habitats associated with coastal aquaculture systems. *Water*, 8(9):369.
17. Harlev, E., Nevo, E., Mirsky, N. and Ofir, R. (2013). Cancer preventive and curative attributes of plants of the Cactaceae family: A Review. *Planta Medica*, 79:713–722.
18. Fernández-López, J. A., Almela, L., Obón, J. M., Castellar, R. (2010). Determination of antioxidant constituents in cactus pear fruits. *Plant Foods for Human Nutrition*, 66(3):253-259.
19. Chougui, N., Tamendjari, A., Hamidj, W., Hallal, S., Barras, A., Richard, T., & Larbat, R. (2013). Oil composition and characterisation of phenolic compounds of *Opuntia ficus-indica* seeds. *Food chemistry*, 139(1-4), 796-803.
20. Rebah, F. B., Siddeeg, S. M. (2017). Cactus an eco-friendly material for wastewater treatment: A review. *Journal of Materials and Environmental Sciences* 8(5): 1170-1182.
21. Loro, J. F., Del Rio, L, Perez-Santana, L. (1999). Preliminary studies of analgesic and anti-inflammatory properties of *Opuntia dillenii* aqueous extract. *Journal of Ethnopharmacology*, 67(2):213-218.
22. Park E.H., Kahng J.H., Lee S.H., Shin K.H. (2001). An antiinflammatory principle from cactus. *Fitoterapia*, 72:288-290
23. Allegra, M., Ianaro, A.; Tersigni, M.; Panza, E.; Tesoriere, L., Livrea, M.A., (2014). Indicaxanthin from cactus pear fruit exerts anti-inflammatory effects in carrageenin-induced rat pleurisy. *Journal of Nutrition* 144, 185–192.
24. Chase M.W., Cameron K.M., Freudenstein J.V., Pridgeon A.M., Salazar G., Berg C., Schuiteman A. (2015). An updated classification of Orchidaceae. Botanical Journal of the Linnean Society. Vol. 177. P. 151-174 Willis K.J. (2017). State of the World's Plants. Report. London: Royal Botanic Gardens, Kew.
25. Willis K.J. (2017). State of the World's Plants 2017 Report. London: Royal Botanic Gardens, Kew
26. White K, Sharma B. (2000). Wild orchids in Nepal: the guide to the Himalayan orchids of the Tribhuvan Rajpath and Chitwan Jungle: Bangkok, Thailand: White Lotus Co Ltd; 12, 307.
27. Sazak, A., Ozender, Y. (2006). Symbiotic and asymbiotic germination of endangered *Spiranthes spirales* (L.) Chavell. and *Dactylorhiza osmanica* (Kl.) SoA3 var. *Osmaica* (Endemic). *Pakistan Journal of Biological Sciences*, 9, 2222-2228.
28. Joshi, G., Tewari, L. M., Lohani, N., Upreti, K., Jalal, J. S., Tewari, G. (2009). Diversity of orchids on Uttarakhand and their conservation strategy with special reference to their medicinal importance. *Reports and Opinions*, 1, 47-52.
29. Khasim, S., Rao, P. R. M. (1999). Medicinal importance of orchids. *The Botanica*, 49, 86-91
30. Kasulo, V., Mwabumba L., Munthali, C. (2009). A review of edible orchids in Malawi. *Journal of Horticulture and Forestry*, 1(7),133-139.
31. Singh, S., Singh, A.K., Kumar, S., Kumar, M., Pandey, P.K., Singh, M.C.K., (2012). Medicinal properties and uses of orchids: A concise review. *Applied Botany*. 52, 11627-11634
32. Debnath P. (2020). Bioactive molecules present in orchids and its medicinal properties: an overview. *International Journal of Research in Ayurveda and Pharmacy*, 11 (3).

33. Gale S.W., Fischer G.A., Cribb P.J., Fay M.F. (2018). Orchid conservation: Bridging the gap between science and practice // Botanical Journal of the Linnean Society. Vo l. 186 . P. 425–434

34. Fay M., Rankou H. (2016). Slipper orchids on the IUCN Red List // 2015 Annual Report to the Environment Agency-Abu Dhabi. Framework Support for Implementing the Strategic Plan of the IUCN Species Survival Commission. Abu Dhabi, UAE. P. 106- 111

35. Fleischmann, A. 2012. The new Utricularia species described since Peter Taylor's Monograph. *Carnivorous Plant Newsletter*, 41, 67 – 76.

36. Dash, P. K. (2016). Carnivorous plants of Odisha. Odisha Biodiversity Board, Bhubaneswar

37. Singh, P., and Sanjappa, M. (2011). Flowering plants of Sikkim - An analysis. In: Biodiversity of Sikkim - Exploring and Conserving a Global Hotspot. Arrawatia, M.L., and Tambe, S. (eds.). Department of Information and Public Relations, Government of Sikkim, Gangtok. 65-88

38. Zaman, M., Naderuzzaman, A.T.M., Hasan, M., and Naz, S. (2011). Ecology, morphology and anatomy of Aldrovanda vesiculosa L. (Droseraceae) from Bangladesh. *Bangladesh Journal of Botany*, 40(1): 85-91

39. Kamble, M.V., Harikrishnan, S., Balakumar, P. (2012). *Utricularia caerulea* (Lentibulariaceae): a new record to flora of Andaman & Nicobar Islands. *Rheedea* 22(2): 116-118.

40. Raju A, Christina AJM (2013) *Drosera burmanii* Vahl: antioxidant potential in Dalton's Ascites Lymphoma (DAL) bearing Mice. *Journal of Medicinal Plants Studies* 1(4):152–159.

41. Vaidyanathan, D., Senthilkumar, M. S. S., Basha, M. G. (2013). Studies on ethnomedicinal plants used by Malayali tribals in Kolli hills of Eastern Ghats, Tamil Nadu, India. *Asian Journal of Plant Science Research*, 3(6), 2249–7412

42. Rao JK, Manikyam P, Reddi TVVS (2011) Some interesting indigenous beverages among the primitive tribal groups of Visakhapatnam district, Andhra Pradesh. *Journal of Non Timber Forest Products*, 18(2), 153–156.

43. Shil, D., Mohanty, J. P., Saleem, T. S., Debnath, J., Uriah, T. (2014). Anti-diabetic activity of leaf extract of *Nepenthes khasiana* hook on dexamethasone induced diabetic rats. *Journal of Pharmaceutical Chemical and Biological Sciences*, 1(1), 6-11.

44. Tiewlasubon, U., Mrityunjaya, B. P., Sivaiah, K. (2015). In vitro antioxidant and hepatoprotective potential of Nepenthes Khasiana Hook. F against ethanol-induced. *Journal of Pharmaceutical Research*,14(4), 81-89.

45. Ramashankar, Deb S, Sharma BK (2015) Traditional healing practices in North East India. Indian *Journal of Historical Science* 50(2), 324–332.

46. Ismail, N. A., Kamariah, A. S., Lim, L. B., Ahmad, N. (2015). Phytochemical and pharmacological evaluation of methanolic extracts of the leaves of Nepenthes bicalcarata Hook. F. *International Journal of Pharmacognosy and Phytochemical Research*,7(6), 1127-1138.

47. Schwallier, R., De Boer, H. J., Visser, N., Van Vugt, R.R., Gravendeel, B. (2015). Traps as treats: A traditional sticky rice snack persisting in rapidly changing Asian kitchens. *Journal of Ethnobiology and Ethnomedicine*, 11, 24.

48. Thanh NV, Thao NP, Dat le D, Huong PT, Lee SH, Jang HD, et al. (2015). Two new naphthalene glucosides and other bioactive compounds from the carnivorous plant Nepenthes mirabilis. Arch Pharm Res;38(10):1774-82.

50. Aung, H. H., Chia, L. S., Goh, N. K., Chia, T. F., Ahmed, A. A., Pare, P. W., (2002). Phenolic constituents from the leaves of the carnivorous plant *Nepenthes gracilis*. *Fitoterapia*, 73(5):445-447.

51. Shin KS, Lee S, Cha BJ. (2007). Suppression of phytopathogenic fungi by hexane extract of *Nepenthes ventricosa* x *maxima* leaf. *Fitoterapia*,78(7-8), 585-586.

52. Divakar, M. C., John, J., Vyshnavidevi, P., Anisha, A. S., Govindum, V. (2013). Herbal remedies of Madayipara hillock tribals in Kannur district, Kerala, India. *Journal of Medicinal Plant Studies*, 1(6), 34 – 42.

53. Buch, F., Rott, M., Rottloff, S., Paetz, C., Hilke, I., Raessler, M., Fer, A.M. (2013). Secreted pitfa ll-trap fluid of carnivorous *Nepenthes* plants is unsuitable for microbial growth. *Annals of Botany* 111, 375–383

54. Bhau, B. S., Ghosh, S., Puri, S., Borah, B., Sarmah, D. K., Khan, R. (2015). Green synthesis of gold nanoparticles from the leaf extract of Nepenthes khasiana and antimicrobial assay. *Advanced Material Letters*, 6(1), 55–58.

55. Majeed, S., Mahmad, A., Rani, N. N. I. B. M. (2016). Biosynthesis of silver nanoparticles using Nepenthes spp. and its bactericidal effect. *Der Pharma Chemica* 8 (19), 279–282.

56. Choosawad, D., Leggat, U., Dechsukhum, C., Phongdra, A., Chotigeat, W. (2005). Anti-tumor activities of fucoidan from the aquatic plant Utricularia aurea Lour. Songk Journal of Science and Technology, 27(3), 799–807.

57. Thao, N.P., Luyen, B.T., Koo, J.E., Kim, S., Koh, Y. S., Thanh, N. (2015). *In vitro* antiinflammatory components isolated from the carnivorous plant *Nepenthes mirabilis* (Lour.) Rafarin. Pharmaceutical Biology, 17, 1-7.

58. Kumar, S., Thorat, S., Labala, R., Patra, J. K. (2018). Insectivorous Plants of India: Sources of Bioactive Compounds to Fight Against Antimicrobial Resistance. In book: Microbial Biotechnology pp.305-318.

59. Zhang Y, Xu HL, Chen H, Wang F, Huai HY. (2014) Diversity of wetland plants used traditionally in China: A literature review. *Journal of Ethnobiology and Ethnomedicine*, 10(72), 1 -18.

60. Bhunia, D., A.K. Mondal. (2009). The exploration of aquatic wetland plants of Paschim Midnapur district of West Bengal. Ecology and Environment, 27, 64-70.

61. Shankar, L.H., P.K. Mishra. (2012). Study of aquatic medicinal plants of Hazaribag district of Jharkhand, India. *International Research Journal of Pharmacy*, 3(4), 405 -409.

62. Pareek, A., & Kumar, A. (2014). Nutraceutical value of aquatic plants. *Medical Science*, 5(17), 42-50.

63. Selvakumari, S., Arcot, S. (2010). Andiabetic activity of *Nymphaea pubescens*Willd-a plant drug of aquatic flora interest. *Journal of Pharmaceutical Research*, 3, 3067-3069.

64. Prasad, K. S., Savithramma, N. (2016). Screening of phytochemical constituents of *Nymphaea caerulea* Savigny. An aquatic plant resource for drug development. *American Journal of Advanced Drug Delivery*, 4, 45-54.

65. Březinová, T. D., Vymazal, J. (2018). Phenolic compounds in wetland macrophytes. *Scientia Agriculturae Bohemica*, 49, 1-8.

66. Subramanian, U., Kishorekumar, M. S., Muthuraman, S., Munusamy, A. P., Sundaram, R. (2018). Marine algal secondary metabolites promising antiangiogenesis factor against retinal neovascularization in CAM model. *Research and Reviews: A Journal of Life Sciences*, 8, 19 -25.

67. Buyel, J. F. (2018). Plants as sources of natural and recombinant anti-cancer agents. Biotechnology Advances, 36, 506-520.

68. Kumari, V., Kaushal, K., Sharma, A. K., Mishra, R. C., Soni, P. (2018). Some phytochemicals found in medicinal plants used in cancer: A review. *Medical Chemistry* (Los Angeles), 8, 423-425.

69. Kumar, S., Madaan, R., Bansal, G., Jamwal, A., Sharma, A. (2012). Plants and plant products with potential anticonvulsant activity - A review. Pharmacognosy Communication, 2(1), 3-99

70. Madhavan V, Arora S, Murali A, Yoganarasimhan SN. (2009). Anti-convulsant activity of aqueous and alcohol extracts of roots and rhizomes of *Nymphoides Indica* (L.) O. Kuntze, in Swiss Albino mice. *Journal of Natural Remedies*, 9(1), 68-73.

71. Murali, A., Sudha, C., Madhavan, V., Yoganarasimhan, S. N. (2007). Anticonvulsant and sedative activity of Tagara (*Nymphoides macrospermum*). *Pharmaceutical Biology*, 45(5), 407-410.

72. Rout SK, Kar DM. (2013). Sedative, anxiolytic and anticonvulsant effects of different extracts from the leaves of *Ipomoea carnea* in experimental Animals. *International Journal of Drug Development Research*, 5(2), 232-243.

73. Amin, A., Tuenter, E., Exarchou, V., Upadhyay, A., Cos, P., Maes, L. (2016). Phytochemical and pharmacological investigations on *Nymphoides indica* leaf extracts. *Phytotherapy Research*, 30, 1624-1633.

74. Ko HJ, Huang SH, Ng LT. (2014). Chemical compositions and antioxidant activities o f a specialty aquatic vegetable *Nymphoides hydrophylla* in Taiwan. *Journal of Aquatic Food Product Technology*,23(6), 591-600.

75. Chung YM, Lan YH, Hwang TL, Leu YL (2011). Anti-Inflammatory and Antioxidant Components from Hygroryzaaristata. *Molecules*, 16: 1917 -1927.

76. Sahakitpichan P, Disadee W, Ruchirawat S, Kanchanapoom T (2010). L-(−)-(N-transCinnamoyl)-arginine, an Acylamino Acid from *Glinus oppositifolius* (L.) Aug. DC. *Molecules*, 15, 6186-6192.

77. Moghal MMR, Foysal KA, Haque MM, Kader MA, Hossain MS, Mogumder S. (2013). In vitro study of cytotoxic, anthelmintic and antioxidant activities of *Nymphoides hydrophylla*. *International Journal of Pharmacy and Phytopharmacology Research*, 2(5), 328-331.

78. Nemati. F., Dehpouri, A. A., Eslami, B., Mahdavi, V., Mirzanejad, S. (2013). Cytotoxic properties of some medicinal plant extracts from mazandaran, Iran. *Iran Red Crescent Medical Journal*, 15(11), 1-4.

79. Lewis, W. H., Lewis, M. P. F. E. (2003). Medical Botany: Plants affecting human health. Wiley Publishers, New Jersey, p.112.

80. Ma G, Chong L, Li Z, Cheung AH, Tattersall MH (2009). Anticancer activities of sesquiterpene lactones from *Cyathocline purpurea* in vitro. *Cancer Chemotherapy and Pharmacology*, 64(1), 143-152.

81. Dua, Y., Wanga, R., Zhanga, H., Liu, J. (2014). Antitumor constituents of the wetland plant Nymphoidespeltata: A case study for the potential utilization of constructed wetland plant resources. *Natural Product Commune*, 10(2), 233-236.

82. Manosroi, J., Boonpisuttinant, K., Manosroi, W., Manosroi, A. (2012). Antiproliferative activities on HeLa cancer cell line of Thai medicinal plant recipes selected from MANOSROI II database. *Journal of Ethnopharmacology*, 142(2), 422-431.

83. Rossi, C. C., Aguilar, A. P., Diaz, M. A., Ribon, A. O. (2011). Aquatic plants as potential sources of antimicrobial compounds active against bovine mastitis pathogens. African Journal of Biotechnology, 10(41), 8023-8030.

84. Bhuvaneswari, R., Balasundaram, C. (2009). Anti-bacterial activity of *Acorus calamus* and some of its derivates against fish pathogen *Aeromonas hydrophila*. *Journal of Medical Plants Research*, 3(7), 538-547.

85. Su, M., Li., Y., Chung, H. Y., Ye, W. (2009). 2β-(Isobutyryloxy) florilenalin, a Sesquiterpene Lactone Isolated from the Medicinal Plant *Centipeda minima*, induces apoptosis in Human Nasopharyngeal Carcinoma CNE Cells. *Molecules*, 14: 2135 -2146.

86. Wu, W., Liang, Z., Zhao, Z., Cai, Z. (2007). Direct analysis of alkaloid profiling in plant tissue by using matrix-assisted laser desorption/ionization mass spectrometry. *Journal of Mass Spectrometry*, 42 (1), 58–69.

87. Mukhtar, M., Arshad, M., Ahmad, M., Pomerantz, R. J., Wigdahl, B., Parveen, Z. (2008). Antiviral potentials of medicinal plants. *Virus Research* 131, 111 –120.

88. Ndungutse, V., Mereddy, R., & Sultanbawa, Y. (2015). Bioactive properties of mushroom (*Agaricus bisporus*) stipe extracts. *Journal of Food Processing and Preservation*, 39(6), 2225-2233.

89. Han, C., & Cui, B. (2012). Pharmacological and pharmacokinetic studies with agaricoglycerides, extracted from Grifola frondosa, in animal models of pain and inflammation. *Inflammation*, 35(4), 1269-1275.

90. Fan, L., Zhang, S., Yu, L., & Ma, L. (2007). Evaluation of antioxidant property and quality of breads containing *Auricularia auricula* polysaccharide flour. *Food Chemistry*, 101(3), 1158-1163.

91. Yuswan, M. H. M. Y., Al-Obaidi, J. R., Rahayu, A., Sahidan, S., Shazrul, F., Fauzi, D. (2015). New bioactive molecules with potential antioxidant activity from various extracts of wild edible Gelam mushroom (*Boletus* spp.). *Advances in Bioscience and Biotechnology*, 6(04), 320.

92. Rathee S, Rathee D, Rathee D et al (2012) Mushrooms as therapeutic agents. *Brazilian Journal of Pharmacognosy*, 22 (2), 459–474.

93. Han, J., Chen, Y., Bao, L., Yang, X., Liu, D., Li, S., Liu, H. (2013). Anti-inflammatory and cytotoxic cyathane diterpenoids from the medicinal fungus *Cyathus africanus*. *Fitoterapia*, 84, 22-31.

94. Walton, E. (2014). Buried treasure: unlocking the secrets of medicinal mushrooms. *Biomedical Journal*, 37(6).

95. Dore, C. M. G., Azevedo, T. C., de Souza, M. C., Rego, L. A., de Dantas, J. C., Silva, F. R., Leite, E. L. (2007). Antiinflammatory, antioxidant and cytotoxic actions of β-glucan-rich extract from Geastrum saccatum mushroom. *International Immunopharmacology*, 7(9), 1160-1169.

96. Anonymous, 2016 (http://arunachalforests. gov.in /sessa % 20orchid% 20sanctuary.html)

97. De, L. C., Rao, A.N., Rajeevan, P. K., Promila Pathak and Singh, D. R. (2015). Medicinal and aromatic orchids: an overview; *International Journal of Current Research*, 7(9), 19931 -19935.

98. Hossain, M. M. (2011). Therapeutic orchids: traditional uses and recent advances—an overview. *Fitoterapia*, 82(2), 102-140.

99. Behera, D., Rath, C.C., Mohapatra, U. (2013). Medicinal Orchids in India and their conservation: A review. *Floriculture and Ornamental Biotechnology*. 7(1), 53-59.

100. Panda, A.K., Mandal, D. (2013). The folklore medicinal orchids of Sikkim. *Ancient Science of Life*. 33(2), 92-96.

101. Pankaj, O. (2013). Medicinal Orchid *Nervilia macroglossa* (Hook.f.) Schltr. based herbal formulations used for male impotency in Indian traditional healing. Pankaj Oudhia' s Ethnobotanical Surveys 1990- 2012.

102. Pant, B. (2013). Medicinal orchids and their uses: Tissue culture a potential alternative for conservation. *African Journal of plant science*, 7(10), 448-467.

Table 1: Some biologically active compounds from mushrooms and their medical applications (as reported in the last decade)

Sl. No	Scientific name	Common names	Bioactive compound	Bioactivity	Reference
1	*Agaricus bisporus*	Champignon, Button mushroom, White mushroom	Pyrogallol hydroxybenzoic acid derivatives Flavonoids Grifolin	Anti-inflammatory	88
2	*Agaricus macrosporus*	Macro mushroom	Agaricoglycerides	Anti-inflammatory	89
3	*Auricularia auricula*	Jew's ear, wood ear, jelly ear	Glucan	Hyperglycemia, Immunomodulatory, anti-tumor anti-inflammatory	90
4	*Boletus spp*	Gelam mushroom	2,4,6-trimethylacetophenone imine Glutamyl tryptophan Azatadine lithocholic acid glycine conjugate	Anti-oxidant	91

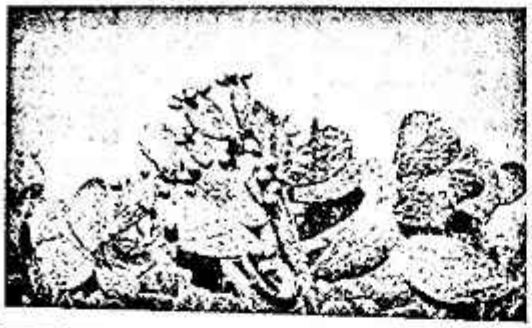
5	*Calvatia gigantea*	Giant puffball	Calvacin	Anti-tumor	92
6	*Cyathus africanus*	Bird's nest fungi	Neosarcodonin, cyathatriol, a	Anti-inflammatory	93
			11-O-acetylcyathatriol		
7	*Ganoderma lucidum*	Reishi, lingzhi, mannentake	Ganoderic acids ganoderiol ganodermanontriol	Anti-tumor, anti-metastasis anti-HIV anti-viral	92, 94
			Ganoderan A and B	Hypoglycemic	
			Ganopoly	Hepatoprotective	
			Triterpenes Lucidenic acids Ganoderic acids Lanostane-type triterpenic acids	Anti-inflammatory	
			Ling zhi-8 (protein)	Immunomodulator	
			Ganodermin (protein)	Antifungal	
			Se-containing protein	Anti-tumor	
8	*Geastrum saccatum*	Rounded earthstar	Polysaccharides (b-glucans)	Anti-inflammatory	95

Table 2: Therapeutic uses of some medicinal orchids as reported in the past decade

Sl. No.	PLANT NAME	PARTS USED	THERAPEUTIC USES	REFERENCES
1	Acampe *carinata*	Roots, Leaves	Root used in acute rheumatism, sciatica, neuralgia, secondary syphilis and uterine diseases. Paste applied externally to treat scorpion and snakebites. Leaf decoction administered orally to get relief chest pain, stomach disorders and acidity	96
2	*Acampe praemorsa*	Roots	Paste applied externally to treat rheumatism and pains and taken orally to cure arthritis	96, 97
3	*Aerides crispum*	-	Extracts in neem oil used for earache	97
4	*Aerides multiflorum*	Leaves, Bulbs, Roots	Leaf paste applied to treat cuts and wounds. Plant parts possess antibacterial properties	97
5	*Aeries odorata*	Roots, Leaves	Root paste relief in pain and cure swelling. Lead juice can control the mild tuberculosis	98
6	*Bletilla striata*	Tuber	Treatment of sores, ulcers and chapped skin, heal wounds, reduce swelling, and promote regeneration of tissue. Have been used to treat pulmonary tuberculosis and as hemostatic agent.	97
7	*Calanthetri plicata*	Roots, flowers, pseudo bulb	Roots are ingredient of local medicine to treat swollen hands and diarrhoea. Flowers as a painkiller in caries, Pseudo bulbs as a masticator, gastrointestinal disorders	97

8	*Coelogyne ovalis*	Whole plant	The whole plant is used in Western and Southern parts of India for cough, urinary infections and eye disorders	97
9	*Cypripedium calceoluspubescens*	Root	Antispasmodic, diaphoretic, hypnotic, nervine, sedative, tonic	97
10	*Cephalanthera longifolia*	Rhizome	Appetizer, tonic and wound healer. Powder used to increase vigour, vitality and to alleviate impotency	96
11	*Coelogyne punctulata*	Pseudobulb	Used in burn injuries and wound	96
12	*Coelogyne nitida*	Pseudo bulb	Juice or juice used to overcome headache, fever and burns	99
13	*Dendrobiumchrysan thenum*	Leaves	Antipyretic, eyes-benefiting, immuno-regulatory purposes, skin diseases	97
14	*Dendrobium longicornum*	Whole plant, Roots	Plant juice used to relieve fever. Boiled roots used to feed livestock suffering from cough.	99
15	*Dendrobium transparens*	Pseudobulbs	Paste used to treat fractured and dislocated bones.	99
16	*Dienia cylindrostachya*	Pseudo bulb	Powder used as tonic	99
17	*Dendrobium densifiorum*	Leaves, Pseudo bulb	Promotes the production of body fluid. Pseudo bulb cures vomiting and quenches thirst. Lowers fever of phlegm. Rejuvenates degenerated power of the digestive system caused due to lack of digestive fluids and loss of appetite. Pulps of the pseudobulbs used in boils, pimples and other skin eruptions. Leaf paste used in fractures bones, sprains and inflammations	96, 99
18	*Oberonia falconeri*	Whole plant	Used in bone fractures	100
19	*Otochilus porrectus*	Whole plant	Used as tonic and also in the treatment of sinusitis and rheumatism	101
20	*Pholidota chinensis*	Pseudo bulbs	Extract used in toothache, stomach ache and inflammation	102

FIG 1: SOME SPECIES OF MEDICINAL CACTI:



Opuntia ficus-indica



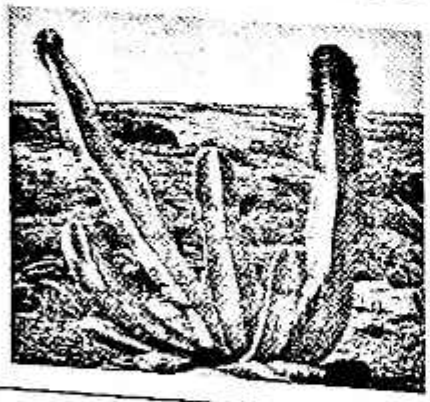
Hylocereus spp.



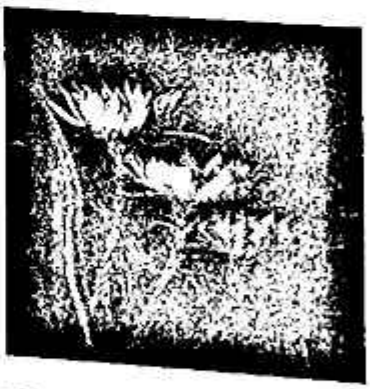
Opuntia lamifusa



P. grandifolia



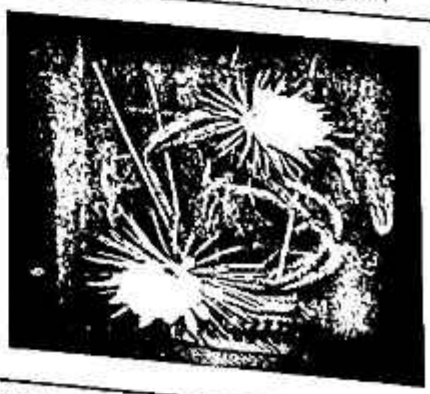
Lophocereus schottii



Peniocereus greggii



Trichocereus pachanoi



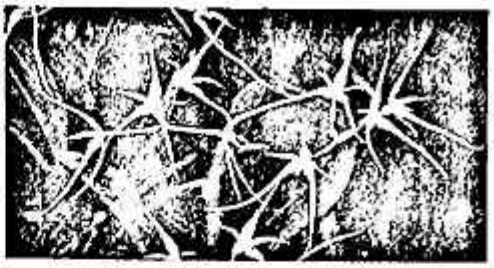
Selenicereus grandiflorus

(Fig. From internet)

FIG 2: SOME SPECIES OF MECINAL ORCHIDS:



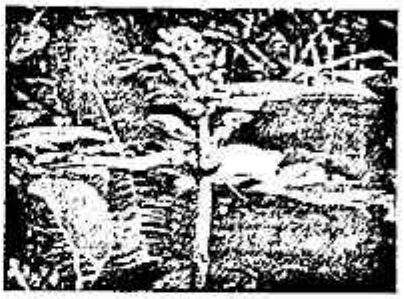
Anoectochilus roxburghii



Bulbophyllum kavangtungense



Dendrobium nobile



Gastrodia elata



Bletilla striata



Coeloglossum viridae



Nidema boothii



Cypripedium macranthos

(Fig. From Internet)

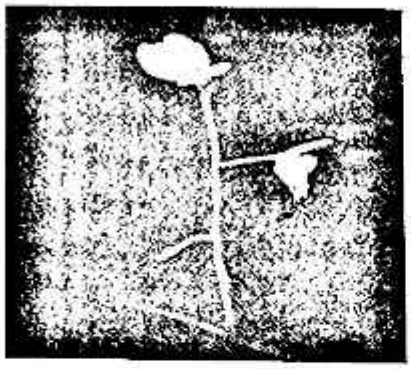
FIG 3: SOME SPECIES OF MECINAL CARNIVOROUS PLANTS:



Drosera burmannii



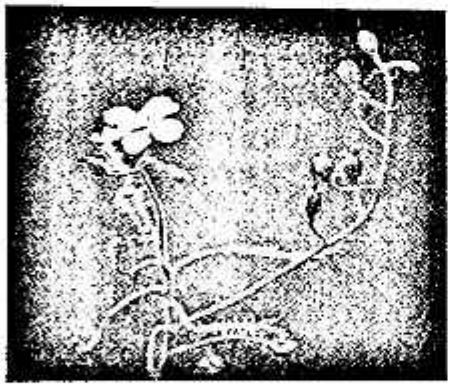
Nepenthes khasiana



Utricularia aurea



Pinguicula alpina



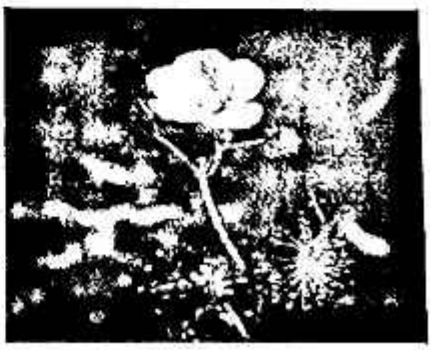
Drosera indica



Utricularia reticulata



Urticularia bifida



Drosera peltata

(Pic. From internet)

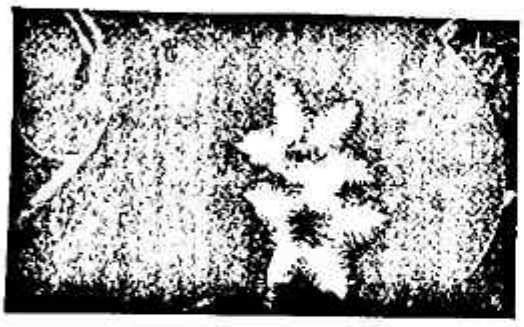
FIG 4 : SOME SPECIES OF MECINAL AQUATIC PLANTS:



Aeschenomene aspera



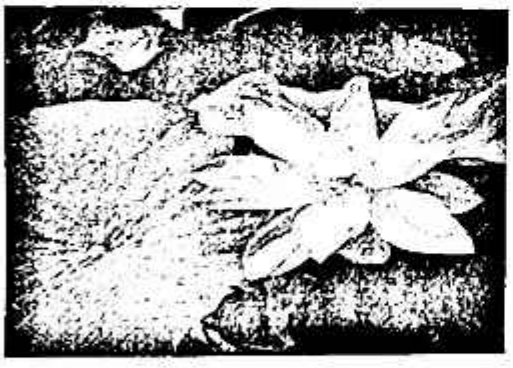
Commelina erecta



Nymphoides indica



Polygonum glabrum



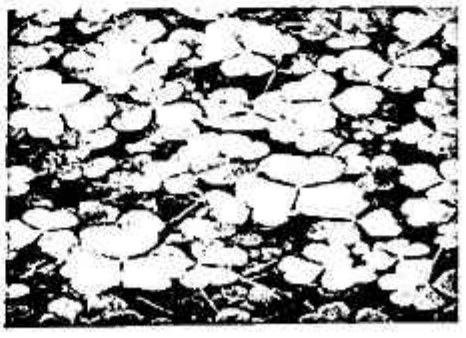
Nelambo nucifera



Sagittaria sagittifolia



Ipomea aquatica



Marsilea quadrifolia

(Fig. From Internet)

Significance of food security and nutrition security as major contributors in sustaining health for all

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Abstract :

For the last few decades, the health of human population is severely getting affected by adversities ranging from the triple burden of malnutrition like undernutrition, micronutrient deficiencies and overnutrition to a wide spectrum of epidemics and pandemics such as life style disorders e.g. obesity, cardiovascular diseases, diabetes, cancer, are causing serious health issues along with ever increasing challenges of malnutrition specifically under nutrition and various nutrient deficiencies in a vast section of population especially in third world countries like India.

The current paper focuses upon Food and Nutrition security, which act as major donator in improving overall health of human. Both of these parameters should be accentuated in this context as they not only mitigate the negative impact of malnutrition and hunger but also provide important inputs in economic development of many countries.

Keywords : Food Security, Nutrition Security, Health challenges, Sustainable Health.

Nutrition is one of the most notable factors in bringing out the maximum capability in both physical and mental sectors in human population. Achieving good health and nutrition status depends on adequate food production, distribution, consumption and utilization of it by masses. Though our country is one of the tops in providing agricultural and livestock produce, yet a huge section of our population is still suffering from the effects of Malnutrition. (1)

Malnutrition is a complex pathological situation which encompasses situations like undernutrition, overnutrition, imbalance and specific deficiencies. With passing of times, various countries are facing the burden of this criticality but the situation in developing countries are far worse. (2)

According to various studies, it is established already that a huge number of children are affected by malnutrition specially under nutrition. It is estimated that around over 33 lakh children in India are malnourished and among them about 17.76 lakh belong to Severely Malnourished Children (SAM) and about 15.46 lakh fall in the category of Moderately Acute Malnourished children as per the report given by WCD Ministry. (3)

Apart from undernutrition or cases of specific deficiencies, the scenario in terms of overnutrition is also showing a grim reality. According to the reports by National Family Health Survey (NFHS) 2019-21, about 24% adult women and 23% adult men are found to be

obese. Also, around 3.5% children were reported to be affected by overnutrition. While going through Global Nutrition Report it can be found that India's nutrition profile is facing extreme imbalance. Where one section of the population due to economic abundance can afford wholesome nutrition, sometimes leading to unnecessary over consumption of foods along with leading sedentary lifestyle, making them face overnutrition, on the other, the left major section of the population are eating low quantity of food or getting the lesser access to adequate food and nutrition which intern making them vulnerable towards undernutrition and specific nutrient deficiencies like Anaemia, Vitamin A deficiencies etc. all these factors point to the one of the burning issues of our country: FOOD AND NUTRITION SECURITY. (4)

Role of food security and its determinants in improving overall nutrition :

During the last decades the agricultural production worldwide has grown more rapidly than the population did and there is, now, more food, at least in terms of macronutrients, available to feed the human population worldwide. Still, the number of people victimised by food insecurity is reported to be increasing and as, the proportion of the overall population suffering from insufficient food. This gives the opportunity for discussing the importance of food security and its various key parameters in mitigating the problem of food insecurity. (5)

By definition, according to world Food Summit 1996, Food Security is termed as when all people, at all time, have physical, social and economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (6). In simpler terms food security mainly points out as access to food that is adequate for all household members for obtaining sufficient and sustainable nutrition.

For obtaining food security, its 4 main determinants must be met properly. These are mainly as follows:

Food Availability : Rendering sufficient quantities of foods are available to all individuals within a country. By definition it can be denoted as "The amount of food that is present in a country or area through all forms of domestic production, imports, food stocks and food aid".

Food Access : this refers to food affordability.All members have the adequate resources to purchaseappropriate food for a nutritious diet. It refers to physical economical and social access to food by all at every time.

Food Utilization : It is the optimum biological utilization of food which can be fulfilled by wholesome nutritious diet, safe water and proper environmental sanitation.

Food Stability : It has to be the only factor which positively influences the other 3 pillars of Food Security. all around supply of food even in adverse situation. Stability of food supplies even in severe adverse natural situations or economical social& political turbulences.

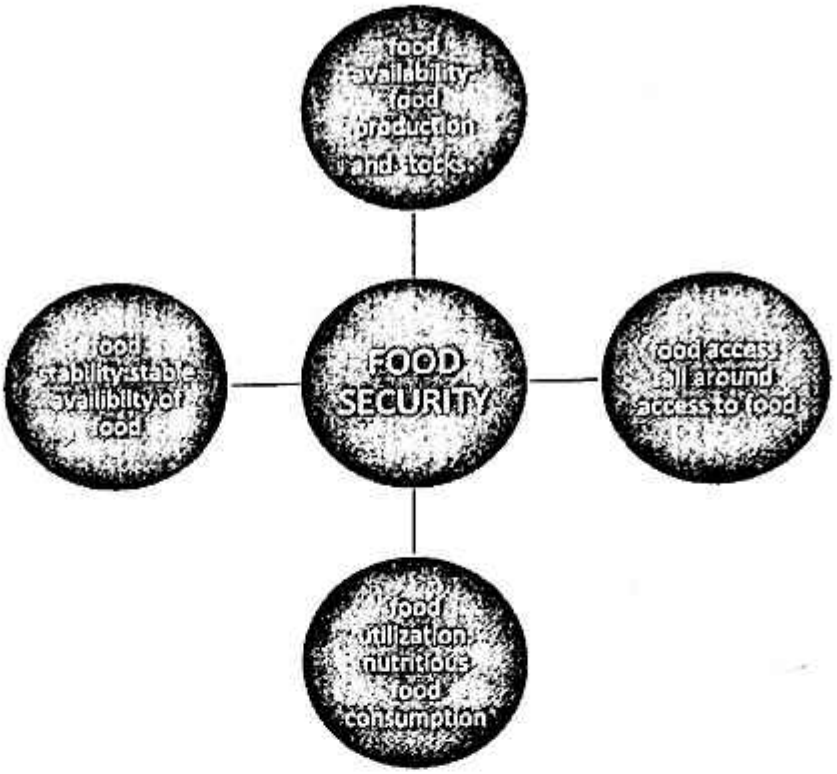


Fig 1: *4 pillars of food security*

The issue of food security is critically important specially in our country for reasons like It provides opportunity to people for maintaining a healthy life, careful arrangement of resources toward procuring of foods, economic well-being & measure of reducing world hunger and poverty (7).

Differentiating features of nutrition security and food security :

Often these 2 important terms are used together generally but they have specific distinguished features. On one hand where food security mainly means access to wholesome food by all at any given time, on the other it is about the community's access to essential nutrients, not just calories.

Nutrition Security implies physical, economic and social access to balanced diet, clean drinking water, safe environment, and health care. Education and awareness are needed to utilise these services (8).

Undernutrition, malnutrition and increasingly overnutrition are still pressing issue inmany developing countries. Promoting nutrition security offers several opportunitiesto stimulate economic and pro-poor development in cost-efficient ways. There are 3 main determinants which help in fulfilling the goals of nutrition security in a community.

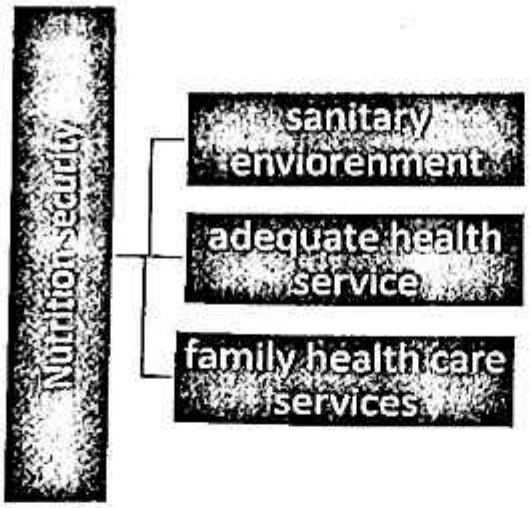


Fig 2: *different parameters of Nutrition Security*

Channels for ensuring food security& nutrition security in India :

For strengthening the 4 main pillars of food security in our country and also to reduce the multiple adversities arising from the triple burden of malnutrition, Govt of India has proposed and launched many strategies, schemes and programs. The following table gives an overall idea regarding some GOI initiatives to improve the health of our population by achieving food security [9].

GOVT PLANS	SERVICES PROVIDED
Public Distribution System now known as Targeted PDS or TPDS	BPL cards are issued, and monthly provision of 35kg of food grains at subsidised rates like 4.15rs/kg Wheat and 6.65Rs/kg Rice to the vulnerable section of population of the community belonging to below poverty line.
Antyodaya Annya Yojona	Providing special food-based assistance to destitute households.
Sampoorna Gramin Rozgar Yojona	Employment generating schemes along with provide food grains at a subsidised rate
National Food for Work Program	Wage employment program for rural people.
National Food Security Mission	Increasing agricultural production specially of rice, pulse and wheat.
National Food Security Bill	Largest food security program in the world. Providing food grains at subsidised rates.
Right to Food Act	Every family below poverty line in rural as well as urban areas will get 25 kg of rice or wheat per month at subsidised rates.

Table 1: *list of programmes by Govt. of India for mitigating malnutrition*

CHALLENGES FACED BY FOOD SECURITY SYSTEM IN OUR COUNTRY:

Though there are several programs which have been initiated and successfully getting carried out in our country, still a majority portion of our population is far from reaching the goals that were taken by food security systems in our country.

Major contributory factors like poverty, increased population, change in climatic conditions, onset of epidemics & pandemics, inadequate distribution of food, lack of education and lack of nutrition awareness, unmonitored Nutrition Program, corruption, unethical practices all lead to Food Insecurity causing the burden of malnutrition and poor health in people and causing hindrance in all over success of our Food & Nutrition Security System.

Conclusion :

In the end it can be concluded, that for the utmost wellbeing of population of a country, Food & Nutrition Security must be highlighted properly, which is not only related with promoting good health but also with all around Economic and Social development of a country.

Few significant measures like improving agricultural production, planning of storage and distribution of products throughout the population, proper implementation of Govt. Strategies, successful monitoring of various govt. program, strong supervision on the schemes at every level and co-Operation from all sectors will be essential in sustaining the overall progress of our people.

References :

1. Srilakshmi, B. (2012) NUTRITION SCIENCE, 4th Revised Edition, page : 91 New Age International Publishers, New Delhi, India.
2. Srilakshmi, B. (2012) Nutrition Science, 4th Revised Edition, page : 02 New Age International Publishers, New Delhi, India.
3. 'Nearly 18 lakh children in India severely malnourished: Centre'-THE HINDU; New Delhi, November, 2021.
4. https://www.orfonline.org/expert-speak/global-nutrition-report-2021/
5. https://www.fao.org/fileadmin/templates/ERP/uni/LIFE.pdf
6. FAO, (1996), World Food Summit: Rome Declaration on World Food Security and World Food Summit Plan of Action, Rome, 1996
7. Das, S. (2018) TEXT BOOK OF COMMUNITY NUTRITION, 3RD Edition, page : 52-53, Academic Publishers, Kolkata.
8. Nutrition Security for India-Issues and way forward -A Position Paper, Dec 2009, Indian National Science Academy, New Delhi.
9. Das, S. (2018) TEXT BOOK OF COMMUNITY NUTRITION, 3RD Edition, page : 59-64,Academic Publishers, Kolkata.

Indian Premier Statistics : An Analysis of the Performers and Disappointers

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Abstract:

In every session of Indian Premier League or IPL, it often happens that some players fail to give good performances. Here we tried to study how the performances of players in each team vary over age and whether united performance in a team gives a better Net Run Rate (NRR). Firstly, three age groups (strata) were created, then nine players were taken by Simple Random Sampling Without Replacement (SRSWOR) from each team. A score was formulated based on their roles. On the basis of these scores top three performers for each team were identified and a team score was obtained. Then a relationship between team score and NRR was obtained. It is established that in IPL the age barrier is not a true surveyor of a player's performance. It was then showed that team score and NRR do not have exact linear relationship but on an average, they follow a strong linear relationship.

Keywords : Strata, SRSWOR, linear relationship.

Cricket is the world's second most popular spectator sport after association football (soccer). It is governed by the International Cricket Council (ICC) which has over one hundred countries and territories in membership although only twelve currently play test cricket. The British brought cricket to India in the early 1700s, with the first cricket match played in 1721. Since then, Indians showed a great affection towards this sport. We, the Indians celebrate cricket as a festival. People not only admire but worship the great cricketers as Gods. Every Indian being an eight years or eighty years old loves to play the 'Gully Cricket'. Nowadays, the T20 (twenty overs match) format has become very popular amongst the cricket lovers.

Indian Premier League or IPL launched a new era of cricket. It is conducted by the BCCI (The Board of Control for Cricket in India). It is the most popular format not only in India but across the globe. In 2020 eight teams played IPL. They were Chennai Super Kings (CSK), Delhi Capitals (DC), Kolkata Knight Riders (KKR), Mumbai Indians (MI), Kings XI Punjab (KXIP), Rajasthan Royals (RR), Royal Challengers Bangalore (RCB), and Sunrisers Hyderabad (SRH).Cricketers from the whole world desire to play in this league. IPL is like a great conjunction of different generation's players "**where talent meets opportunity**". Every match witnesses a huge number of crowds. Indians and foreigners just somehow blend into this celebration. It is a huge source of entertainment. IPL has given many fabulous players like - Hardik Pandya, Jasprit Bumrah, KL Rahul etc and is still providing emerging players like - Rishabh Pant, Shubman Gill, Prithvi Shaw etc. We can't forget how the Greatest Of All Time (G.O.A.T.) like Virat Kohli, Rohit Sharma, David Warner, Sunil Narine and the others

are still providing much enthusiasm and charisma in this league. IPL has been playing a great role to increase the popularity of cricket around the world.

Statistics is an important tool in any kind of analysis. It helps us to see in depth of the data, to understand what the data is trying to tell us. Most importantly, Statistics teaches us how to infer different aspects from it. In cricket we have a wide variety of data, and the spectrum is so vast as well. We can infer so much about the performance of a player or his contributions to the team and many more, and even we can predict the result of a certain ongoing match before the ending, with a minimal margin of error.

In every session of IPL, players are bought by teams with a huge amount of money in the bidding. But it so happens that after spending a huge amount for a player he fails to perform up to the mark. Even the performances of some players may vary drastically throughout the tournament. Sometimes it goes up and sometimes comes down. On the other hand, we can see some players are consistently contributing to every match. It can also be seen that most of the players of a team have done excellent jobs but still the team failed to gain a better position in the league table and a team gained a top position based on the performances of a few players, but the others failed to perform well. As mentioned before, players from different ages participate in IPL. So, it is expected that the performance of a twenty years old would be much different from thirty or forty years old. Every player has a different role in his team. Some contribute with bats, some with balls and some do both. So, there should be a way to analyze every player's performance and his contribution to the team despite his age or role. It should also be verified how untidily a team performs and if that always agrees to the position in table.

In this paper our objectives are to formulate a score based on the performances and roles (e.g., batsmen, bowlers, all-rounders), identify the top 3 players for each team based on their scores, calculate intra-class correlation coefficient of score from different age groups for each team, calculate Pearson's correlation coefficient between team score and NRR and comment to what extent the results comply with reality.

1. Data

2.1. Data Description :

Age : Age is recorded as on 10.11.2020 (Finale of IPL 2020). Players are divided in 3groups according to their ages viz. age group A: ≤ 26, age group B: [27,30] and age group C: ≥ 31.

Matches : Total number of matches where the player was included in the playing 11.

Innings : Batting innings - Total number of matches where the player faced at least one fair delivery and **Bowling innings** - Total number of matches where the player bowled at least one ball.

Stats : 5 parameters are chosen under stats for each player based on his role- batsman bowler, and all-rounder. For a batsman, the parameters are a) runs - total number o runs scored by a batsman, b) batting average -it shows how many runs a batsman coul

score on an average before he got out. It is calculated as total number of runs scored by the batsman divided by total number of times he got out, c) 50's - number of times the batsman scored 50 or more runs, d) 4's - number of times the batsman scored 4 runs by hitting a boundary and e) 6's - number of times the batsman scored 6 runs by hitting an over-boundary. For a bowler, the parameters are a) bowling average - It shows how many runs a bowler has given for taking a wicket. It is calculated as total number of runs conceded by the bowler divided by total number of wickets taken by him, b) economy rate -economy rate is the average number of runs a bowler has conceded per over bowled, c) total number of wickets taken by the bowler, d) strike rate - it is calculated as total number of balls bowled by the bowler divided by total number of wickets taken by him. It shows how many balls the bowler must bowl to take a wicket and e) dot balls - total number of fair balls bowled on which no runs were conceded. For an all-rounder, we have considered all the ten parameters mentioned above.

NRR : NRR stands for net run rate. It is a measurement that is calculated by how each team has performed in a match. For example - by how many wickets the team won or how fast the run was chased in terms of over etc. If the team wins, a positive score is awarded and if looses a negative score is given according to the rules of NRR.

2.2. Data Collection

Only the players that played at least one inning (either batting or bowling) in IPL 2020 are considered in this paper. Players are divided in three age groups according to the rule mentioned in section 2.1. Each group must have more than three players. For each team total number of players in each group is recorded.

2. Methods

3.1. Strata and stratification

In stratified sampling, the population of N units is first divided into say, L subpopulations containing $N_1, N_2, \ldots, N_L$ units respectively. These subpopulations are called strata. They are non-overlapping and together they comprise the whole set of population, so that $N_1+N_2+\ldots+N_L = N$, i.e., the strata should define a partition of the population and it should be collectively exhaustive and mutually exclusive. Stratification is the process of dividing members of the population into homogeneous sub groups before sampling. If each unit of the population has an equal probability of being selected at each drawing, then the sampling is called simple random sampling. After creating strata, simple random sampling is applied within each stratum. This process is called stratified random sampling.

The objective is to improve the precision of the sample by reducing sampling error. Here stratified random sampling is chosen because in this analysis measurements within strata (players performance in a certain age group) have lower standard deviation (as compared to the overall standard deviation in the population), thus stratification gives smaller error in estimation, and simple random sampling without replacement

(SRSWOR) is chosen over simple random sampling with replacement (SRSWR) because the previous has lower standard deviation than the latter.

3.2. Sample selection

In this experiment there are total 8 teams i.e., total 8 populations. From each population samples are taken separately using stratified random sampling. Three age groups mentioned earlier are the strata for this experiment. After creating the strata, three players from each stratum are selected by SRSWOR. So, for each team total nine players are selected.

Now the following steps are followed for performing an SRSWOR. Let, from it stratum (age group) of size N_i a sample of size three is taken, where $i = 1,2,3$.

Step 1 : The N_i players are labeled from 1 to N_i.

Step 2 : The highest 2 digit multiple of N_i is taken and is denoted by M, say.

Step 3 : A 2-digit number say R from a random number table is taken.

Step 4 : If R=00 or $M+1 \leq R \leq 99$, R is rejected and go to step 3. Otherwise go to step 5.

Step 5 : If $01 \leq R \leq M$, R is accepted.

Step 6 : Divide R by N_i and let p be the remainder.

Step 7 : If p = 00, the player with label N_i is selected. Otherwise, the p–th player is selected.

Step 8 : If the same player is selected twice, the later one is rejected and go to step 3.

Step 9 : The process is followed until three distinguishable players are selected from the i–th stratum.

This process is followed for all the eight teams' three strata. Finally, there are total seventy-two players, nine from each team.

3.3. Formulation

Now some formulae have been generated based on which there will be a score for each player. It is calculated based on his role. The parameters bear the same meanings as mentioned in section 2.1. The Score will indicate how he performed and how much he contributed for the team.

For a batsman, score = (batting average $\times w_1$) + (runs $\times w_2$) + (50's $\times w_3$)+ (4's $\times w_4$) + (6's $\times w_5$).

For a bowler, score = (w_6/ bowling average) + (w_7 / economy rate) + (wickets $\times w_8$) + (w_9 / strike rate) + (dot balls $\times w_{10}$).

For an all-rounder, if the number of bowling innings is greater than batting innings,

score = (batsman's score+ w_{11} $\times$bowler's score) / (1 + w_{11}).

Or, if number of batting innings is greater than bowling innings,

score = (bowler's score+ w_{11}×batsman's score) / (1 + w_{11}), where the weights are:

$w_1 = \frac{100}{\text{average of batting average}}$, $w_2 = \frac{100}{\text{average of runs}}$, $w_3 = \frac{10}{\text{average of 50's}}$, $w_4 = \frac{100}{\text{average of 4's}}$, $w_5 = \frac{100}{\text{average of 6's}}$, w_6 = median of bowling average × 100, w_7 = average of economy rate × 100, $w_8 = \frac{100}{\text{average of wickets}}$, w_9 = median of strike rate × 100, $w_{10} = \frac{100}{\text{average of dot balls}}$, w_{11} = (difference between the batting and bowling innings) + 1. (To be calculated separately for each player.)Each weight is calculated differently for different teams.

Finally, the team score is calculated by taking the average score of the selected nine players. So, we will have eight team scores corresponding to eight teams.

3.4. Experimentation

From the calculated score for each player, the top three performers of each team are identified. Then it is verified to what extent the results comply with reality. If it is required to find the correlation with respect to a particular variate between members of the same class, Intra-class Correlation Coefficient (ICC) is taken into consideration. By correlation it's meant the extent to which the members of the same class resemble each other with respect to the given variable. Suppose there are p classes of k members each and x_{ij} denotes the value of variate x corresponding to i –th class and j –th member. Then the Fisher's ICC is given by:

$$ICC = \frac{1}{k-1}\{k\frac{s_m^2}{s^2} - 1\}, \text{ where}$$

$s_m^2 = \frac{1}{p}\sum_{i=1}^{p}(\bar{x}_i - \bar{x})^2$, variance of the means of p classes.

$s^2 = \frac{1}{pk}\sum_{i=1}^{p}\sum_{j=1}^{k}(x_{ij} - \bar{x})^2$, total variance of x.

$\bar{x}_i = \frac{1}{k}\sum_{j=1}^{k} x_{ij}$, mean of the ith class, i = 1(1)p

$\bar{x} = \frac{1}{pk}\sum_{i=1}^{p}\sum_{j=1}^{k} x_{ij}$, grand mean

The Intra-class Correlation Coefficient (ICC) of score (x_i) from different age group has been calculated for each team using Fisher's ICC mentioned above. Here, p = number of age groups = 3 and k = number of players in each age group =3.

3.4.1. Testing

Our problem is to test the hypothesis: H_0: $\rho = \rho_0$ v/s H_1: $\rho \neq \rho_0$, where ρ = population intra-class correlation coefficient and ρ_0 is its hypothesized value. The model we consider here is: $y_{ij} = \mu + \beta_i + e_{ij}$, i=1(1)p,j=1(1) k, n= p × k, where

y_{ij} =score of the jth player in the ith age group

μ = general effect

β_i = additional effect due to the ith group.

e_{ij} = random error, $e_{ij} \sim N(0,\sigma^2)$, σ^2 is the variance of the normal distribution.

The Confidence Interval (CI) of ρ at 100α% level of significance based on p groups each with k observations is given by:

$$\left(\frac{F_L-1}{F_L+k-1}, \frac{F_U-1}{F_U+k-1}\right), \text{ where}$$

$F_L = \frac{F_0}{F_{\frac{\alpha}{2};n_1,n_2}}$, $F_U = \frac{F_0}{F_{1-\frac{\alpha}{2};n_1,n_2}}$, $F_0 = \frac{MSB}{MSE} = \frac{k\sum_{i=1}^{p}(\overline{y_{i0}} - \overline{y_{00}})^2/(p-1)}{\sum_{i=1}^{p}\sum_{j=1}^{k}(y_{ij}-\overline{y_{00}})^2/(n-p)}$, $F_{\alpha;\, n1,n2}$ = upper α point i.e. $P[F > F_{\alpha;\, n1,n2}] = \alpha$ and F follows an F distribution with n_1 and n_2 degrees of freedom. We reject H_0 at 100α% level of significance if calculated ICC falls outside the CI. Here α is taken as 0.05.Here,$n_1 = p - 1 = 2$, $n_2 = n - p = 6$. Now, $F_{0.025;2,6} = 7.25985568$ and $F_{0.975;2,6} = 0.02542494$.

A correlation between variables indicates that as one variable changes in value, the other variable tends to change in a specific direction. The Pearson correlation coefficient or simply the correlation coefficient is a measure of linear relationship between two sets of data. The result always has a value between −1 and 1. Pearson's correlation coefficient, when applied to a sample, is commonly denoted by r and may be referred to as the sample correlation coefficient. Suppose there are n bivariate observations $(x_1,y_1),(x_2,y_2),\ldots,(x_n,y_n)$, the Pearson correlation coefficient is given by:

$$r = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2 \cdot \sum_{i=1}^{n}(y_i-\bar{y})^2}} \text{ and } \bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i,\ \bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i.$$

Here the correlation between NRR(x) and team score(y) has been calculated to see the extent to which they form a linear relationship. It was enquired if a high NRR gives a high team score or not. In our case, n = number of teams = 8.

Again, we test the hypothesis : $H_0: \rho^* = \rho_0^*$ v/s $H_1: \rho^* \neq \rho_0^*$, where ρ^* = population correlation coefficient, and the CI of ρ^* at 100α% level of significance based on sample points is given by:

$$\frac{e^{2(z-\frac{\tau_{\alpha/2}}{\sqrt{n-3}})}-1}{e^{2(z-\frac{\tau_{\alpha/2}}{\sqrt{n-3}})}+1}, \quad \frac{e^{2(z+\frac{\tau_{\alpha/2}}{\sqrt{n-3}})}-1}{e^{2(z+\frac{\tau_{\alpha/2}}{\sqrt{n-3}})}+1}$$

Here, $z = \frac{1}{2}\ln\left(\frac{1+r}{1-r}\right)$, $\tau_{\alpha/2}$ = upper α/2 point of a standard normal (N(0,1)) distribution. i.e. $P[\tau > \tau_{\alpha/2}] = \alpha/2$, $\tau \sim N(0,1)$.We reject H_0 at 100α% level of significance if calculated r falls outside the CI. Here α is taken as0.05 and $\tau_{0.025} = 1.96$.

4. Results

4.1. Calculations for the teams :

1. **CSK** : Hypothesis:H_0: ρ = -0.3837 v/s H_1: ρ ≠ -0.3837 (Table 4.1.1). C.I.:[-0.4312, 0.8981].

2. **DC** : Hypothesis:H_0: $\rho = 0.6336$ v/s H_1: $\rho \neq 0.6336$ (Table 4.1.2). C.I.:[-0.0215, 0.9889].

3. **KKR** : Hypothesis:H_0: $\rho = -0.2909$ v/s H_1: $\rho \neq -0.2909$ (Table 4.1.3). C.I.:[-0.3807, 0.9416].

4. **MI** : Hypothesis:H_0: $\rho = -0.0828$ v/s H_1: $\rho \neq -0.0828$ (Table 4.1.4). C.I.:[-0.2794, 0.9701].

5. **KXIP** : Hypothesis:H_0: $\rho = -0.1315$ v/s H_1: $\rho \neq -0.1315$ (Table 4.1.5). C.I.:[-0.3018, 0.9663].

6. **RR** : Hypothesis:H_0: $\rho = 0.4029$ v/s H_1: $\rho \neq 0.4029$ (Table 4.1.6). C.I.:[-0.0924, 0.9861].

7. **RCB** : Hypothesis:H_0: $\rho = -0.1795$ v/s H_1: $\rho \neq -0.1795$ (Table 4.1.7). C.I.:[-0.3246, 0.9614].

8. **SRH** : Hypothesis:H_0: $\rho = -0.3192$ v/s H_1: $\rho \neq -0.3192$ (Table 4.1.8). C.I.:[-0.3958, 0.9328].

For all the above eight cases we do not have enough evidence to reject H_0 at 5% level of significance. The Pearson's correlation coefficient between the NRRs and team scores is $r = 0.61277$ (Table 4.1.9). The scatter diagram is given in Figure 4.1.1.

4.2. Discussions

1. **CSK** : Top 3 performers: -

1^{st}: Shane Watson (617.4320):He was the 3rd highest run scorer for his team and 2nd highest number of 4's and 6's hitter. His performance was not the best for his team but in the chosen sample he had the best figures. That is why he got the 1^{st} position.
2^{nd}: Deepak Chahar (608.6244):He was the 2nd highest wicket taker for his team and bowled the greatest number of dot balls for his team. Indeed, he was one of the leading bowlers of CSK.
3^{rd}: Sam Curran (574.9202) : He contributed both with bat and ball. He had the 3rd best batting strike rate of CSK. He was the highest wicket taker for his team. The youngster had 2nd best bowling average and strike rate of team. He bowled 2nd highest number of dot balls for CSK. He contributed more with ball than with bats. This is the reason he got 3rd place otherwise he could have got the 2nd position.

ICC : -0.3837 : The negative sign signifies that the variability within groups exceeds the variability across groups, i.e., the SCORE in a group diverges relative to the noise present in the individual. In all the age groups a huge variability is observed within them. There is a high peak in every group which caused a low negative value of the ICC. Clearly the players within an age group did not resemble each other in terms of performance.

2. **DC:** Top 3 performers: -

1^{st}: Kagiso Rabada (864.9066):He was the highest wicket taker of IPL 2020. He had the best bowling average and strike rate of his team. He became the 2nd most valuable

player of that session. Without any doubts he was the most important player of DC a
inarguably the holder of 1st position for his team.
2nd : Shikhar Dhawan (743.5941): He was the highest run scorer for his team and 2
highest of the league. He hit 2 consecutive hundreds. He had the greatest number of
in IPL 2020. Due to these, it leaves no reason to question about his contributions a
position.
3rd : Marcus Stoinis (707.7420) : He was the most important all-rounder for DC. He h
the best batting strike rate for his team. 3rd highest run scorer and 4's hitter for his tea
and had 2nd highest 6's of DC. He also had the 3rd highest number of 50's for DC.
was the 4th highest wicket taker for his team and had 2nd best bowling average. H
bowling strike rate was 5th best in the league and 2nd best in the team. His performan
earned him this position undoubtedly.

ICC : 0.6336: Here the performances within each group cannot said to be exactly al
but the variability between the groups is quite high. The variability within age groups
quite low, which resulted in a moderately positive ICC. So, the players within an a
group performed more identically rather between the groups.

3. **KKR :** Top 3 performers :

1st : Eoin Morgan (680.6023): He was the 2nd highest scorer for his team and was ma
the captain halfway through the tournament. He saved many matches for his team
destructive batting in the middle order. So, his contributions earned him the 1st positio
2nd : Varun Chakravarthy (629.5767) : The spinner was the only one to clench a
wicket haul in IPL 2020 which was the best bowling figure. He got the highest num
of wickets for his team. He had the best economy and bowling average figures
KKR. His talent earned him the 2nd position.
3rd : Shubman Gill (579.4119): The 21 years old was the highest run scorer for his tea
He played an anchoring knock whenever wickets kept falling rapidly in the other stri
end. He hit the highest number of 4's for his team and 7th highest in the league. He a
had highest number of the 50's for KKR.

ICC : -0.2909: The negative sign signifies that the variability within groups exceeds
variability across groups, i.e., the score in a group diverges relative to the noise pres
in the individual. This is the reason the ICC becomes negative. So, it can be conclu
with firmness that the performance within the groups do not resemble each other.

4. **MI:** Top 3 performers: -

1st : Jasprit Bumrah (784.3234): He was the highest wicket taker and dot balls bow
for his team and 2nd highest in the league. His bowling average was best in the wh
tournament. He had the best bowling strike rate of MI. He took wickets both in po
play and death overs. So, he deserves the 1st position in his team and also was on
the top players of the league. He was the 3rd most valuable player of the league and
for team.

2nd :Trent Boult (697.1842):He was the 2nd highest wicket taker for his team and
highest in the league. He bowled 2nd highest number of dot balls and has the

highest bowling average of MI. He had the 2nd best bowling strike rate for MI. He proved very critical for taking wickets in the power play. There are no arguments for his contributions towards the team. He was the 5th most valuable player of the league and 2nd for team.

3rd : Ishan Kishan (544.8023):He was the highest run scorer for his team and 5th highest run scorer of IPL 2020. He hit the greatest number of 6's in the league. His batting average was best in the team and 4th in the league. He was a destructive opener. His highest score was 99. Despite his age he became a valuable player for his team and that is why he grabbed higher position than rest of the popular players.

ICC : -0.0828: The negative sign signifies that the variability within groups exceeds the variability across groups, i.e., the score in a group diverges relative to the noise present in the individual. That caused the negative sign in ICC. So, it is safe to say that the players within an age group did not perform alike.

5. **KXIP** : Top 3 performers: -

1st : Mohammed Shami (804.9746):He was the highest wicket taker and dot balls bowler for his team. He had the best bowling average and strike rate of KXIP. His name is not unaware by any cricket fan, and he lived throughout the tournament up to his mark. His contributions for the team were huge. These made him the best performer of his team.
2nd : Kl Rahul (770.3223) : He was the top run scorer in the IPL 2020, thus orange cap holder. His 132 not out knock was the highest score of the session and highest by any captain throughout all the 13 sessions. He hit 3rd highest number of 4's in the league and highest for his team. Clearly, he made a great impact on his team and inarguably deserved this position.
3rd : Ravi Bishnoi (613.8646) : He was the 2nd highest wicket taker and dot balls bowler for his team. He has the best economy of KXIP. He was one of the youngsters who blazed out the tournament. The spinner proved to be a very important player for his team and that earned him the 3rd position.

ICC : -0.1315: The negative sign signifies that the variability within groups exceeds the variability across groups, i.e., the score in a group diverges relative to the noise present in the individual. These things caused a high negative value of ICC. Thus, most of the players performed identically within the group rather between the groups.

6. **RR:** Top 3 performers :

1st: Jofra Archer (835.6850) : This all-rounder was the most valuable player of IPL 2020. He had the 2nd best batting strike rate of the session and best for his team. He clenched most wickets for his team and has the best economy and best bowling strike rate of RR. He bowled highest number of dot balls in the league. His bowling average was 5th best in the tournament and best for RR. So, he was indeed the true contender for the 1st position in his team RR.

2nd : Sanju Samson (553.8444) : He was the highest run scorer for his team. He hit most number of 6's in the league and highest for his team. He scored most numbe 50's for RR. He was a consistent player and played some crucial knocks. In this cho sample he surely deserved this position.

3rd : Rahul Tewatia (549.4147): He almost created history by hitting 5 6's in an against KXIP and saved his team from a certain defeat. He hit 2nd most number of for his team. He also contributed with bats, was the 2nd highest wicket taker and balls bowler for his team. He had the 2nd best bowling average and economy for These helped him to get the 3rd position.

ICC : 0.4029: The variability within groups is less than that of between groups. Thu low positive ICC is obtained. It can be concluded that most of the players perfor like each other despite of their age groups.

7. **RCB:** Top 3 performers :

1st : Ab De Villiers (757.9718): He was the 2nd highest run scorer for his team. scored 50's most number of times in IPL 2020. He had the best batting average strike rate in RCB. He hit most number of 6's in his team. No other except him c have the top position in RCB.

2nd : Yuzvendra Chahal (653.9917): He was the most valuable player of his team in 2020. He was 5th highest wicket taker of the league and highest of RCB. He bowled greatest number of dot balls in RCB. His brilliant technique of spinning earned him position.

3rd : Devdutt Padikkal (640.6678): This 20 years old lad was the highest scorer fo team. He hit the highest number of 4's for RCB. He scored 50's most number of tim IPL 2020. He had the 2nd best strike rate in RCB. He was named the emerging pl of IPL 2020. That makes clear of him getting the 3rd position in team.

ICC : -0.1795: The negative sign signifies that the variability within groups exceed variability across groups, i.e., the score in a group diverges relative to the noise pr in the individual. A high peak is observed in all the three groups but rests of the values do not differ much from each other within the groups. The variability withi groups is a little higher than between the groups. These caused a high negative Thus, it can be said that most of the players played alike.

8. **SRH:** Top 3 performers: -

1st : David Warner (846.7217): He was the 3rd highest run scorer of IPL 2020 an highest for team. He hit the highest number of 4's and 50's for his team. The capta his team to many glorious victories. His performance earned him the top spot.

2nd : Rashid Khan (834.0862): He had the best economy in this league. He ha highest number of wickets and dot balls for his team. His bowling average was th for SRH.

3rd : Thangarasu Natarajan (605.6752): He came to the light in IPL 2020 due yorker balls. He bowled the highest number of yorker balls in the league. He ha

2nd highest number of wickets and dot balls for his team. He was one of the rising stars of IPL 2020.

ICC : -0.3192: The negative sign signifies that the variability within groups exceeds the variability across groups, i.e., the score in a group diverges relative to the noise present in the individual. These resulted in a moderately low negative value of ICC. It is concluded that not all the players within a group performed identically.

The values within the parenthesis are the scores that we have computed for the corresponding players. For all the eight teams the ICCs fall inside the CI, so there is not enough evidence to reject the null hypotheses, i.e., the computed ICCs may be taken as true population ICCs.

An outlier is a data point that differs significantly from other observations. An outlier may be due to the variability in the measurement, or it may indicate experimental error. An outlier can cause serious problems in statistical analyses. Naïve interpretation of statistics derived from data sets that include outliers may be misleading. So, it is necessary to detect and delete outlier(s) from any experimental data.

There are various methods of outlier detection. Some are graphical and some are model based. From Figure 4.1.1 the data point corresponding to MI (1.107, 489.9580) is suspected to be an outlier, due to an unusual value of x which therefore might cause a huge deviation in the calculated correlation coefficient. After deletion of the above-mentioned point from the rest of the data, the modified correlation coefficient is given by $r^* = 0.8096$.

To test the hypothesis : H_0: $\rho^* = 0.8096$ v/s H_1: $\rho \neq 0.8096$, we found that the confidence interval is given by: C.I. = [-0.4551,0.8994]

Therefore, we do not have enough evidence to reject H_0 at 5% level of significance.

4.3. Interpretation

Before deleting the outlier, the data gave a moderately positive value of Pearson's correlation coefficient, which indicates that NRR and team score do not follow a strong linear relationship i.e., a high NRR does not guarantee a high team score. After detecting and deleting the outlier, the correlation coefficient is recalculated. The modified correlation coefficient r^* gives a strong positive value which indicates they follow a strong linear relationship on an average. The calculated r^* falls inside the CI. So, there is not enough evidence to reject null hypothesis. Now it is evident that a high NRR promises a high team score with more firmness. The computed r^* may be taken as true population Pearson's correlation coefficient.

5. Conclusions

For six teams the performance of the players within age groups varies more than between groups. On the other hand, for teams like DC and RR it is exactly opposite. It is expected that players' performance will depend on their ages. For example, the young players do not have much experiences but their fitness level is expected to be higher than who have lot of experiences. But in IPL the age barrier did not prove to be a speed

breaker in a player's performance. It shows that if a player has talent, he will perf well despite of age and experience.

After deletion of the outlier, it was observed that team score and NRR follow a str linear relationship on an average. It is expected that if a team performs with unity all play with excellence nothing can stop them from winning. NRR is given to team what margin (in terms of wickets or balls left, defended how many runs etc.) they or lost. But some players of a team performed commendably excellent, but the failed to do so. As a result, the team lost the match. In that case the team score bigger due to player's individual performance though the team gets a negative N That happened in this analysis for teams like RCB, SRH, RR. On the other hand, was the most consistent team of IPL 2020. They all performed together and won number of matches in that session resulting a high NRR, though team score is not in comparison to NRR. That was the result of MI's data point to be an outlier. Thus, established that NRR and team score do not follow an exactly linear relationship, they have a strong linear relationship on an average.

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We express my sincere thanks to Prof. Krishna Roy, Principal, Bethune Coll Kolkata. We pay our deep sense of gratitude to the Statistics department, Beth College, Kolkata for providing us the opportunity to prepare the work. We are hi obliged in taking the opportunity to sincerely thank all the respected professor Statistics department.

7. References

7.1. Websites

1. www.crictracker.com.

2. www.espncricinfo.com.

3. www.iplt20.com.

7.2. Books

1. Casella, G. and Berger R.L. (2002).: Statistical Inference, 2nd Ed. Thomson Learn

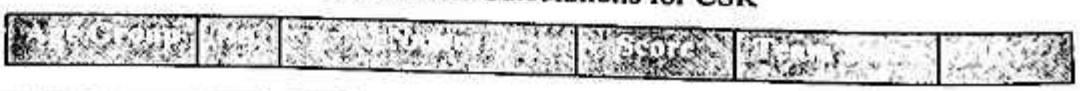
2. Cochran, W.G. (1984): Sampling Techniques, 3rd Ed., Wiley Eastern.

3. Goon A.M., Gupta M.K., & Dasgupta, B. (2005), Outline of Statistics, Vol. I The World Press, Kolkata.

4. Goon, A.M., Gupta, M.K., & Dasgupta, B. (2002): Fundamentals of Statistics, I& II, 8th Ed., The World Press, Kolkata.

8. Tables

Table 4.1.1. Calculations for CSK



A	1	Sam Curran	574.9202	439.6955	-0.3837
	2	Rituraj Gaikwad	457.7869		
	3	Narayan Jagadeesan	92.0077		
B	4	Deepak Chahar	608.6244		
	5	Shardul Thakur	559.2984		
	6	Josh Hazelwood	272.6643		
C	7	Ravindra Jadeja	413.5168		
	8	Ms Dhoni	361.0090		
	9	Shane Watson	617.4320		

Table 4.1.2. Calculations for DC

Age Group	No.	Name	Score	Team Score	ICC
A	1	Rishabh Pant	434.5338	482.7276	0.6336
	2	Shreyas Iyer	621.3105		
	3	Kagiso Rabada	864.9066		
B	4	Alex Carey	79.7642		
	5	Daniel Sams	123.7974		
	6	Harshal Patel	276.6095		
C	7	Marcus Stoinis	707.7420		
	8	Shikhar Dhawan	743.5941		
	9	Ravichandran Ashwin	492.2903		

Table 4.1.3. Calculations for KKR

Age Group	No.	Name	Score	Team Score	ICC
A	1	Shubman Gill	579.4119	467.9657	-0.2909
	2	Shivam Mavi	456.0386		
	3	Nitish Rana	534.7381		
B	4	Varun Chakravarthy	629.5767		
	5	Pat Cummins	471.6666		
	6	Rahul Tripathi	361.4565		
C	7	Eoin Morgan	680.6023		
	8	Dinesh Kartik	243.0873		
	9	Andre Russell	255.1136		

Table 4.1.4. Calculations for MI

Age Group	No.	Name	Score	Team Score	ICC
A	1	Ishan Kishan	544.8023	489.9580	-0.0828
	2	Rahul Chahar	478.1178		
	3	Jasprit Bumrah	784.3234		

B	4	Hardik Pandya	323.4411		
	5	James Pattinson	428.3907		
	6	Surya Kumar Yadav	487.5813		
C	7	Kieron Pollard	324.0697		
	8	Rohit Sharma	341.7117		
	9	Trent Boult	697.1842		

Table 4.1.5. Calculations for KXIP

Age Group	No.	Name	Score	Team Score	ICC
A	1	Deepak Hooda	296.4552	470.8685	-0.1315
	2	Ravi Bishnoi	613.8646		
	3	Nicholas Pooran	465.2004		
B	4	KI Rahul	770.3223		
	5	Mohammed Shami	804.9746		
	6	James Neesham	245.8477		
C	7	Chris Gayle	410.5842		
	8	Glenn Maxwell	141.0750		
	9	Chris Jordan	489.4927		

Table 4.1.6. Calculations for RR

Age Group	No	Name	Score	Team Score	ICC
A	1	Sanju Samson	553.8444	463.0692	0.4029
	2	Jofra Archer	835.6850		
	3	Kartik Tyagi	502.4259		
B	4	Jos Buttler	494.0102		
	5	Ben Stokes	418.6776		
	6	Rahul Tewatia	549.4147		
C	7	Steeve Smith	440.8159		
	8	Robin Utthappa	269.3455		
	9	Varun Aaron	103.4032		

Table 4.1.7. Calculations for RCB

Age Group	No.	Name	Score	Team Score	ICC
A	1	Devdutt Padikkal	640.6678	507.7792	-0.1795
	2	Mohammed Siraj	489.6706		
	3	Washington Sundar	400.4564		
B	4	Navdeep Saini	349.3422		
	5	Yuzvendra Chahal	653.9917		
	6	Shivam Dube	258.9924		

C	7	Virat Kohli	565.0276		
	8	Ab De Villiers	757.9718		
	9	Chris Morris	453.8925		

Table 4.1.8. Calculations for SRH

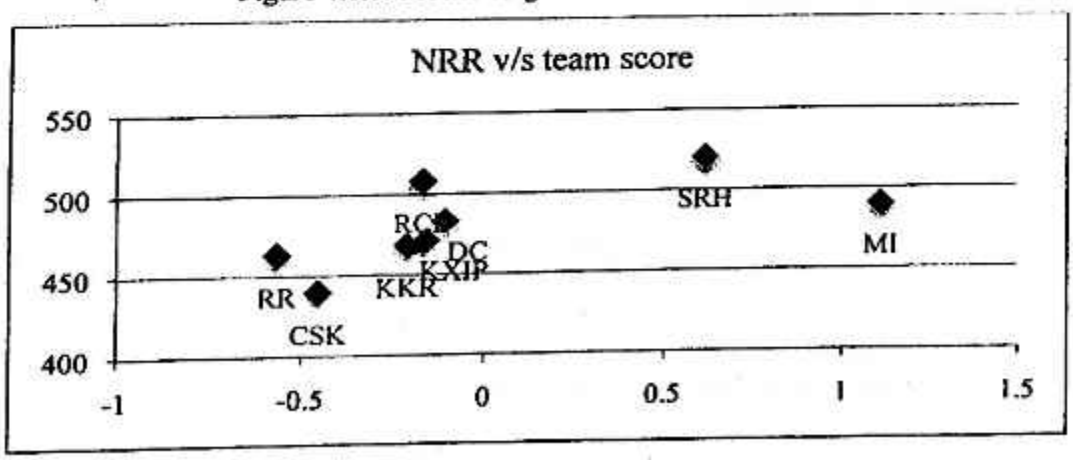
Age Group	No.	Name	Score	Team Score	ICC
A	1	Rashid Khan	834.0862	520.1537	-0.3192
	2	Priyam Garg	211.6593		
	3	Abhishek Sharma	185.7213		
B	4	Kane Williamsons	565.4925		
	5	Thangarasu Natarajan	605.6752		
	6	Jason Holder	577.1963		
C	7	David Warner	846.7217		
	8	Shabaz Nadeem	356.1197		
	9	Wriddhiman Saha	498.7111		

Table 4.1.9. Calculations for Pearson's correlation coefficient

No.	Team	NRR (X)	Team Score(Y)
1.	CSK	-0.455	439.6955
2.	DC	-0.109	482.7276
3.	KKR	-0.214	467.9657
4.	MI	1.107	489.9580
5.	KXIP	-0.162	470.8685
6.	RR	-0.569	463.0692
7.	RCB	-0.172	507.7792
8.	SRH	0.608	520.1537

9. Figures

Figure 4.1.1. Scatter diagram for NRR v/s team score



A review on urban biodiversity protection in relation with high specie diversity and variety of valuable ecosystem services

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Abstract :

The literature on the role of cemeteries in biodiversity conservation has grown significantly over the last de Protection of biodiversity is internationally regarded as the main challenges for the future of hum Cemeteries offer a variety of structures enabling a wide range of species. Cemeteries have a deep hist connection to the local community. They hold great significance to communities across the country, an important to remember their value throughout our lives. Cemeteries are important green spaces in environments, offering nature's benefits to city residents. Hence, cemeteries are particularly valuable for biodiversity conservation. Therefore, it is obvious that loss of urban biodiversity will cause the degradatio collapse of ecosystems that will threaten our existence on earth.

Key words : Cemetery; Urban Biodiversity; Conservation Management

"The cemetery, by definition a place of memories, became a location for memory of the comm (Sloane,1995). According to Rogers (1997), "Virtually all remaining open spaces, including cemeteries increase in value to local neighborhoods and to the region. Cemeteries, especially ones owned by M Regional Parks and Green spaces, should be managed in a way that provides multiple values, including w habitat, to the community around them." Wasserman (1998) defined "Cemetery spaces as memory capes seen as places for ritual action, fulfilling community requirements. The memorial landscape serves intell emotional, spiritual and communal functions, including: (i) a place for memory, (ii) a place for mourning, place for reflection and healing, (iv) a place for ceremony, and (v) a place for collective action. Each o contributes to enriching our community places, revealing their history and significance".

According to Curl (1999) the cemeteries "often larger in scale and predominantly owned by secular autho have been in common use only since the 19th century". According to Arffmann (2000), cemeteries hav functions; the hygienic function, places for sorrow, contact with eternity and marking of social status. It r became recognized that sacred burial places are key in conserving natural vegetation in their area (Barr Barrett, 2001).According to Moore house and Hassen (2004), "cemeteries are dynamic, reflecting changi ethnic composition. Biodiversity functions of cemeteries have long been addressed as habitats (Gilbert, Sukopp, 1990), mostly illustrated for birds (Lussenhop, 1977; Kocian *et al.*, 2003). Cemeteries and othe of burial grounds are regarded as sacred places all over the world, closely linked to community history 2000).Numerous countries have recognized the nature conservation and cultural importance of cemeter churchyards (Laske, 1994; Dudley et al., 2010); urban domestic gardens (Smith *et al.*, 2006);burial (Deak *et al.*, 2016, 2018; Valko *et al.*, 2018); sacred groves and forests (Bhagwat and Rutte, 2006; Brand 2013) in recent decades. Biodiversity functions of urban cemeteries in Europe studied by Kowarik (20 Loki *et al.* (2019). Saha and Islam (2020) studied on species composition and diversity of insects in th Park Street Cemetery and Banabitan Park in Kolkata. Cemeteries therefore are "islands" of natural veget close proximity of urban areas, often harbouring rare and endangered plant species and key importance i conservation (Bhagwat, 2009).Studies on 'green spaces' (e.g. cemeteries, parks, gardens) have in research area within cities to determine urban ecology by Pickett and Cadenasso (2008).The role of cer in biodiversity conservation in the close proximity of urban areas is unquestionable in the new era. R indicates that urban cemeteries may have changed their role from being secluded, secret area due to their function as burial grounds, to become more inter-religious spaces and also multifunctional spaces for re and contemplation (Francis *et al.*, 2000; Woodthorpe, 2011; McClymont, 2016).The urban biod

conservation is important and necessary to sustain various kinds of ecosystem services for human well-being. In this review paper therefore focuses exclusively on cemeteries with special attention to their conservation values and encouraging a holistic approach to urban ecosystem management.

PROTECTION AND MONITORING OF URBAN BIODIVERSITY

Protection of biodiversity is internationally regarded as the main challenges for the future of humanity. Protected areas are thought to be the cornerstones of biodiversity conservation and the safest strongholds for wildlife (Bruner *et al.*, 2001).Natural sacred sites, protected by local traditions, are often situated within agricultural landscapes. They can play a valuable role in biodiversity conservation because of their long history and the local people's willingness to protect and conserve them. In India, many sacred groves were destroyed by commercial forestry operations, and local individuals also began to make use of these formerly community owned forests (Chandrakánth *et al.*, 2004). With rapid urbanization, cemeteries have thus become increasingly valuable for biodiversity conservation. They act as habitat islands for some native species. Their role in urban biodiversity conservation is often linked to their size, habitat heterogeneity and habitat continuity (Kowarik, 2016). Nature and green spaces contribute directly to public health by reducing stress and mental disorders (Ward Thompson *et al.*, 2012; Annerstedt *et al.*, 2012), increasing the effect of physical activity (Mitchell, 2012), and increasing perception of life quality and self-reported general health (Maas *et al.*, 2006; Stigsdotter *et al.*, 2010). Cemeteries are a window through which a city can view the hopes, fears and designs of generations that created it and are buried within it (Sloane, 1991). Urban cemeteries are very much important to special places for nature and species protection (so-called "islands") that require be duly considering and promoting because of their value (Schroder, 2007). Green cemeteries provide an ecological link to the future by preserving and fostering nature. It is therefore important to develop management approaches that encourage the conservation of cemeteries.

WHY PROMOTE BIODIVERSITY IN CEMETERIES?

Biological diversity is the base for upholding the ecosystems and the functional aspects of the species that provide goods and services for human well-being. It is recognized that sacred burial places are key in conserving natural vegetation in their area (Barrett and Barrett, 2001). Their landscape reflects society's interest in plants that stems from different reasons, including their aesthetic, cultural and ideological values. Cemeteries mirror people's relationship with nature. Friends and relatives are given an opportunity to visit the resting place of the deceased, to commemorate the lost and to process their grief. Cemeteries and other types of burial grounds are regarded as sacred places all over the world, closely linked to community history (Rugg, 2000). Cemeteries are publicly accessible spaces but with private graves, thereby not necessarily thought of as open spaces accessible to the local community (Blomley, 2005; Woodthorpe, 2011).

Cemeteries are also urban green areas that are central and close elements of an urban green space network especially in densely populated urban areas. With increasing pressure on urban land cemeteries have spatial competition and compression pressures (Kong, 2012) and are subject to other uses, such as open space (Deering, 2010). These areas are important for local recreation, as they are natural green space that offer visitors room for relaxation. Cemeteries ensure the crucial function of balancing the city's climate and the microclimate ("green lung"). Hence, cemeteries are particularly valuable for urban biodiversity conservation.

THE URBAN CEMETERIES MAY FUNCTION AS A BIODIVERSITY HOTSPOT

The fauna diversity in cemeteries is high and particularly worth protecting. Gilbert (1991) and Laske (1994) have reported cemeteries as areas with potentially high levels of biotic diversity and within urban matrix especially. Trees in cemeteries tended to be larger and more decayed and have more excavated cavities in cemeteries than parks; therefore cemeteries have the potential to be refuges for primary and secondary cavity nesters and maintain more diverse bird population by Orstan and Kosemen (2009). Kocian *et al.* (2003) studied that old trees and its area as well as the structure and age of its vegetation all influence the prevalence of nesting birds. It is thus the interactions of design, management and natural processes that likely drive important habitat features of cemeteries. Tree cavities provide shelter and essential resources to not only diverse groups of birds (Newton 1998; Smith*et al.*, 2000) but also many species of mammals, insects and other organisms (Ranius and

Jansson, 2000; Gibbons and Lindenmayer, 2002; Carpancto *et al.*, 2010; Bryant*et al.*, 2012; Hennesseye 2012; Fleming and Jones 2013). Sacred places have long and diverse histories in human cultures demonstrate ancient links between peoples and their environment (Anderson *et al.*, 2005). During the period, insect individuals belonging to 38 species from 16 families belonging to 5 orders i.e. Lepidop Odonata, Hemiptera, Orthoptera and Coleoptera were recorded from Park Street Cemetery in Kolkata (Sah Islam, 2020). Insects play an important role in the functioning of ecosystem and potentially useful bioindic of land management (Andersen *et al.*, 2001). Rare and endangered species are found in urban cemet (Kowarik, 1992). Cemeteries with a high structural diversity are an important habitat especially for in (Richter, 1994; Schmidt, 1994; Hottinger, 2004). The relationship between biodiversity (here mainly refe species diversity) and ecosystem functioning has received increasing scientific interest in recent dec (Balvanera *et al.*, 2006). Cemeteries take over various functions in urban areas like providing important hab for a variety of species. Insect populations maintain the diversity and balance between system components enhance urban cemetery management. They form a major component of ecosystem biodiversity, complexity stability. Cemeteries are particularly worthy for biodiversity protection due to high species diversity and va of valuable ecosystem services and thus promotes biodiversity.

THE ECOLOGICAL VALUE AND ECOSYSTEM SERVICES PROVIDED BY CEMETERIES

In cemetery potential habitats are formed by paths, graves and tombstones, lawn and meadow areas, natural planted trees, shrubs, hedges, bushes, groups of trees, flower beds and ornamental plants as well as pile leaves or compost. A very old cemetery may maintain the original soil profile or native plants providing ecological link to the past (Wexler, 2008). Nature provides us with goods and services free of any visible ch and as reflected in the concept of ecosystem services. These are the benefits that people obtain from ecosyste e.g. food, freshwater, timber, climate regulation, protection from natural hazards, erosion con pharmaceutical ingredients and recreation. The value of ecosystem services provided by nature is substa (Balmfort *et al.* (2002). Therefore, cemeteries in many cities have been designated as "climate regulation ar and partly as "cold air producing areas" (Laske, 2002). Cemeteries perform various tasks as part of a g infrastructure. Cemeteries may provide important ecosystem services and function as refuges for endange species. This is due to characteristic features of cemeteries such as: (i) Multi-layered (ii) Semi-open habitats, Old age of soils and locations; and (iii) High level of habitat diversity. Cemeteries are among the most valu of historic resources. They are reminders of various settlement patterns, such as villages, rural communi urban centers, and ghost towns. The purpose this study is to demonstrate that cemeteries should be managed researched as urban green spaces that provide ecosystem services. Green cemeteries provide an opportunity people to reconnect with the biotic community and can also facilitate ecological restoration and landscape-l conservation.

The Importance of Cemeteries to the Community

Cemeteries have a deep historical connection to the local community. They hold great significanc communities across the country, and it's important to remember their value throughout our lives. They b residents closer to an understanding of the past and help to provide insights into how people within the area u to live. Local cemeteries can help offer as pace that brings comfort to families as they struggle with their g while remembering loved ones. Beyond their functional value as an area in which to place people after they passed, cemeteries can act as a place of memorial. We found that besides their religious function, cemete have a considerable conservation role in worldwide. A successful return to the traditional local commu management practices will only be possible if the communities can meet the challenges posed by the mod world and adapt to its social and economic changes. The importance of a cemetery's age for its ecological va has been described by Richter (2003). He suggests that age is an important criterion for the differentiation cemeteries due to the partially forest-like structures, the often- extensive care and the preferred ornamental p species of old cemeteries.

Cemeteries create less environmental pollution and enhanced understanding of natural processes (Francis et 2000). Cemeteries have also been in use for a variety of activities throughout history (Brendalsmo 20

Deering 2014). Many cemeteries have important cultural values as historical landscapes and through their long history can illustrate changing views about landscape design and management. Brechin *et al.* (2002) reported that informal conservation traditions also have a high degree of acceptance among local communities as historical and cultural landscapes they hold shared social meanings for the public. Their natural resources offer aesthetic and sustainable environmental benefits to urban areas. Cemeteries can reveal information about historic events, religions, lifestyles, and genealogy. The significant biodiversity at sacred burial grounds documented worldwide highlights the importance of customs in maintaining elements of the landscape for centuries, while currently their existence is largely threatened by changing demands of the modern world. As ethics is a communal matter, we need to develop our social skills and mechanisms as well in order to develop our attitude towards such sensitive cases like the conservation of natural values in cemeteries. The future of biodiversity will depend on the global collective action of an educated society, including efforts to promote local and indigenous knowledge of biodiversity. There is an urgent need to protect and conserve this enormous diversity of life which is so vital to many ecosystem functions.

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References :

- Andersen, A. N., Ludwig, J. A., Lowe, L. M. and Rentz, D. C. F.(2001). Grasshopper biodiversity and bioindicators in Australian tropical Savannas: responses to disturbance in kakudu National Park. Austral Ecology26: 213-222.
- Anderson, D. M., Salick, J., Moseley, R. K. and Xiaokun,. O.(2005). Conserving the sacred medicine mountain: A vegetation analysis of Tibetan sacred sites in Northwest Yunnan. Biodiversity and Conservation14: 3065-3091.
- Annerstedt, M., Ostergren, P. O., Bjork, J., Grahn, P., Skarback, E. and Wahrborg, P.(2012). Green qualities in the neighbourhood and mental health - results from a longitudinal cohort study in Southern Sweden. BMC Public Health12: 337.
- Arffmann, L.(2000). "Whose cemetery?" Mortality 5(2): 125-126.
- Balmford, A., Bruner, A., Cooper, P., Costanza, R., Farber, S., Green, R. E., Jenkins, M., Jefferiss, P., Jessamy, V., Madden, J., Munro, K., Myers, N., Naeem, S., Paavola, J., Rayment, M., Rosendo, S., Roughgarden, J., Trumper, K. and Turner, R. K.(2002). Economic reasons for conserving wild nature. Science297: 950-953.
- Balvanera, P., Pfisterer, A. B., Buchmann, N., He, J. S., Nakashizuka, T., Raffaelli, D. and Schmid, B.(2006). Quantifying the evidence for biodiversity effects on ecosystem functioning and services. Ecology Letters9: 1146-1156.
- Barrett, G. W. and Barrett, T. L.(2001). Cemeteries as repositories of natural and cultural diversity. Conservation Biology15 (6):1820-1824.
- Bhagwat, S. A. and Rutte, C.(2006). Sacred groves: potential for biodiversity management. Frontiers in Ecology and the Environment4(10):519-524.
- Bhagwat, S. A.(2009). Ecosystem services and sacred natural sites: reconciling material and non-material values in nature conservation. Environmental Values: 417-427.
- Blomley, N.(2005). "Flowers in the bathtub: Boundary crossings at the public-private divide." Geoforum 36: 282-296.
- Brandt, J. S., Wood, E. M., Pidgeon, A. M., Han, L. X., Fang, Z. and Radeloff, V. C.(2013). Sacred forests are keystone structures for forest bird conservation in southwest China's Himalayan Mountains. Biological Conservation166: 34-42.
- Brechin, S. R., Wilshusen, P. R., Fortwangler, C. L. and West, P. C.(2002). Beyond the square wheel: toward a more comprehensive understanding of biodiversity conservation as social and political process. Society and Natural Resources15: 41-64.
- Brendalsmo, J.(2014). "Gildeskal kirkegård." In Gildeskal gamle kirke. Marmorkirka ved Nordvegen edited by M. Stige and O. Ekroll 75-96. Trondheim: Fagbokforlaget.

- Bruner, A.G., Gullison, R.E., Rice, R.E. and da Fonseca, G.A.B. (2001). Effectiveness of parks in pro tropical biodiversity. Science291: 125–28.
- Bryant, G. L., Dundas, S. J. and Fleming, P. A.(2012). 'Tree Hollows Are of Conservation Importance for a Threatened Python Species'. Journal of Zoology286: 81–92.
- Carpaneto, G. M., Mazziotta, A.,Coletti, G., Luiselli, L. and Audisio, P. (2010). Conflict between Conservation and Public Safety: The Case Study of a Saproxylic Beetle (*Osmoderma eremita*) in Urban Journal of Insect Conservation14 (5): 555–65.
- Chandrakanth, M. G., Bhat, M. G. and Accavva, M. S.(2004). Socio-economic changes and sacred groves in India: protecting a community-based resource management institution. Natural Resources Forum28: 102–11.
- Curl, J. S.(1999). Oxford Dictionary of Architecture. Oxford University Press, - Oxford.
- Deak, B., Tothmeresz, B., Valko, O., Sudnik-Wojcikowska, B., Moysiyenko, I.I., Bragina, T. M., Apostolo Dembicz, I., Bykov, N. I. and Torok, P.(2016). Cultural monuments and nature conservation: a review of th of kurgans in the conservation and restoration of steppe vegetation. Biodiversity and Conservation25(3): 1-18
- Deak, B., Tolgyesi, C., Kelemen, A., Batori, Z., Galle, R., Bragina, T. M., Yerkin, A. I.and Valko, O.(2018 effects of micro-habitats and grazing intensity on the vegetation of burial mounds in the Kazakhsteppes. Ecology and Diversity10: 509-520.
- Deering, B.(2010). From anti-social behaviours to X-rate: exploring social diversityand conflict in the cem In: Maddrell, A., Sidaway, J.D. (Eds.), Death-scapes, Spaces for Death, Dying, Morning and Remembe Ashgate Publishing Limited, Farnahm, England.
- Deering, B.(2014). "In the dead of night." In The power of death: Contemporary reflections on death in w society edited by M. J. Blanco and R. Vidal, 183–197. New York, Berghan Books.
- Dudley, N., Bhagwat, S., Higgins-Zogib, L., Lassen, B., Verschuuren, B. and Wild, R.(2010). Conservati biodiversity in sacred natural sites in Asia and Africa: a review of the scientific literature. In: Verschuure Wild, R.A., McNeely, J., Oviedo, G. (Eds.), Sacred Natural Sites: Conserving Nature and Culture. Earth London and Washington DC, pp. 19-33.
- Fleming, H. L. and Jones, J. C.(2013). 'Multi-scale Roost Site Selection by Rafinesque's Big-eared (*Corynorhinus rafinesquii*) and Southeastern Myotis (*Myotis austroiparius*) in Mississippi'. American Mi Naturalist169(1): 43–55.
- Francis, D., Kellaher, L. and Neophytou, G.(2000). Sustaining cemeteries; The user perspective. Mortality5(1 52.
- Gibbons, P. and Lindenmayer, D.(2002). Tree Hollows and Wildlife Conservation in Australia, Collingwood, CSIRO Publishing.
- Gilbert, O.L.(1989). The Ecology of Urban Habitats, London: Chapman and Hall.
- Gilbert, Q. L.(1991). The Ecology of Urban Habitats. New York, Chapman and Hall.
- Hennessey, C. A., Dubach, J. and Gehrt, S. D.(2012). 'Long-term Pair Bonding and Genetic Evidenc Monogamy among Urban Coyotes (Canis Latrans)'. Journal of Mammalogy93:732–42.
- Hottinger, H.(2004). Grundlagen zum Schutz von Tagschmetterlingen in Städten (Lepidoptera: Papilionoid Hesperioidea). Oedippus 22: 1-48zit nach Rabitsch (2009).
- Kocian, L., Nemethova, D., Melicherova, D. and Matushkova, A.(2003). Breeding bird communities in cemeteries in the City of Bratislava (Slovakia). Folia Zoologica52(2): 177-188.
- Kong, L.(2012). No place, new place: death and its rituals in urban Asia. Urban Studies 49(2): 415–433.
- Kowarik, I.(1992). Das Besondere der städtischen Flora und Vegetation. Natur in der Stadt – der Beitra Landespflege zur Stadtentwicklung. Schriftenreihe des Deutschen Rates für Landespflege. Bonn Heft61: 33–
- Kowarik, I., Buchholz, S., von der Lippe, M. and Seitz, B.(2016). Biodiversity functions of urban ceme Evidence from one of the largest Jewish cemeteries in Europe. Urban Forestry & Urban Greening19(1): 68-7
- Laske, D.(1994). "Cemeteries: Ecological Niches in Populated Areas."The Science of Nature81(5): 218-223.
- Laske, D.(2002). Ökologische Nische und Erholungsraum. In: Stadt + Grün, Fachzeitschrift für die ge öffentliche Grüngestaltung und Grünpflege11: 40-47.
- Loki, V., Deak, B., Andras Balazs Lukacs, A. K. and Molnar, V. A.(2019). Biodiversity potential of burial ca review on the flora and fauna of cemeteries and churchyards. Global Ecology and Conservation. 18: 1-15
- Lussenhop, J.(1977). Urban cemeteries as bird refuges. Condor79(4): 456-461.
- Maas, J., Verheij, R. A., Groenewegen, P. P., De Vries, S. and Spreeuwenberg, P.(2006). Green space, urb and health: how strong is the relation? Journal of Epidemiology and Community Health60: 587-592.
- McClymont, K.(2016).That Eccentric Use of Land at the Top of the Hill: Cemeteries and Stories of the Mortality21(4):378–396. doi: 10.1080/13576275.2016.1151865.
- Mitchell, R.(2012). Is physical activity in natural environments better for mental health than physical activ other environments? Social Science & Medicine, 10.1016/j.socscimed.2012.04.012.

- Moorehouse, A. K. and Hassen, H.(2004). Protecting pioneer cemetery prairies: balancing the need to preserve cultural and natural heritage values. In: Proceedings of the 19th North American Prairie Conference 81: 163-167.
- Orstan, A. and Kosemen, M.(2009). Graves and snails: biodiversity conservation in an old cemetery in Istanbul, Turkey. Triton19: 40-41.
- Newton, I.(1998). Population Limitation in Birds, London: Academic Press.
- Pickett, S. T. A. and Cadenasso, M. L.(2008). Linking ecological and built components of urban mosaics: an open cycle of ecological design. Journal of Ecology96: 8–12.
- Ranius, T. and Jansson, N.(2000). The Influence of Forest Regrowth, original Canopy Cover and Tree Size on Saproxylic Beetles Associatedwith Old Oaks. Biological Conservation95: 85–94.
- Richter, G.(1994). Gestaltung und Pflegegrundsätze für Dorffriedhöfe und Kirchhöfe. – Laufener Seminarbeiträge 1/94: 65-75 zit nach Rabitsch (2009).
- Richter, M.(2003). Die Bedeutung städtischer Gliederungsmuster für das Vorkommen von Pflanzenarten unter besonderer Berücksichtigung von Paulownia tomentosa (Thunb.) Steud. – dargestellt am Beispiel Stuttgart. Dissertation, Hohenheim.http://opus.ub.uni-hohenheim.de/volltexte/2003/38.
- Rogers, R.(1997). "Cemeteries as Greenspaces." Urban Naturalist2(Summer): 8.
- Rugg, J.(2000.) Defining the place of burial: what makes a cemetery a cemetery? Mortality5(3): 259-275.
- Saha, H. K. and Islam, L.(2020). Comparative study on species composition and diversity of insects in the South Park Street Cemetery and Banabitan Park, West Bengal, India. Ecology Environment and Conservation26: S236-S242,
- Schmidt, A.(1994). Friedhöfe und Naturschutz – Bedeutung der Friedhöfe für die Tier- und Pflanzenwelt. – Laufener Seminarbeiträge, 1/94, 53-59, zit nach Rabitsch (2009).
- Schröder, R.(2007). Friedhöfe als planerische Herausforderung für die Stadtplanung. Jahrbuch Stadterneuerung 2006/2007: 113.
- Sloane, D. C.(1991). "The Last Great Necessity: Cemeteries in American History." The Johns Hopkins University Press.
- Sloane, D. C.(1995.)The last great necessity: cemeteries in American history. Baltimore, M.D: Johns Hopkins University Press.
- Smith, K. G., Withgott, J. H. and Rodewald, P. G.(2000). 'Red-headed Woodpecker (*Melanerpes erythrocephalus*)', in A. Poole (ed.) The Birds of North America Online. Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online:<http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/518>accessed December 2014. doi: 10.2173/bna.518.
- Smith, R. M., Thompson, K., Hodgson, J. G.,Warren, P. H. and Gaston, K. J.(2006). Urban domestic gardens (IX): composition and richness of the vascular plant flora, and implications for native biodiversity. Biological Conservation129: 312-322.
- Stigsdotter, U. K., Ekholm, O., Schipperijn, J., Toftager, M., Kamper-Jorgensen, F. and Randrup, T. B.(2010). Health promoting outdoor environments - Associations between green space, and health, health-related quality of life and stress based on a Danish national representative survey. Scandinavian Journal of Public Health38: 411-417.
- Sukopp, H.(1990). Stadtökologie. Das Beispiel Berlin. Reimer Berlin, 455 S.
- Valko, O., Toth, K., Kelemen, A., Miglecz, T., Radocz, S. and Sonkoly, J.(2018). Cultural heritage and biodiversity conservation - plant introduction and practical restoration on ancient burial mounds. Journal for Nature Conservation24: 65-80.
- Ward Thompson, C., Roe, J., Aspinall, P., Mitchell, R., Clow, A. and Miller, D.(2012). More green space is linked to less stress in deprived communities: evidence from salivary cortisol patterns. Landscape and Urban Planning105(3): 221-229.
- Wasserman, J. R.(1998). "To Trace the Shifting Sands: Community; Ritual, and the Memorial Landscape." Landscape Journal 17(1): 42-61.
- Wexler,M.(2008). Peaceful islands of biodiversity. National Wildlife12-13.
- Woodthorpe,K.(2011).Sustaining the Contemporary Cemetery: Implementing Policy Alongside Conflicting Perspectives and Purpose. Mortality16(3):259–276. doi:10.1080/13576275.2011.586125.

Air Pollution in Some Selected States of India: A Study

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Abstract :

The present study is an attempt to analyze the level of air pollution during 2007 to 2020 in the 16 polluting states of India. Also the relative performance of the states in terms of total air pollutants are tried understood. The total pollutants considered is the sum of SO_2, NO_2, PM10 and PM2.5. National Abateme Quality Monitoring Program Data, World Bank Group data and CAPM data are used. There is clear evide inter state disparity found. 9 out of 16 states shows pollution level either increased or remain unchanged the sample period. The pollution level of the sample states is found to be less compared to all states' a except UP and MP.

Key Words : Air Pollution; NO_2; PM10; PM2.5; SO_2

During the last two decades or so, many experts have drawn attention to the close between environment and development. According to the 'World Development Report environment problems can undermine the goals of development in two ways. First, wate is safe and plentiful and air that is healthy is itself part of the improvement in welfare development attempts to bring. Secondly, Environment damage can undermine productivity. With India's economic growth, its production sector like steel manufacturing industry, oil refining industries have expanded. On the one way In economic growth has increased and it also lead to increase in number of jobs, on the side this economical growth has increased pollution in India mostly in Delhi, West Be Madhya Pradesh, etc. There are various types of pollution like air pollution, water poll sound pollution, and also soil pollution. Among this pollution, air pollution has most i on our environment, and health in India. WHO (2002) estimated that 1.6 million people each year globally due to indoor smoke from the use of traditional fuels in home. The common is incomplete combustion of fuels such as wood, agricultural residues, animal and charcoal. Pollution affects the organs of respiration of human bodies, nose, throa According to the World Bank study, children under 5 years and female are mostly affect indoor air pollution. Outdoor air pollution is measured by particulate matter (PM), extr particles smaller than 2.5 micro meters (PM2.5). It can go further into lungs and airwa carry metals, SO2 and NO2. Air pollution increases with increase in the number of ve engines, factories, industries etc. The air pollution (Prevention and Control of Poll Act,1981 is the main enactment for regulating air quality through the Pollution C Boards (PCBs) in the dates.

The present study therefore attempts to access the pollution level of the major polluting of India overtime. The next portion of the present paper is organized as follows:

Section 2 presents literature survey and the scope of the study. In methodology Section and data source are presented. Results of analysis and summary and concluding remarks are made in next sections respectively.

The survey of literature reveals that there are studies on air pollution in India and around the globe considering different aspects. In this connection mention should be made of the names such as Dinda, Coondoo, Pal (2000), Zivin & Neidell (2011), Khan & Tarique (2015), Li, Liu, & Salvo (2015), He, Liu & Salvo (2016), Fotourehchi (2016) Fu, Viard and Zhang (2017), Khan and Tarique (2019) among others.

The literature review on air pollution reveals that all the studies are in global perspective or focused on a particular state in India. But study ondifferent statesover time and analyzing the major polluting states for different years is practically lacking in the literature. The present study is in the footsteps of earlier studies on India. It is different from earlier studies in the sense that it attempts to understand state level pollution. Thus the present study is an attempt to fill the gap in the existing literature.

Thus the major objectives of the present study are twofold: First it tries to analyze the level of air pollution overtime in the major polluting states of India and secondly it attempts to understand the relative performance of the Indian states in terms of pollution.

Material & Methods

The pollutants considered in the present studyare SO_2, NO_2, PM10 and PM2.5. Sulphur Dioxide (SO_2) is one of the dangerous environmental pollutant gases. It mainly effused from eruption of volcanoes and combustion of fossil fuel. It has direct impact on human body and also damages stone, concrete, paint etc. Also it causes skin irritation, reduction of visibility, asthma, etc. Nitrogen Dioxide (NO_2) is also one of the hazardous environment gases. It increases a person's vulnerability to, damage to the human respiratory tract and respiratory infections and asthma. Particulate matter 10 (PM10) particles are very small that they effectively act as a gas as SO_2. When we breathe this molecule it entered into our lungs. High concentration of PM10 can result in a number of deaths, coughing and wheezing to asthma attacks and bronchitis to high blood pressure, heart attack, strokes and also premature death occurs due to this concentration. Particulate matter 2.5 (PM2.5) are able to travel deeply into the respiratory tract and reaching the lungs. It affects our eyes, lungs, nose, and throat. For this concentration coughing, sneezing, runny nose and shortness of breath, etc diseases occur.

To analyze the level of air pollution overtime in the major polluting states of India, comparison of the total pollution among the selected states are done for each sample year i.e. from 2007 to 2020 and are ranked accordingly.

To understand the relative performance of the Indian states in terms of total air pollutants, the arithmetic mean of total air pollutants is calculated for each of the 16 sample states as well as for all states taken together i.e. the grand mean (GM).Then the arithmetic mean of total air pollutants for each of the 16 sample states is compared with GM to have an idea about the relative performance of the states. The states are classified as bad performer or good performer on the basis of the following criterion:

Good performing state : Average total air pollutants level for any state is less than GM

Bad Performing State : Average total air pollutants level for any state is more than GM

The data on total air pollutants is the sum of SO_2, NO_2, PM10 and PM2.5. Da these four pollutants for 16 states during 2007 to 2020 are collected from National Abate Air pollution data for different years, World Bank Group data and CAPM data.The considered are Delhi (DE), Madhya Pradesh (MP), Rajasthan (RJ), Uttar Pradesh (UP), Bengal (WB), Andhra Pradesh (AP),Assam (AS), Maharashtra (MH) , Orissa Chhattisgarh (CH), Karnataka (KA), Kerala (KE), Tamilnadu (TN), Punjab (PU),Him Pradesh (HP) and Gujarat (GU).

Results and Discussion

India is done. Comparisons of the total air pollution among the selected states are done the In this section, analysis based on the level of air pollution overtime in the 16 sample of states for each time period are ranked which is presented in Table 1. The state maximum pollution is assigned rank 1 and vice versa. To understand the relative perform of the states in terms of total air pollutants, comparison of the average value of all 16 with the GM is done which is represented in Table 2.

This analysis shows how much affected are the sample states by the total pollu which is the sum of SO_2, NO_2, PM10 and PM2.5. There is clear evidence of inter disparity based on the level of total air pollutants. By comparing the total air pollution ar the selected states for each time period, states are ranked which is presented in Table year 2007, UP is in the 1st position and Assam is in the last position. In year 2008, again in the 1st position and Assam in the last position. In year 2009, UP remained in position, WB takes the 2nd position and Rajasthan take the last position. In year 2010 again take the 1st position and HP take the last position. From 2011 to 2013, UP is in t position and WB is in the last position. In year 2014, UP is in the 1st position and Delhi the last position. In year 2015, AS is in the 1st position and UP is in the last position. 2016 to 2019, UP is the highest pollutant state and Chhattisgarh is the least pollutant among the selected states. In year 2020, Tamilnadu is in the 1st position and Chhattisg again in the last position.

During the sample period, states whose rank increased are Chhattisgarh, Gu Delhi, Himachal Pradesh, Kerala, Uttar Pradesh and West Bengal which suggests that pollution level decreased. For Assam, Madhya Pradesh, Orissa, Punjab, Rajas Tamilnadu and Maharashtra rank decreased which implies that these states' pollution increased. The states whose rank remained unchanged are Karnataka and Andhra Prades for most of the states i.e. 9 out of 16 states shows pollution level either increased or rem unchanged.

By comparing the mean pollution of the 16 states with GM, it can be seen th average value of UP and MP is much higher than GM. For the rest of the states, the av values of total pollution are below the GM. Thus Table 2 represents that the average valu total pollutant in most of the states are below the GM excepting UP and MP whose pol

level is level is more than all states' average. It can be concluded that excepting UP and MP, all the states are performing good when compared to all states taken together.

Conclusion :

The present study tries to analyze the level of air pollution overtime in the major polluting states of India. Also the relative performance of the Indian states in terms of total air pollutants are tried to be understood.

From the above analysis it can be concluded that there is clear evidence of interstate disparity. During the sample period, states whose rank increased are Chhattisgarh, Gujarat, Delhi, Himachal Pradesh, Kerala, Uttar Pradesh and West Bengal which suggests that their pollution level decreased. For Assam, Madhya Pradesh, Orissa, Punjab, Rajasthan, Tamilnadu and Maharashtra rank decreased which implies that these states' pollution level increased. The states whose rank remained unchanged are Karnataka and Andhra Pradesh. So for most of the states i.e. 9 out of 16 states shows pollution level either increased or remained unchanged. All the sample states are good performer excepting UP and MP which are bad performer.

References :

- World Development Report 1992: Development and the Environment. New York: Oxford University Press. © World Bank. https://openknowledge.worldbank.org/handle/10986/5975 License: CC BY 3.0 IGO."
- Bell, M. L., McDermott, A., Zeger, S. L., Samet, J. M., & Dominici, F. (2004). Ozone and short-term mortality in 95 US urban communities, 1987-2000. *Jama*, *292*(19), 2372-2378.(WHO 2002 data work)
- Dinda, S., Coondoo, D. and Pal, M. (2000). Air quality and economic growth: An empirical study, Ecological Economics, 2000, vol. 34, issue 3, 409-423
- Fotourehchi, Z. (2015). Health effects of air pollution: An empirical analysis for developing countries, October 2015, Atmospheric Pollution Research 7(1), DOI: 10.1016/j.apr.2015.08.011
- Mele1, M. & Magazzino, C. (2020). Pollution, economic growth, and COVID-19 deaths in India: a machine learning evidence.
- Li, Teng. Liu, H. and Salvo, A. (2015). Severe Air Pollution and Labor Productivity, IZA Discussion Papers, No. 8916, Institute for the Study of Labor (IZA), Bonn, DOI:10.13140/RG.2.1.2680.5286
- He,J., Liu,H. and Salvo, A. (2016). Severe Air Pollution and Labor Productivity: Evidence from Industrial Towns in China, American Economic Journal: Applied Economics, Vol. 11, No. 1, January 2019.
- Fu, S. &Viard, Brian & Zhang, Peng(2017). Air Quality and Manufacturing Firm Productivity: Comprehensive Evidence from China, MPRA Paper 78914, University Library of Munich, Germany.
- Khan, A. W., Adnan, M., Hussain, S., & Tariq, M. (2015). Decline of Film Industry in Pakistan Causes and Future Prospects. International Journal in IT & Engineering, 3, 1-22.
- Joshua Graff Zivin and Matthew Neidell (2013). Environment, Health, and Human Capital.
- Journal of Economic Literature, Vol. 51, No. 3 (September 2013), pp. 689-730.
- Khan, M. and Tarique, M. (2015). Industrial Pollution in Indian Industries: A Post Reform Scenario Journal of Energy Research and Environmental Technology (JERET), Volume 2, Number 2; January-March, 2015; pp. 182-187.

Table 1: Rank of the Indian States over the sample period in terms of Total pollution

States	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	20
AP	6	7	5	7	7	3	3	3	4	10	10	5	
AS	16	15	11	14	13	10	7	10	1	14	15	14	1
CH	7	10	8	13	12	15	13	13	13	16	16	16	1
DE	5	9	14	12	14	13	15	16	12	12	11	11	1
GU	3	5	7	3	3	5	5	8	8	8	7	6	9
HP	13	8	6	16	10	9	10	6	10	13	14	13	1
KA	11	4	9	11	8	8	6	7	7	11	9	12	1
KE	8	14	11	10	15	14	9	9	9	15	13	15	1
MH	10	2	4	5	4	4	8	11	5	6	8	8	6
MP	9	6	12	2	2	2	2	2	2	2	3	3	3
OR	14	11	10	9	5	6	11	5	3	5	5	9	8
PU	12	12	13	4	6	7	4	4	6	7	6	7	7
RJ	15	13	15	8	9	11	14	14	14	4	4	4	4
TN	4	7	3	6	11	12	12	12	11	9	12	10	1
UP	1	1	1	1	1	1	1	1	16	1	1	1	1
WB	2	3	2	15	16	16	16	15	15	3	2	2	2

Table 2: Relative performance of the States in terms of Total pollution

	Relative performance	
	Good	Bad
States	Andhra Pradesh, Assam, Chhattisgarh, Delhi, Gujarat, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Orissa, Punjab, Rajasthan, Tamilnadu and West Bengal.	Madhya Pradesh Uttar Pradesh

Celebrating Spectral : Exploring the Essence of Carnival in Anik Dutta's *Bhooter Bhabishyat* (2012) and *Bhobishyoter Bhoot* (2019)

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Abstract :

After Satyajit Ray, Ritwik Ghatak, and Mrinal Sen, Bengali Film industry witnessed a dissociation of aesthetics in representation on screen. The films followed a typical theme and structure where hardly any thread of creative mind is identified. The gothic films too were never appealing to audience's sensations and were blunt in representation. It was the high time when the directors should change the currency of Bengali films by emphasizing the creative mind, and in this regard Anik Dutta's *Bhooter Bhabishyat* (2012) and *Bhabishyoter Bhoot* (2019) stand as iconoclastic pieces. After Ray's *Aranyer Din Ratri* (1970), Bakhtin's idea of 'Carnival' was not so properly used by the directors in Bengali films. Dutta tried to fuse the essence of Bakhtinian Carnivalesque into the genre of comic-horror to attribute novelty to existing film-literary practices. The satire and the comedy used in both films attributed a sense of 'Carnival' to them, and at the same time the de-crowning of the Authority has been shown through the help of metaphoric devices. This paper aims to identify the link as to how Anik Dutta has used Bakhtin's idea of 'Carnival' into his films, and by doing so, has restored the proper aesthetics through creative representation.

Key words : Mikhail Bakhtin, Carnival, Anik Dutta, Satire, Comic-Horror, Deconstructing Spectral.

Charles Lock, the famous Bakhtin critic, is of the opinion that: "In the history of modern thought few can match Bakhtin's contribution, in depth, generosity, range of application. Yet, to consider Bakhtin's thought in terms of contributions to ideas and concepts and disciplines already formulated or established is to obscure his true importance—that of the re-thinker." (Lock, 1991, p.68). This is true in certain ways. Bakhtin's works and ideas gained popularity after his death. Much of what he wrote was initially shrouded in controversy. This was partly because of the limited access to the Russian archives for Bakhtin scholars. However, after the archives opened up, scholars obtained information that gave a new dimension to his works. Bakhtin stands as one of the key figures who introduced a new stance to the existing literary traditions, and one such stance was 'Carnivalesque'. The 'Seriocomic' literature was not a new discourse in the history of English literature, but Bakhtin attributed novelty to it. Carnivalisation has its relation to the ancient and medieval literature and the genre which was influenced by and has influenced this was Folk-lore. When Bakhtin started writing about carnival, he saw it as one of the key roots [besides epic and rhetoric] through which the novelistic genre came into existence as he remarks:

> "Speaking somewhat too simplistically and schematically, one could say that the novelistic genre has three fundamental roots: the epic, the rhetorical, and the carnivalistic (with, of course, many transitional forms in between). It is in the realm of the seriocomic that one must seek the starting points of development for the diverse varieties of the

> third, that is the carnivalistic, line of the novel, including that variety which leads to Dostoevsky". (Bakhtin, 1984, p.109).

It is true that Bakhtin's book was heavily engaged in analyzing Dostoevsky's w and how Dostoevsky dealt with seriocomic elements in his writings. But at this momen face a serious question- can Carnivalesque only be attributed to the genre of fiction? The a sheer challenge in contextualizing the Carnival as to whether and how we can see it thro different lenses. This paper aims to analyze how Carnivalesque has been applied by Dutta, the famous Bengali Indian film director who has very deliberately dealt seriocomic issues in his two films *Bhooter Bhabishyat* (2012) and *Bhobishyoter B* (2019). *Bhooter Bhabishyat* is an Indian-Bengali ghost comedy film that was the bigges in the 2012 box office. Critically discussing about the social problems, the film was an ou out comedy film. Many believed that it was a comic-horror film, but some claimed it to satire on the social changes that took place under the veil of metropolitanization. On the o hand, *Bhobishyoter Bhoot* is a Bengali-satirical comedy film that was initially banne theatres by the West Bengal police after its quick release due to its rich attacks on so political issues. However, the film was again screened at theatres after the order issued by Hon'ble Supreme Court of India where it is said that: "Free speech cannot be gagged for of the mob...It expressed concern over 'growing intolerance' in society against art freedom." (2019, www.scroll.in). Both the films somehow grabbed the essence of Carnivalesque which is to be analyzed through a discussion under this paper.

Before going onto any discussion related to Carnival, we should understand first carnivalistic seriocomic devices are different from those of satires and tragic-comedies; how the two films which are selected as primary texts fit into the very idea of Carn Tragicomedy is a literary genre that blends aspects of both tragic and comic forms. often seen in dramatic literature, the term can describe either a tragic play that con enough comic elements to lighten the overall mood or a serious play with a happy en (Dewar-Watson, 2017, p.17). The tragic elements with serious issues can be seen in al theatre as well, but whether they are tragic or comic, that is always inconclusive. In the of satires, the earliest and later prominent examples deal with the serious in a round- way, but the comic element is not an obligatory part of the satires. So technically, both and tragic-comedy have serious elements in them so as Carnival, but what makes it diff is the idea of 'fooling' [presenting the king/ authority as fools] at the centre of a car which helps the writer to fuse serious elements under the curtain of comic Carnivalis While defining Carnival, Bakhtin remarks:

> "The primary carnivalistic act is the mock crowning and subsequent decrowning of the carnival king. This ritual is encountered in one form or another in all festivities of the carnival type: in the most elaborately worked out forms-the saturnalia, the European carnival and festival of fools (in the latter, mock priests, bishops or popes, depending on the rank of the church, were chosen in place of a king); in a less elaborated form, all other festivities of this type, right down

to festival banquets with their election of short-lived kings and queens of the festival." (Bakhtin, 1984, p.124).

This decrowning ceremony is a flattery so that the inefficiency of the authority [King, Church, Clergymen or Politicians] can be presented before the mass through the help of satiric devices. So, the serious issues are presented through comic incidents and that becomes the essence of Carnival. *Bhooter Bhabishyat* highlighted the destruction of the heritage buildings in Kolkata and how the government officials are aloof in guarding the heritage of Bengal. The decrowning is seen when the renowned industrialist Ganesh Bhutoria tried to demolish the Choudhury Palace to create a shopping mall. The film is also important as it throws light into several socio-political issues. On the other hand, *Bhabishyoter Bhoot* highlighted the controversy between Communist- Marxists and the newly established affiliation of the Congress party. This is a satiric commentary on the political power shifting that took place in West Bengal, and how after the political shift, under the name of 'Development', the cut-money is sought by the barkers of the ruling party. The film also emphasizes why the Leftist-communism failed to secure its place in West Bengal, and how traditional aesthetics has been rinsed from Bengali culture.

While defining Carnival, Bakhtin mentioned certain typical characteristics of this genre. Though it is still not clear whether they are particularly addressed towards Carnival or not. Bakhtin used the term 'all seriocomic genres' which include Carnival as well. The first characteristic of Carnival is its 'new relation to reality'. (Bakhtin, 1984, p.108). By reality, Bakhtin does not mean the kind of reality which we see in Victorian texts. This reality is oriented towards a better understanding of real life existence. Both the films have one common reality in representation where they invoke the past. The demolition of the heritage buildings in Kolkata stands as the demolition of colonial history as they remind of the contribution of too many people who in some way or the other instrumental in bringing independence. The ghosts who live in Choudhury palace are united by their diverse cultural identity, but the sense of patriotism, if called for, is vigorously present in them. Similarly, *Bhobishyoter Bhoot* talks about the possibilities of 'Time' and what could have been achieved if the government was instrumental in bringing the same. Secondly, the seriocomic do not rely on legend and do not sanctify themselves through it, they consciously rely on experience [to be sure, as yet insufficiently mature] and on the free invention (Bakhtin, 1984, p.108). While defining 'Carnival', Bakhtin is of the opinion: "Carnival is the place for working out, in a concretely sensuous, half-real and half-play-acted form, a new mode of the interrelationship between individuals, counterposed to the all-powerful socio-hierarchical relationships of noncarnival life." (Bakhtin, 1984, p.123). This is true for both the films. *Bhooter Bhobishyat* has changed the currency of Bengali cinema because it was not like a typical horror film. Though it deals with ghosts, the film has an altogether new style in which the plot is presented. There is a shift in time and place, and the idea of the film is seen to be emerging as a dream out of the director's mind. There is a constant urge in characters to hold their identity because their past life, in some way or the other, had suffered an identity crisis. Many claimed *Bhobishyoter Bhoot* to be a sequel to the earlier film, but the director has firmly disagreed on it. "The only similarity remains in the fact that it is another film on modern-day ghosts where we have also commented on certain social and political issues

confronting the present times. The comments come from the mouths of ghosts," Dutta said (business-standard.com). Thirdly, the texts of this genre are generally multi-styled and hetero-voiced as Bakhtin remarks: "Characteristic of these genres are a multi-toned narration, the mixing of high and low, serious and comic; they make wide use of inserted genres-letters, found manuscripts, retold dialogues, parodies on the high genres, parodically reinterpreted citations..." (1984, p.108). Apparently, the language of both the films is lucid, but the films have overt messages to convey. That is why many of the dialogues are ambiguous and paves the way for multiple interpretations. We'll discuss it in the latter part of the paper. Let us delve into the analysis of these characteristics, and see how we can look at them from a carnivalistic angle.

Bappa Maji, Dr. Surajit Saha, and Dr. Ritwij Bhowmik are of the opinion in their article that, "Bengali films had been divided into two types like commercial and art house." (2019, p.2550). Both the films which I would like to talk about i.e. *Bhooter Bhabishyat* (2012) and *Bhobishyoter Bhoot* (2019) were artistic and commercially successful. *Bhooter Bhabishyat* was a superb box-office success as Anik Dutta, the director of the film, said in Times of India: "I have heard many people are going to theatres for the second or third time." (Quoted in Maji 2551). The films shook the pillars of traditional ghost-literary ideologies and the use of 'horror comedy' attracted Bengali viewers. The film challenges the traditional role of ghost played in earlier films and amuses the audience through witty and sharp humor. Though the title of the film refers to ghosts, yet there is no sense of eeriness. Instead, there is a sense of celebration from the very beginning till the end. The figures no longer frighten us; rather there is deconstruction in representation. The ghost world traditionally was non-carnivalistic. The first instances we find, perhaps, in *Jomaloye Jibonto Manush* (1958) and *Gupi Gayen Bagha Bayen* (1969) where the ghosts are fond of dance and merry-making. But the first infusion of comic and carnival within Ghost culture is, perhaps, done by Anik Dutta in *Bhooter Bhabishyat*. *Bhooter Bhabishyat* creates a world of ghosts with such problems that are very prominent in the human world as well. So, the problems are not directed towards the ghost world, but the human world. 'Promoting' as a business, nowadays, has flourished much and as a result, many of the heritage buildings in Kolkata, built during the Raj, or, perhaps before the Raj, have come to demolition with the hands of promoters. Anik Dutta tries to project that as a result of this demolition of these buildings, the 'Ghost Community' has started facing severe problems. All these became an issue that is being incarnated through the character Mr. Ganesh Bhutoria. The film also denotes a major problem like 'deforestation' which has already taken place in huge amount for the development of the locale and it is evident in Bhootnath's dialogue : "তারপর ওই যে বাইপাস না ছাইপাস কি একখান রাস্তা হইসে, সব গাছ কাট ফ্যালাইসে। ভূত হয়ে থাকনের কোন জায়গাই নাই। বাইছ্যা থাকতে রিফুজি হইয়া ছিলাম, মইরায়া গিয়াও রিফুজি হয়া গেলাম গা।" [Then there is bypass and all for which all the trees have been cut down. There is no place for ghosts. I was a refugee when I was alive and still have become after my death]. The most important part of the speech is where he calls himself a 'refugee' enhances the significance of the film. Through the dialogues and plotline, Dutta again emphasizes the crucial distinction between the 'Home' country and the 'Host' country- the very primary binary opposition in Diaspora studies. People for the sake of a better economy and social living had begun to move overseas. Similarly, the ghosts here have faced the same problem

and in a way, this is a very contemporary issue as it also encompasses a very crucial question that how much time does the authority need to designate us not as 'immigrant' but as 'citizen'? The interview period in the film can also be seen as a metaphor for the proof of citizenship where the very terms 'accepted' and 'rejected' may signify who is going to come under the Citizenship Amendment Bill (CAB). So, in a way, the questions Bhootnath raises are very contemporary and essential. When the 'Home' and 'Host' dichotomy gloom, what becomes more crucial is the question of 'Identity'. And this is inextricably linked with community and culture. Music, dance, and Language- these are the three major tools through which one can present one's identity, and that is what we see in this film. Culture cannot be homogenous in nature and it may lead to debates. But Unity can be homogenous. The ghosts we find in the film who live at Choudhury Palace are from the different socio-religio-economic background but they believe in communal harmony. And that is why the spirit of carnival gives *Bhooter Bhabishyat* a more secular tone.

All carnivals must have a sense of 'carnival' in them, and this is essential. Though the carnivals are supposed to be shrewdly represented, yet the spirit of enjoyment must be there as Bakhtin said that: "In carnival everyone is an active participant, everyone communes in the carnival act. Carnival is not contemplated and, strictly speaking, not even performed; its participants live in it, they live by its laws as long as those laws are in effect; that is, they live a carnivalistic life. Because carnivalistic life is life drawn out of its usual rut, it is to some extent 'life turned inside out'..." (1984, p.122). Carnival brings together, unifies, weds, and combines the sacred with the profane, the lofty with the low, the great with the insignificant; the wise with the stupid. This idea of celebration is represented in *Bhooter Bhabishyat* through the celebration of the Bengali Halloween. The celebration of Bangla Halloween, popularly known as 'Bhoot Chaturdashi' in Bangla culture, gives the members to celebrate their identity in a more unique way. The Medley they presented through their participation explores a more secular tone and gives them the scope to present their own identity through Music and Dance. Kadalibala and Koyel sing a song that is a musical parody of the famous Tagore song- "Amra Notun Jouboneri Doot" [We, the frontiers of youth], and it gives them their own native identity. Brigadier Yudhajit Sarkar, who was an army general, sings a musical parody on a famous Dwijendralal Roy song representing his love towards the nation. Darpa Narayan Choudhury, who represents the Zamindar class, sings a 'toppa' which is a stylistic parody on Nidhubabu's Toppa [The style of Ramnidhi Gupta] explaining the fact that the then landlords tend to visit their concubines for the pleasure of this sort of music. Mr. Ramsay, who represents British Colonial authority, sings a song in opera style. Bhoothnath Bhaduri, who was a Bangladeshi refugee, sings a folk song representing his own native culture. Khaja Khan, who was a Muslim by community, sings a 'Kawali' representing his own cultural identity. Atram Paswan, the Behari rickshaw driver, sings a Bhojpuri song presenting his culture. And finally, Pablo, who does not believe in any categorization, sings a rock song based on communal harmony. Significant enough, all the songs represent somewhat a parody of all the existing Indian classical forms. And that is why the film also suits the context of Carnival because Bakhtin believed that parody is an essential criterion for Carnival: "In the narrowly formal literary parody of modern times, the connection with a carnival sense of the world is almost entirely broken. But in the parodies of the Renaissance

(in Erasmus, Rabelais, and others) the carnival fire still burned: parody was ambivalent sensed its bond with death/renewal. Thus could be born in the bosom of parody one of greatest and at the same time most carnivalistic novels of world literature." (1984, p.1 The representation of identity has a more important role to play here. The cultural distinc can also be seen when we see Dorpo Narayan and Bhoothnath fighting over the supremit "Ilisher Paturi' and 'Chingri Macher Malakari', which in a way can be also seen as a cult fight between East-Bengal and Mohun bagan respectively.

When it comes to Carnival, it cannot happen that we miss the idea of folklore. A all, folklore was the first genre with which the idea began. In Bangla literature, sev writers have tried their hands in Ghost stories. The representation varied one to one bec Bangla myth and culture do not provide any homogenous idea of 'Ghost'. Rather, we h several concretizations of them. Bangla myth and culture believe in several concretization the idea of 'Ghost', for example - অপদেবতা [Demon], পিশাচ [Ghoul Spirit], ডাকিনী [N Hag], বেতাল [Vampire], শাকচুন্নি or পেতনি [Female Ghosts]and so on. All these come u the big tree what we call – ভূত or Ghost. Satyajit Ray's genius creation, Tarini Khur fictional storyteller, introduces Ray's categorization of ghosts in the film *Jekhane Bho Bhoy (2012)*. He categorized them specifically into four categories- 'অশরীরী আত্মা' invisible ghost], 'ছায়া মূর্তি' [the shadow], 'নিরেট ভূত' [those who are like living hu beings], 'নর কঙ্কাল' [skeleton]. All these variations have immense popularity and spac children's literature as many of them share a relation with Bangla folk culture. representation of Ghosts here has more native-like qualities. And we can see both Native Western influences in this regard. For example- Kadali Bala represents the 'Shaakchun the female ghost who died unmarried; Bhootnath represents both the 'Mecho Bhoot'[the who loves to eat fish] as well as 'Gecho Bhoot'[the one who lives in tree]; Khaja K represents 'Mamdo Bhoot' as he belongs to the Islamic community. Being a Brahmin, Dorpo Narayan and Bhootnath represent themselves as 'Brahma-Daitya'. Mr. Ran represents what Satyajit Ray himself terms as 'Saheb-Bhoot' in *Gupi Gayen Bagha Ba* though the representation varies. And the face of Atmaram with a superimposition skeleton designates him as a 'Konkaal'. On the other hand, western influences can als seen in the particular scene where Kodoli Bala sings 'Tumi je Elena Fire' [You never c back] on a full-moon night. In native Bangla culture, we see the new-moon day to b invocation day for ghosts. Full-moon nights are there in western culture symbolizing invocation of Werewolves and Vampires. Similarly, the character Bhutoria represents [Shaman- the witch doctor], as his name suggests someone who can diagnose spirits.

One of the fundamental aspects of Carnival is to deconstruct the existing ideolo discourses through the over-representation of different contexts. *Bhooter Bhabis* deconstructs the existing ideologies of spectre and challenges the traditional folk and n preconceived notions of Ghost culture:

i. **Deconstructing the idea of Darkness, Silence, and loneliness** : For somehow world of Choudhury Palace is very bright. Due to the carnivalesque elements, they always maintained a bright white picture where there is no prevalence of 'Darkn

They are found always in the company of each other and there is no space for silence. So, in way, it divorces us from the traditional notion that Silence, Darkness, and Loneliness are necessary for a ghost film.

ii. **Ghost as not a 'Spoiler' but a 'Rescuer'**: In traditional ideas, the ghost only caused harm to human beings. But here we find Ghosts who help others in their crisis. Hat-Kata Kartick and Lakhshmi are two characters who rescue other ghosts from their crisis.

iii. **Ghosts love to play with 'Fire'**: As 'Fire' is one of the five elements, it is believed that Ghosts can never touch fire. But here we see ghosts bursting crackers.

iv. **Human – Ghost binary is erased** : All the ghosts in this film have attributed human-like qualities. They drink, eat, smoke, play, sing, dance, and whatnot. They even have their own social networking site named "Spookbook' and know the use of CCTV cameras.

v. **Representing 'Unity' instead of 'Chaos'** : Ghosts are entities that are always associated with chaos and disturbances. Here we find a ghost community that does not like any disorder and love to live in peace.

Bhobishyoter Bhoot (2019) is different in nature as the whole film is a commentary on the contemporary political activities of West Bengal. The first thing about the film is that it does not follow a definite structure. In the case of *Bhooter Bhabishyat* (2012), we can still sense a structure where there is a narrative that emerged out of a dream that the director had. This film is a conjunction of sufferings and victimization of different characters in different times and places but the voice for justice has made these characters come at one place. The fascinating thing about the film is that though the commentaries are absolute, yet the whole representation is comic and there is a constant sense of carnival. On asking what led Dutta to make this movie, he replied:

> "For most of my life, I have been apolitical. Much later, I realised there is no such thing as 'being apolitical'. That's also a political stand. Then, I started getting involved and getting affected by the political developments in the country as well as abroad. I thought what's happening around us should be shown in my movie. My earlier movies have had different layers. The political statements were not so apparent. My first movie (Bhooter Bhabishyat, 2012) was a satire... Afterwards, I felt the need to spell out things as directly as possible." (2019, indianexpress.com).

The film represents different people who belong to different professions and how these people are affected either individually or collectively by the intrigues of politics. First we get, the director, Mr. Khanik who would like to make good political satire. By the term 'good', it is meant something which can revive the aesthetics of the film that are not properly found in recent films of Bengal. After Satyajit Ray, Ritwik Ghatak, and Mrinal Sen, the Bengali film industry witnessed a great dissociation of aesthetics. The films made during 1980s to 2010 were purely melodramatic in nature and they followed stories and structures where the novelty is suppressed. Mr. Khanik satirically represents Anik Dutta himself who is

searching for a new language in cinema; films that should have artistic excellence dramatic aesthetics. Next, we find a group of people who are willing to cater to the audie the essense of Ghost tourism. They would like to arrange walks with ghosts of Ben [people disguised as ghosts] who would be giving them the sense of 'Bangla Bho Satirically to look upon, this group represents those readers who had the greatest regards Ghost literature of Bengal which is sustaining itself only through the means of audiobook leisure reading. Despite being a fact that these stories are marvellous and stand as iconi the world of horror fiction, very little importance has been given to them. But, nowada people are reading them and trying to have the best of the gothic sensation and that is w has become the 'commodification' of the ghosts. Next, we find, Mr. Satyajit who wa journalist and tried to present his voice which an ideal journalist should. But, idealism Journalism may become someone's headache and that is why he was murdered by the l goons of a political activist. Bholanath Khara, an interesting character, represents ordinary daily wage worker who tried his hands at different jobs to get a promin placement. But, fate was not kinder to him, and at last, he joined Mr. Ambubachi, the sa political activist who killed Mr. Satyajit. Unfortunately, Bholanath was also killed by goons. Samyabrata Sarkar, a nearly seventy years old man was a political supporter of Left-Front [Communist Party of West Bengal] who was threatened by the political goons Mr. Ambubachi. Later, Mr. Sarkar dies due to an unfortunate heart attack. Mrityun Biswas, on the other hand, represents the struggle which the local theatre troops or Ja troops [popular folk-theatre of Bengal] had to face for their living. It is true that after Cine was introduced to the audience of Bengal, the demand of Jatra was lessened and there is v less number of troops exist till now who perform regularly. But the economic condition these people is getting worse as the modern audience have a greater love for cinema halls multiplex. However, this is the heritage of Bengal which must be kept alive by supporting troops. Next, we meet Miss Rupali who was a bar dancer and almost lead a life o prostitute. In some way or the other, there is a western influence we can find, as the woma jollities which she represents remind us of Moll Flanders and her eight affairs.

All these characters become different voices that represent either their politic affected life or they talk about the loss of aesthetics that the Bengali culture is facing. A from Mr. Khanik, Mr. Ambubachi, the Ghost Tourism group, and the Tnyak-khosh softw developers, all the characters are ghosts and they meet at a dilapidated cinema hall wh they discuss how they can communicate with humans and solve their problems out. In this is also ironic, because many of the cinema halls in West Bengal are demolished for sake of shopping malls. These cinema halls have witnessed the emergence of cinema and historical developments of the city. As an example, we can talk about Mitra cinema ha Hatibagan, Kolkata. The projector stopped and the curtains came on down on Mitra cine one of the last single-screen theatres in north Kolkata, and thus ended the history of 88 y (2017, timesofindia.com). They are also a part of our cultural heritage. But, it is unfortunate that we are unable to restore the importance of these places.

Bhobishyoter Bhoot (2019) is important for too many reasons which provide us a depth stance as to why we should consider it as a Carnival. The film is an amalgamatio

too many issues which can be divided broadly into two categories. One is obviously the satirical portions where the 'de-crowning' of the authority takes place. And the other one is associated with the cultural destruction which Bengal is witnessing for more than one decade under the heavyweight of modernization and metropolitanization. To discuss the satirical implications, we can briefly mention them accordingly:

i. **Film City : The Developmental Project-** In the film, it is shown that the government is trying to build a film city- 'Cine মা' in a rural area which will give employment to the local habitats. The political ministers are trying to persuade farmers so that they hand their fields over to the government. And those who are unwilling to do so are getting deadly threats. The idea of the film city seems impractical at every point because the farmers are hard-working people and they generally do not have any time to spend leisure time with the cinema. The whole idea seems eccentric as the issue of employment is not at all properly addressed. Moreover, this is a satirical reference to the Singur issue (2008) that took place in West Bengal between the Tata Industry and the Opposition party. The then West Bengal government tried to persuade people to hand over their lands to the Tata Authority so that West Bengal can witness Industrial development. There is no doubt that it could have been a good opportunity for the people of West Bengal if the industry settled. But unfortunately, the whole issue light up a great opposition as the lands of the farmers were taken illegally. It is true that the Industrial development could have given the youth of Bengal new hope. But whether there is any hope of employment in the film city or not, can be contested.

ii. **The Scams :** In the film, we witnessed that the Journalist, Satyajit was killed by political goons because he recorded some videos where the political activists were taking bribes from people and permitting their tender. This is a direct reference to the videos that the citizen of Bengal witnessed regarding the contemporary political activists of Bengal who were oriented towards the scams.

iii. **Computer and English Language : Threats in Past, Boons in Present-** Around the 1980s, when the then Prime minister of India, Mr. Rajiv Gandhi promoted science and technology associated industry, he also tried to implement computerization in India. (Shekhar, indiatoday.in). But the then West Bengal government authority heavily protested against this decision as they believed it would kill the manpower. If man-made gazettes destroy job opportunities and kill manpower, then there is no such practical logic as to why we should support this decision. This issue has been satirically represented by Mr. Sarkar and Mr. Harry in the film who indulged in a complicated conversation regarding computerization in Bengal. Furthermore, Mr. Harry also claimed that the Leftist Communist party opposed the decision of implementing the English Language at the school level which was a disaster for the Bengal education system. Thinking English to be the language of the colonizers, the then Leftist activists failed to realize the importance of English as a global language as well as a second language.

iv. **The Army for Battle :** When the Film city controversy was at its peak, the Ghosts tried to form an army that will overtly help the farmer to fight against the political activists.

This army is unique and integral for our discussion on Carnival because it is for the de-crowning of the authority will be possible. To look at this army, we find subtle sh references of history and politics which underpins the importance of nationalism army consisted of seven people belonging to seven different cultural communities is very interesting to note that none of them belonged to a posh economic backgr Rather they are named as 'The sons of the soil' who have the greatest regards for motherland. Dohor Mahato- the activist from Santal Movement; Smritilata Wadekar in appearance reminds us of Pritilata Waddedar; Bengal Jehadi represents the Is community who are misguided under the extreme ideologies of Islam; Shikhanji- w probably the satiric ego of Kishenji; the political leader of Politburo who become the of 'Maoism' in India (www.ndtv.com); Rajan Ragappan- who in appearance remin of Veerappan, the famous Indian bandit from South India; Sardar Nirbhik Singh- rer us of the contribution of the Sikh community during Raj and finally Mochiro Tafun Samurai. The inclusion of the Japanese into the army, perhaps, satirically refers t Japanese sponsorship which helped Netaji Subhas Chandra Bose to form Azad Hind In fact, the army is on a secret mission which may also serve as an implied referen Netaji's Army which he formed to fight against the British Empire. This whole form can be seen as a symbol that may emphasize how the contemporary parties are fig over communal adversity that is seen during NRC and CAAB unrest. This is also c seen as a disgrace to the freedom fighters and Nationalist activists who together fo against the Empire irrespective of their cultural identities; and yet, the political le from independent India who have not participated in any freedom fighting and hav idea of nationalism, causing a rift in national integration in the name of caste and reli

Apart from the socio-political satire, the film also talks about certain important i which are represented through the means of parody. One such issue is the ideological between the spiritual art and the art of commodification. When all the ghosts got bored, organized a competition for searching talents in ghosts. This is also a satirical referen different reality shows which showcase the talents of different people through the mea competition. At this competition, we witness the vocal recital of Mrs. Sangeeta Sur who a trained singer in Tagore Music. Her style of representation typically portrays the sty 'Dakhini' which is popular for nasalized clenched teeth style of singing. The deman Tagore songs is decreasing day by day and it has lost its glory under the lid of moderniz The same thing is applicable to Indian classical music as well. We find another chara Moti bai, who used to sing Tappa and Thumri of Indian Classical schools, but she is now and so is her music. On the first level, Dutta talks about the commodification of fin and how as an aftermath of Modernization and Americanisation, people of India have sh their focus from Eastern spiritualism to Western materialism. The sharp contrast bet Tradition and commodification has been portrayed through the character of Miss San and Miss Rupali respectively. It is a fact that cannot be ignored that the Classical Sy began with Dhrupad and Dhamar but what remains today is the beautiful gesture of Kh Kumar Prasad Mukhopadhyay, an Indian scholar of music is of the opinion tha aristocratic culture helped in the degradation of Khayal music. They used sublime satisfy their sensual appeals. The colonial culture gave rise to Renaissance, but in Beng

gave us the 'Babu' culture. It is my personal opinion that this is a religious, social, and cultural destruction that caused the loss of high values in us. As a result, what we got is non-standard culture. (2003, p.89).

If we take a closer look, possibly we will be able to understand that both the films have a common aspect i.e. we see the plot of the film is presented through a director's mind. In *Bhooter Bhabishyat* (2012), the film is born out of the mind of the director who heard about the storyline from a ghost in a dream. Similarly, *Bhobishyoter Bhoot* (2019) is born out of the director's mind and what we see is the external representation of his ideas. Here at this point, we have to understand what Anik Dutta is trying to do, and what he wants to achieve through this. After Ray, there has been an aesthetical gap we find in Bengali films till the end of the 20th century. From the beginning of the 21st century, the representation in films changed severely because of the commodification of the films where the genre 'Horror Comedy' contributed a lot. Most of the renditions were humdrum in nature and there was no aesthetic value as such. All of them followed a very typical structure [for example-couples going on an adventure and discover supernatural occurrences are common.] which stroke the audience back with disappointment. Then after some time, like the change in the theoretical paradigm from 'matteur-en-scene' to 'auteur-en-scene', the essence of horror changed. The directors started changing their stance and emphasized 'thinking' as a productive process. In some cases, the directors can also be termed as 'auteur' who 'invents' as the famous French director Francois Truffaut remarks: "...they are auteurs who often write their dialogue and some of them themselves invent the stories they direct." (Truffaut, p.16). So, the elements of social justice, social issues and comicfarce started to be penetrated into the storyline. The Ghost films no longer remained a horror tale only; it started to take the form of heteroglossic narratives where one can identify multiple discourses. And to implement this task, the form of Carnival becomes instrumental. The use of Carnival in comic horror is very unusual. That is the reason, perhaps, why these films were so popular. But each of them has a core concern for society and humanity which is to be understood thoroughly through the understanding of aestheticism in art.

References :

- Lock, Charles. (1991). Carnival and Incarnation: Bakhtin and Orthodox Theology. *Literature and theology*, 5.1, 68-82. www.jstor.org. https://www.jstor.org/stable/23926648
- Bakhtin, Mikhail. (1984). *Problems of Dostoevsky's Poetics*. In Caryl Emerson (Ed.). University of Minnesota Press.
- Dewar- Watson, Sarah. (2017). Aristotle and Tragicomedy. *Early Modern Tragicomedy*. In Subha Mukherji and Raphael Lyne (Ed.), 22. www.jstor.org. www.jstor.org/stable/10.7722/j.ctt81ghk
- *Bhobishyoter Bhut' not a sequel to Bhooter Bhabishyat: Dutta.* (2019). www.business-standard.com.https://www.business-standard.com/article/pti-stories/bhobishyoter-bhut-not-a-sequel-to-bhooter-bhabishyat-dutta-119021400659_1.html
- Maji, Bappa, et al. (2019). Marketing Fear: Studying the Impact of Bengali Horror Movie on the Bengali Audience and the Domestic Market. *European Academic Research*. VIII.5, p.2548.
- Dutta, Anik. (Director). (2012). *Bhooter Bhabishyat*. Mojo Production Ltd.
- Dutta, Anik. (Director). (2019). Bhobishyoter Bhoot. Star Synergy Entertainment.

- Truffaut, Francois. (n.d.). A Certain Tendency in French Cinema. *Cahiers du Cinema*. www.learning https://filePDF_A_Certain_Tendency_in_French_Film_by_Francois_Trauffaut_pdf_HCbC_Learning_Web
- Ray, Sandip. (Director). (2012). *Jekhane Bhooter Bhoy*. Shree Venkatesh Films and Surinder Films.
- Banerjee, Tamaghna. (April 2019). *88 years on, curtains come down on Mitra cinema*. www.timesofi https://timesofindia.indiatimes.com/city/kolkata/88-yrs-on-curtains-come-down-on-mitra-cinema/articleshow/68696008.cms
- Shekhar, Kumar Shakti. (2018). *5 ways how Rajiv Gandhi changed India forever*. www.indiato https://www.indiatoday.in /india /story/5-ways-how-rajiv-gandhi-changed-india-forever-1318979-2018-08-20
- Sahani, Alaka. (2019). *Ghosts of politics present: Anik Dutta on Bhooter Bhabishyat, Bhobishyoter Bhoo future*. www.indianexpress.com. https://indianexpress.com/article/express-sunday-eye/ghosts-of-politics 5648763/
- *SC orders West Bengal to pay 'Bhobishyoter Bhoot' producer Rs 20 lakh for 'virtual ban' on film*. (2019). ww https://scroll.in/latest/919686/sc-orders-west-bengal-to-pay-bhobishyoter-bhoot-producer-rs-20-lakh-for-virtual-ban-on-fi
- *Who is Kishenji?* (2011). www.ndtv.com. https://www.ndtv.com/india-news/who-is-kishenji-566488
- Mukhopadhyay, Kumar Prasad. (2003). *Kheyal – o – Hindustani Sangeeter Abakshyaya*. Dey's Publishing.

Induction of autoimmune Graves' Disease as a post COVID-19 complication – a short review

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Abstract :

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a single stranded, enveloped RNA virus is the causative agent of coronavirus disease 2019 (COVID-19), which has been declared a pandemic since early 2020. It is a transmissible infectious disease associated primarily with the respiratory system. Although mainly a respiratory infection, it affects other organs such as thyroid, adrenal gland, kidney, heart, brain to name a few. Thyroid dysfunction including Graves' disease has been observed as a post COVID-19 complication. Graves' Disease is an autoimmune hyperthyroidism. The Angiotensin converting enzyme2 (ACE2) help SARS-CoV-2 to bind with them and enter into the host cell. These proteins are abundantly expressed in the thyroid gland and therefore promote thyroid related dysfunction like the Graves' Disease associated with COVID-19. Some COVID-19 vaccines also induce Graves' disease. This review shortly describes about the induction of Graves' disease as a post COVID-19 complication, the autoimmune factors that influence its progression and how it increases the risk of COVID-19 related morbidity. A brief note has also been added about the role of gene HLA in Graves' disease and its possible therapeutic aspects.

Keywords : COVID-19, SARS-CoV-2, Thyroid, Hyperthyroidism, Autoimmune disease, Graves' disease

Abbreviation :

ACE2	–	Angiotensin converting enzyme 2
AITDs	–	autoimmune thyroid diseases
anti-TSHR-Ab	–	anti-thyroid stimulating hormone receptor-antibody
COVID-19	–	coronavirus disease 2019
HLA	–	Human Leukocyte Antigen
RAAS	–	renin-angiotensin-aldosterone system
SARS-CoV-2	–	severe acute respiratory syndrome coronavirus 2
TgAb	–	thyroglobulin antibodies
TPOAb	–	thyroid peroxidase
TRAb	–	Thyrotropin receptor antibody
TSH	–	thyroid stimulating hormone
TSI	–	Thyroid stimulating immunoglobulin

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a single stranded, enveloped RNA virus is the causative agent of coronavirus disease 2019 (COVID-19), which is a transmissible infectious disease associated primarily with the respiratory system. The outbreak began in Wuhan, China during December 2019 and has been declared a pandemic since then. Although it is mainly a respiratory infection, it affects other organs such as thyroid, adrenal gland, kidney, heart, brain to name a few (Sharma *et al*, 2021).

Thyroid dysfunction including Graves' disease has been observed as a post COVID-19 complication. Graves' Disease is an autoimmune hyperthyroidism. Auto antibodies such as Thyrotropin receptor antibody (TRAb), Thyroid stimulating immunoglobulin (TSI) are triggered by immune system that causes overproduction of thyroid hormones. Graves' disease shows many symptoms including goitre, arrhythmia, heat intolerance to name a few. Angiotensin converting enzyme 2 (ACE2) is the key player at the entry point of the SARS-COV-2 virus in the human cell. ACE2 is present on the epithelial cells of the outer membrane of the organs including thyroid gland and therefore promote thyroid related dysfunction like the Graves' Disease (Duntas *et al*, 2021). This review discusses about the induction of autoimmune Graves' disease associated with COVID-19.

COVID-19 and SARS-CoV2 :

COVID-19 is a zoonotic disease originating from bats and has affected million worldwide. SARS-COV-2 causes common cold to severe acute respiratory syndrome, that shows high morbidity and mortality in some people. Sepsis and death also occur due to cytokine storm. It can also affect gastrointestinal tract, neurological and cardiovascular system. Kawasaki like disease is noticed in children. Anosmia and ageusia (loss of smell and taste) are also observed in many cases. Older people and people with comorbidities show higher rate of morbidity and mortality (Duntas *et al*, 2021; Chan *et al*, 2020, Murugan*et al* 2021a).

ACE-2 mainly presented in the epithelial cells of lungs, heart kidney small intestine blood vessels, testes, adipose tissue thyroid gland, helps the initial entry of SARS-COV-2. As ACE-2 is extensively present on the surface of thyroid cells, thyroid get affected by the virus. Variable density and different level of expression of ACE-2 receptor may cause different symptoms and different effects in organ of the patients (Murugan*et al*, 2021 a, b).

Graves' Disease :

Graves' disease is principally characterized by diffuse goitre and hypersecretion of thyroid hormones. Symptoms develop increasingly over a period of time and revolves around unintentional weight loss, heat intolerance, insomnia, muscle weakness, increased sweating, tachycardia, irritability, restlessness, nervousness / anxiousness, and fatigue. Patients show symptoms of brittle nails, hair loss, hyperreflexia, increased appetite, and frequent bowel movements, irregular menstrual cycles in females, and erectile dysfunction in males. Graves' disease is at times associated with Graves' ophthalmopathy (protrusion of eyeballs from the sockets). Infrequently, the disease leads to the development of thickened, reddish skin lesions called pretibial myxedema. Congestive heart failure and osteoporosis are also occasional

outcome of this disease. In most cases females are affected, female: male ratio being 5-10:1 (Murugan*et al*, 2021a).

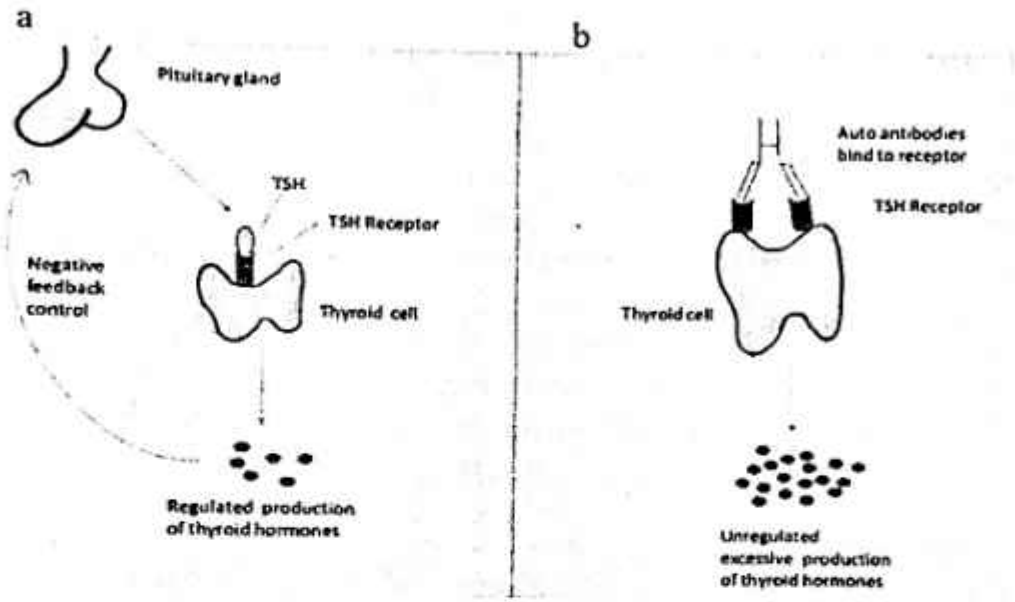


Figure 1:

a. In normal condition, the thyroid-stimulating hormone (TSH) binds to the TSH receptor and transduces signal for production of thyroid hormone.

b. In Graves' disease, binding of auto-antibodies to the TSH receptor induces unrestricted activation of the thyroid, leading to overproduction of the thyroid hormones

Graves' disease is an autoimmune disorder causing hyperthyroidism associated with generation of IgG antibodies stimulating the thyrotropin receptor and thyrocyte hyperplasia (goitre). Autoantibodies are produced against the TSH receptor or TRAb (Gallo *et al*, 2020) which mimic the normal action of thyroid stimulating hormone (TSH), activating adenylate cyclase and resulting in production of the thyroid hormones. Unlike TSH, however, the autoantibodies are not regulated, and consequently they overstimulate the thyroid. For this reason, these auto-antibodies are called long-acting thyroid-stimulating (LATS) antibodies (Kindt 2006, Figure 1 and 2). It is an outcome of interaction between genetic and environmental factors that causes the loss of immune tolerance to thyroid antigens and activation of autoimmunity (Xu *et al*, 2015).

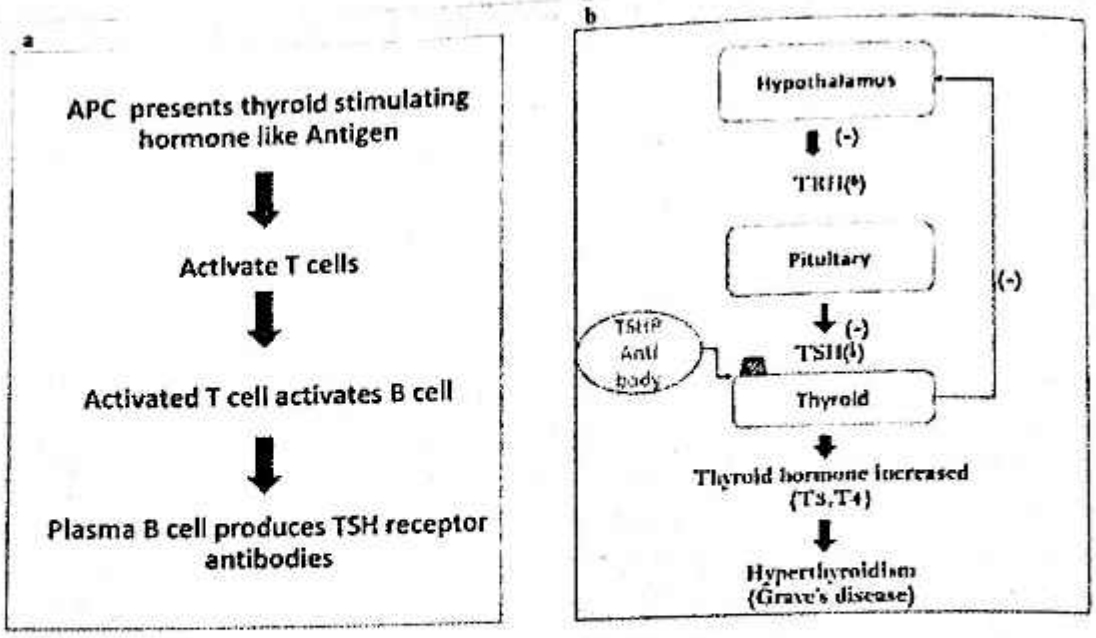


Figure 2 : a. Production of auto-antibodies to the TSH receptor;b. Endocrine control in Graves' disease

Graves' Disease after COVID-19 infection: Case Studies :

After COVID-19 infection, along with several other thyroid dysfunctions, SA COV-2 infection induced Graves' disease was noticed in some individuals by scien Identified patients were females from 21 to 61 years age group. The disease progression noted within 1 to 2 months of COVID-19 infection (Murgan *et al.*, 2021a and b; Inaba 2021).

Symptoms included palpitations along with nervousness, fatigue and tr (Murugan *et al,* 2021). Graves' ophthalmopathy was seen into few cases. Low level of increased triiodothyronin (FT3), and thyroxine (FT4) are noted in Graves' disease. positivity of anti-thyroid stimulating hormone receptor-antibody (anti-TSHR-Ab), th peroxidase (TPOAb) and thyroglobulin antibodies (TgAb) and increasing of uptake of io were also indicative of Graves's disease (Murugan *et al.*,2021).

About 15% patients reported abnormalities in thyroid function after Covid infe Some had low TSH level. Three of them were positive for TRAb, among them one TPOAb positive also. In addition to this ten, two patients with high FT4, one of them with low FT3 and TRAb positive, that means mild Graves' disease present. (Lui *et al*, Inaba *et al.* 2021).

Autoimmune factors and break down of tolerance induce Graves' Disease after CO 19

In COVID-19, many latent autoimmune thyroid diseases (AITDs) get activa Th1 and Th2 mediated cellular immunity and by the dysfunction of Treg cells. inflammatory syndrome rises the serum IL-6 level and /or cytotoxic effects of T cel might be the reason of thyroid dysfunction during COVID-19. In general, autoi response of Th2 is the cause of Graves' disease but in SARS-COV-2 influenced C

disease, Th1 cells are found to regulate. Th17 and Th22 and their cytokine have important role in autoimmune thyroid disease. Apoptotic pathways of thyroid follicular cells are activated by Th1 mediated immune response, that destroy the thyroid cells. On the other hand, thyroid cell proliferation and hyper activation of the thyroid gland occurred by production of TSHR-Abs that caused by activation of B lymphocyte for the activity of Th2 mediated immune response. Since the Th1 and Th2 cells were identified in intrathyroidal infiltrate and also reacted with TSHR peptides and TSHR antigens, it is thought that T cells are the cause of chronic inflammation in Graves' disease. Effector T cells are inhibited by regulatory CD4+ T cells or Tregs and autoimmunity occurs due to insufficiency of Tregs (Murugan *et al.*,2021; Inaba *et al*; 2021; Figure 3).

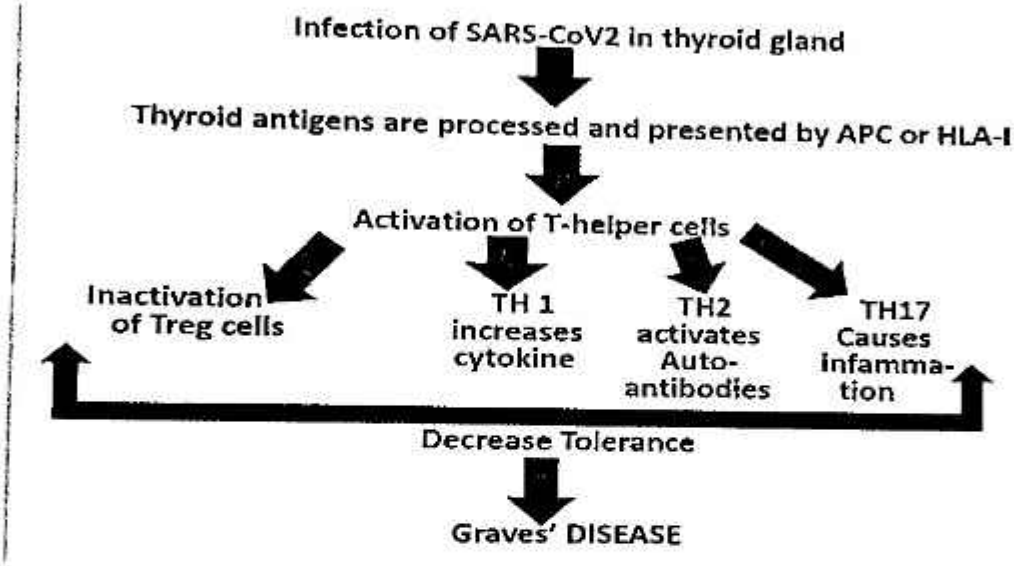


Figure3: Autoimmune factors related with Graves' disease

HLA gene and its association with Graves' disease :

Human Leukocyte Antigen (HLA) is an important factor in the immune system that also the principal gene, associated with Graves' disease. It helps in the antigen presentation by the T Cells (Inaba *et al.*,2021).The HLA region is the first candidate genetic region to be studied for association with AITD because the HLA region contains many genes which are highly polymorphic and are associated with other autoimmune diseases. HLA-B8 was related to the Graves' disease with relative risks for Graves' disease ranging from 1.5 to 3.5. Subsequent research, found that Graves' disease was more strongly related with HLA-DR3, which is now known to be in linkage disequilibrium with HLA-B8 (Jacobson *et al* 2008; Heward *et al*, 1998; Farid*et al*,1981). Many patients of COVID-19 of the country of China and Italy have reported increased appearance of certain HLA genotypes. A Japanese patient with COVID-19 contains the same HLA alleles predisposing to AITD (HLA-DP5 and HLA-B51) (Inaba *et al.*, 2021).

Protein : Enhances the chance of Graves' disease after COVID-19 infection

ACE2 is an 805 amino acids protein receptor that helps to the entry of SARS-COV-2 into the host. The primary location of ACE2 is membrane and extracellular is the secondary

localization of ACE2. The ACE2 is a secretory protein that noticed in plasma and different biological fluids (Bianet *al*, 2020).The SARS-COV-2 enter into the host cell by binding with ACE2 receptors. It is the part of the renin- angiotensin- aldosteron system (RAAS). SARS-COV-2 enters into the cell by endocytosis after binding with ACE2 that leads to down regulation of the Angiotensin- converting -enzyme- 2(Kumar *et al*, 2021).

ACE2 protein is differentially expressed in individuals that leads to thyroid dysfunction. The expression of ACE2 is high within thyroid tissue. Different expression level of ACE2 is connected positively with male and unfavorably with female in the thyroid. Thyroid is also a favourable centre for SARS-CoV2 infection and that facilities thyroid dysfunction after COVID-19. The thyroid gland and the entire hypothalamic-pituitary-thyroid axis is targeted by SARS-CoV-2, that also induces thyrotoxicosis, hypothyroidism, and nonthyroidal illness syndrome. The thyroid gland and the viral infection, with its associated inflammatory-immune responses, are related in a complex interplay. Case study reported that people with previous history of Graves' disease are affected with thyrotoxic crisis by SARS-CoV2 (Muruganet *al.*,2021; Figure 4).

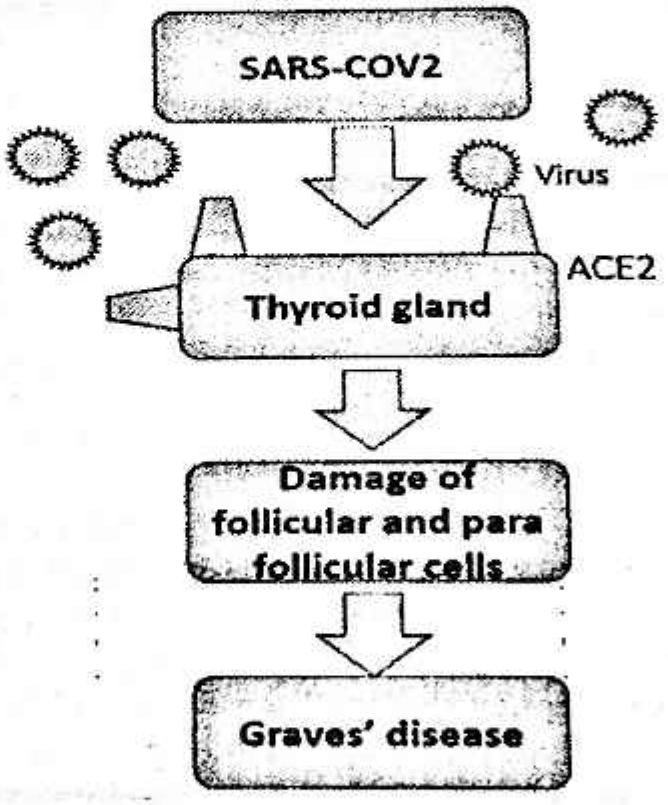


Figure 4 : ACE2 highly expressed in Thyroid gland and helps in binding of SARS-COV2

COVID-19 vaccine involved in inducing Graves' disease :

It was reported that many autoimmune disorders including thyroid diseases are ca by various undesirable immune responses by few vaccines. At a recent time, SARS-C vaccine induced Graves' disease cases were reported in two health care workers. It noticed after 2–3 days of Pfizer-BioNTech (BNT162B2 SARSCoV-2) vaccina

Autoimmune syndromes-induced by adjuvants (ASIA) is the cause of this autoimmune/inflammatory conditions. A small number of substances including polyethylene glycol (PEG) act as an adjuvant by inducing an immune response but most of the constituents of the vaccines are safe. The recently reported Graves' disease in vaccinated cases certainly indicates that it is a pathological phenomenon of autoimmune conditions induced by adjuvants (Murugan*et al.*, 2021; Vera- Lastra, 2021; Garvey, 2021).

Treatment :

The medicines prescribed mainly include Thiamazole and propranolol. Administration of methimazole (MMI) showed improvement in three months. Beta blocker was also used to treat the patient of USA (Murugan*et al.*, 2021; Figure 5).

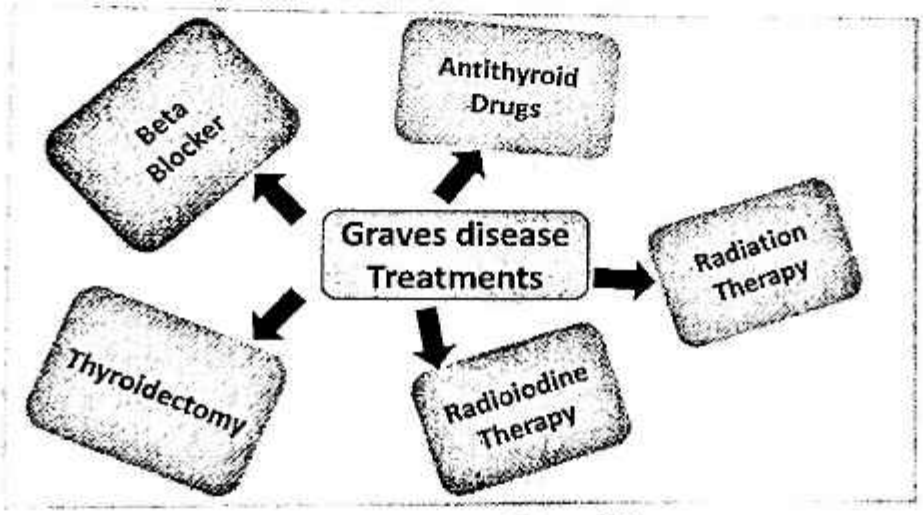


Figure 5: Treatment of Graves' disease

Conclusion :

Normally people have the risk of getting thyroid disease including sub acute thyroiditis and Graves' disease in the postCOVID-19 scenario. On the other hand, hyperthyroidism was shown to trigger the over expression of the ACE2 due to vital regulation of the counter-regulatory components of RAAS. It suggests that people with thyroid disease, particularly hyperthyroidism, are a condition that could predispose the enhanced chances of acquiring SARS-CoV-2 infection while normal people readily get thyroid disease in the post-COVID-19 scenario. Thyroid dysfunction is noted in about 15% of patients with mild to moderate COVID-19.

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Reference :

1. Sharma A, Ahmad Farouk I, Lal SK. COVID-19: A Review on the Novel Coronavirus Disease Evolution, Transmission, Detection, Control and Prevention. Viruses. 2021 Jan 29;13(2):202. doi: 10.3390/v13020202. PMID: 33572857; PMCID: PMC7911532.
2. Duntas LH, Jacqueline Jonklaas, COVID-19 and Thyroid Diseases: A Bidirectional Impact, Journal of the Endocrine Society, Volume 5, Issue 8, August 2021, bvab076, https://doi.org/10.1210/jendso/bvab076
3. Chan JF, Yuan S, Kok KH, To KK, Chu H, Yang J, Xing F, Liu J, Yip CC, Poon RW, Tsoi HW, Lo SK, Chan KH, Poon VK, Chan WM, Ip JD, Cai JP, Cheng VC, Chen H, Hui CK, Yuen KY. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. Lancet. 2020 Feb 15;395(10223):514-523. doi: 10.1016/S0140-6736(20)30154-9. Epub 2020 Jan 24. PMID: 31986261; PMCID: PMC7159286.
4. Murugan AK, Alzahrani AS. SARS-CoV-2 plays a pivotal role in inducing hyperthyroidism of Graves' disease. Endocrine. 2021 Aug;73(2):243-254. doi: 10.1007/s12020-021-02770-6. Epub 2021 Jun 9. PMID: 34106438; PMCID: PMC8188762 (a).
5. Murugan AK, Alzahrani AS. SARS-CoV-2: Emerging Role in the Pathogenesis of Various Thyroid Diseases. Inflamm Res. 2021 Nov 24;14:6191-6221. doi: 10.2147/JIR.S332705. PMID: 34853527; PMCID: PMC8628126 (b).
6. Gallo D, Piantanida E, Gallazzi M, Bartalena L, Tanda ML, Bruno A, Mortara L. Immunological Drivers in Graves' Disease: NK Cells as a Master Switcher. Front Endocrinol (Lausanne). 2020 Jul 17;11:406. doi: 10.3389/fendo.2020.00406. PMID: 32765422; PMCID: PMC7379480.
7. Xu MY, Cao B, Yin J, Wang DF, Chen KL, Lu QB. Vitamin D and Graves' disease: a meta-analysis update. Nutrient 2015 May 21;7(5):3813-27. doi: 10.3390/nu7053813. PMID: 26007334; PMCID: PMC4446781.
8. Kindt TJ, Osborne BA, Goldsby RA Kuby Immunology, Sixth Edition 6th edition (2006)
9. Inaba H, Aizawa T. Coronavirus Disease 2019 and the Thyroid - Progress and Perspectives. Front Endocrin (Lausanne). 2021 Jun 24;12:708333. doi: 10.3389/fendo.2021.708333. PMID: 34276567; PMCID: PMC8279745.
10. Jacobson EM, Huber A, Tomer Y. The HLA gene complex in thyroid autoimmunity: from epidemiology to etiology. Autoimmun. 2008 Feb-Mar;30(1-2):58-62. doi: 10.1016/j.jaut.2007.11.010. Epub 2008 Jan 4. PMID: 1817805; PMCID: PMC2244911.
11. Heward JM, Allahabadia A, Daykin J, Carr-Smith J, Daly A, Armitage M, Dodson PM, Sheppard MC, Barnett A, Franklyn JA, Gough SC. Linkage disequilibrium between the human leukocyte antigen class II region of the ma histocompatibility complex and Graves' disease: replication using a population case control and family-based study ClinEndocrinolMetab. 1998 Oct;83(10):3394-7. doi: 10.1210/jcem.83.10.5137. PMID: 9768636.
12. 24. Farid NR, Stone E , Johnson G. Graves' disease and HLA: clinical and epidemiologic associations. ClinEndocri (Oxf) 1980;13:535-544.
13. Bian J, Li Z. Angiotensin-converting enzyme 2 (ACE2): SARS-CoV-2 receptor and RAS modulator. Acta Pharm B. 2021 Jan;11(1):1-12. doi: 10.1016/j.apsb.2020.10.006. Epub 2020 Oct 13. PMID: 33072500; PMC PMC7553008.
14. Kumar P,Sat, A.K., Triparthi, G. et al. Role of ACE2 receptor and the landscape of treatment options from convalesc plasma therapy to the drug repurposing in covid-19 Mol cell biochem 476 ,553 - 574(2021).
15. Lui DTW, Lee CH, Chow WS, Lee ACH, Tam AR, Fong CHY, Law CY, Leung EKH, To KKW, Tan KCB, Woo Y Lam CW, Hung IFN, Lam KSL. Thyroid Dysfunction in Relation to Immune Profile, Disease Status, and Outcom 191 Patients with COVID-19. J ClinEndocrinolMetab. 2021 Jan 23;106(2):e926-e935. doi: 10.1210/clinem/dgaa PMID: 33141191; PMCID: PMC7665541.

A *boat*-piperazine bridged Co^{II}_2 complex from two anionic salicylaldehyde clips and a *bis*-tridentate ligand: Strategy for coordination induced ligand backbone conformation isomerism

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Abstract :

Ethylene-piperazine-ethylene spaced tetramine (N_4) molecule has been condensed to two salicylaldehyde molecules to result H_2L ligand. During reactivity exploration the anionic form (L^{2-}) assembled around two cobalt(II) centers from the clipping supports of two anionic forms of salicylaldehyde (2-formyl phenol, Hfp) molecules. During the assembly formation these clips are forced to function as two unique μ-η^1,η^2 bridging modes. Initial mixing of 2-formyl phenol and $Co(OAc)_2{\cdot}4H_2O$ in 1:1 molar ratio provide some intermediate species in which one fp^- is bound to one Co^{II} ion and attract two such fragments to come in close vicinity under the wrapping coordination of the single L^{2-} in complex **1**. The work established the binding of two 2-formyl phenolate units as unique chelating-*cum*-bridging ligands, not observed in routine synthesis from the use salicylaldehyde as stand alone ligands, in the presence of the linear hexadentate N_4O_2 ligand. The X-ray structure determination confirmed the twist boat orientation of the bridging piperazine unit as disclosed from the torsion angles (φ_1) of N–C–C–N within the ring of 29.02° and 27.52°. Similar to known dicobalt enzymes found in biologythe experimental Co···Co distance is found to be 3.183 Å.

Keywords : Piperazine; dicobalt (II/II); Schiff base; *twist boat*; *bis*-tridentate; N_4O_2 donor

The synthesis of coordination compounds of *3d* metal ions in many times holds an enormous range of techniques and approaches, not routinely tried in synthetic laboratories. The necessity and desire for new compounds bearing two adjacent metal ions often demands increasingly sophisticated and imaginative synthesis strategies. Time and energy efficiency, use of earth-abundant resources of metal ions and organic molecules, and many other standard room temperature solution chemistry principles become key parameters in the design of new synthetic processes. Synthesis through the use of the appealing simplicity of 'one-pot' methods is thus a challenge to the practicing chemists to enhance their skills.

Synthesis and characterization of Co^{II}_2 complexes, from reactivity scrutiny of new ligand anions, have received immense attention because of their varying mode of ligand anion support, compact structures and functional properties as well as for magnetostructural correlations.[1-4] The nature and number of metal ion coordination by any acyclic hexadentate ligand can be reversed through the incorporation of a spacer group such as 2-phenolate imidazolidine, forcing the parent hexadentate ligand to function as a *bis*-tetradentate one. Chelating arm bearing substituted 1,4-piperazine can bind metal ions in both the *boat* and *chair* conformations of which the latter is thermodynamically more favorable in metal ion free condition. Designed synthesis of dinuclear entities is still a big challenge and needs the presence of ancillary ligands in a specific coordination positions around the metal ions. The *boat* form gives mononuclear complexes, whereas the *chair* form can result bimetallic complexes with no exogenous bridging for *trans-N,N'*-coordination from the piperazine ring. In this regard the substituted piperazine based ligands have drawn attention

due to its various conformations which also controls the geometry of the resulting metal ion complex.[5] N,N′–disubstituted piperazines provide tertiary nitrogen containing building blocks for self-assembly.[6-8] The self-assembly of first-row transition metal ions using bridging ligand such as N,N′-alkyl disubstituted piperazine as aliphatic nitrogen donor building block has proved to be a potential synthetic approach for new dimetallic coordination complexes. The piperazine based ligands at the same time have drawn renewed interest due to its binding of metal ions in different backbone conformations. The substituted 1,4-piperazine moiety without metal ions coordination can have four distinct conformations such as *chair*, *boat*, *twist boat* and *half-boat*[9a-g] (Scheme1).

Out of these, crystal structures of several metal ion complexes established the existence of first three forms. In *boat*, *twist boat* and *chair* forms, the piperazine unit coordinatation or bridge two metal ions to give mono[10-12] and dinuclear[13-16] complexes.

In chair conformation the unit provides trans-N,N′-coordination.[17-18] Only recently the equatorial-axial (e-a) coordination mode is established with a cis-tetranuclear Cu_4 complex,[19] in the chair form, the available bridging modes are axial-axial (a-a)[17] equatorial-equatorial(e-e)[18] and equatorial-axial (e-a),[19] analogous to the syn-syn and syn-anti coordination modes of bridging acetate groups.[20] In chair form the important bridging mode is equatorial-equatorial (e-e) responsible for binuclear complex formation. In particular the chair form of piperazine allows structurally and functionally directing polymeric structures.[21-26]Currently synthesis and characterization of tetra nuclear copper(II) complexes are interesting to rationalize the involvement of Cu_4 cluster in the catalytic cycle for reduction of N_2O to N_2.[27] In this chapter we have discussed the reactivity of the hexadentate, sterically constrained schiff base ligand H_2L {(2-hydroxobenzylidene)-[2-(4-{2-[(2-hydroxobenzylidene)amino]ethyl}-piperazin-1-yl)ethyl]amine}[19,28] toward Co^{II} ion to establish different molecular architectures with different conformations of semi-rigid piperazine backbone. Herein we report the room temperature one-pot synthesis, crystal structure and detail description of the complex **1**.

2. Experimental section

2.1. Materials and methods :

All the chemicals were reagent grade and used as received without further purificati The chemicals used were obtained from the following sources: salicylaldehyde (S. D. F Chem.), cobalt (II) acetate tetrahydrate used were obtained from Loba. FT-IR spectra w recorded on a Perkin-Elmer 883 spectrometer. Elemental analyses (C, H, N) were perform with a Perkin-Elmer model 240C elemental analyzer. ^1H and ^{13}C NMR spectra of the lig were obtained on a Bruker AC 200 NMR spectrometer using TMS as the internal standar

2.2. Room Temperature One-potSynthesis

Synthesis of Ligand :

2-Hydroxo-benzylidene-[2-(4-{2-[(2-hydroxo-benzylidene)-amino]-ethyl}-pipera

1yl)-ethyl]-amine (H_2L). To the methanolic solution of H_2L (1g, 5.8 mmol), salicylaldehyde (1.21 mL, 11.6 mmol) was added under ice-cold condition and stirred for 3 h to give a yellow solid which was separated by filtration through G4 sintered bed and washed thoroughly with hexane and water. Finally, the isolated compound was dried in vacuo over P_4O_{10}. The single crystals suitable for X-ray analysis were obtained from hot MeOH during 4 days and found to be same as reported earlier.[26] Yield 1.92 g (87%), m.p. 152^{0}C. Anal. Calc. for $C_{22}H_{28}N_4O_2$ (380.49): C, 69.44; H, 7.42;N, 14.72%. Found: C, 69.32; H, 7.32; N, 14.68%. Selected FT-IR bands (cm^{-1}, KBr): ν = 2939(b), 2823(b),1641(vs), 1499(s), 1441(s), 1281(vs), 1159(s), 1017(s), 863(s), 764(s). ^{1}H NMR ($CDCl_3$,ppm): δ (phenolic OH) 13.43 (s, 2H); 8.35 (s, 2H); 7.35-6.83 (m, 8H); 3.73(t, 4H); 2.70(t,4H); 2.57 (s, 8H). ^{13}C NMR (CDCl3, ppm): δ(C7,16) 165.52; (C1,22) 161.16; (C6,17)132.13; (C3,5,18,20) 131.14; (C4,19) 118.44; (C2,21) 116.98; (C9,14) 58.59; (C8,15) 56.98; (C10,11,12,13) 53.33

Synthesis of Complex :

$[Co_2(\mu\text{-fp})_2(\mu\text{-L})]\cdot 3H_2O\cdot EtOH$ (1). To a MeOH solution of $Co(OAc)_2\cdot 4H_2O$ (0.65 g, 2.62 mmol), salicylaldehyde (Hfp, 2-formyl phenol)(0.28 mL, 2.62 mmol) was added drop wise under stirring condition and then refluxed for 15 minutes. Then methanolic solution of H_2L^4 (0.50 g, 1.32 mmol) was added and refluxed for 1 h to give a clear reddish-brown solution. Then the solution was cooled to room temperature and kept undisturbed for 7 days to give green crystalline compound. The solid was isolated, washed with cold methanol, and dried under vacuum over P_4O_{10}. Yield: 0.903 g (82%). Anal. Calc. for $C_{38}H_{48}N_4O_{10}Co_2$(838.68): C, 54.42; H, 5.76; N, 6.68; Co, 14.05%. Found: C, 54.37; H, 5.58; N, 6.58; Co, 13.98%. Selected FT-IR bands (cm^{-1}, KBr): ν = 2862(b), 1640(vs), 1597(s), 1534(m), 1444(vs), 1344(m), 1321(m), 1288(m), 1185(m), 1180(m), 756(m), 738(m).Λ_M: (MeCN solution) 8 $\Omega^{-1}cm^2mol^{-1}$.

2.3. X-ray crystallographic analysis :

Suitable crystals of 1 were grown from the MeOH-H_2O solution following the solvent evaporation, at room temperature over a period of 7 days. For X-ray structure analysis suitable single crystal was selected under microscope. Diffraction data for 1 were collected on Bruker AXS SMART APEX-2 CCD diffractometer. Data were collected at 295 K and all these measurements use graphite-monochromated Mo-Kα radiation (λ = 0.71073 Å). The intensities of three reference reflections of each complex were monitored every 1h though out the data collection shows no sign of crystal deterioration. The structure was solved using the program SIR97[29] followed by successive Fourier synthesis and least-square refinement using SHELXS97 program[30] The refinement was performed using full-matrix least-squares with all non-hydrogen atoms anisotropically and hydrogen atomswere included on calculated positions, riding on their carrier atoms. Hydrogen atoms on water molecules in complexes could not be located. Crystal data for complex 1 was shown in Table 1. The selected bond lengths are summarized in Table 2.

3. Results and discussion

3.1. Synthesis and characterization :

The functionally *bis*-tridentate ligand H_2L was synthesized using 2-[4-(2-amino ethyl)-piperazine-1-yl]-ethylamine[30] and salicylaldehyde through Schiff base condensatio reaction (Scheme 3). The solid ligand thus isolated after workup was characterized by the FT IR, ^1H and ^{13}C NMR spectral analyses.

The ligand H_2L can exist in four different conformations, A-D[17-19] and has earlie been shown to transform from A to B in a Cu_2 complex formation, leading to an equatoria equatorial (e-e) *trans*-binding. In a similar Fe_2 complex the piperazine conformation found be axial-axial (a-a) *trans*-binding.[31] The conformation C, responsible for *cis*-binding, h been identified in a Cu_4 complex.[19] Now the conformation D, again responsible for *ci* binding, has been identified in the Co_2 complex initially template by two formyl phenola ligands. Thus, the ligand shows unique conformational isomerization at the piperazi backbone available for metal ion coordination (Scheme 4).

Addition of 2-formyl phenolate (fp^-) in the chosen reaction media, as templat inhibiting the binding of L^{2-} in *trans* conformation, lead to the synthesis of complex **1** wh the piperazine backbone locked in *twist-boat*conformation in $[Co_2(\mu\text{-}L)(\mu\text{-}fp)_2]\cdot 3H_2O\cdot EtO$ **(1)**.

$$H_2L^4 + 2Co(OAc)_2\cdot 4H_2O + 2Hfp + NEt_3 \xrightarrow[\text{DMF (Crystalisation)}]{\text{MeOH-DCM (Synthesis)}}$$

$$[Co_2(\mu\text{-}L)(\mu\text{-}fp)_2]\cdot 3H_2O\cdot EtOH\ \mathbf{(1)} + 2\ HNEt_3OAc + AcOH$$

Complex **1** featuring *twist-boat*-piperazine (a-a),[15-16] imine, terminal and bridg phenolato, and terminal carbonyl coordination toward each Co^{II} center in octahe geometry.

FT-IR Spectra. The IR spectra of H_2L^4 shows C=N stretching frequencies at ~1 cm^{-1}. The sharp strong band at ~1380 cm^{-1} and broad band at 3430 cm^{-1} indicates the and ν_{O-H} stretching frequency for the phenolic groups of H_2L^4. The asymmetric and symmetric stretching vibrations of the bound carboxylate groups are detected at 1597 cm $\nu_{as(COO)}$, while $\nu_{s(COO)}$ appeared at 1344 cm^{-1} with $\Delta\nu = \nu_{as(COO)} - \nu_{s(COO)} = 253cm^{-1}$. This value is in accord with the presence of $\mu_{1,1}$-carboxylato bridge ($\mu_{1,3}$ bridge leads to $\Delta\nu$ ca. cm^{-1}).[25] As expected, for 1, the ν_{COO} bands is missing and the ν_{OH} is observed at 3400 cm

3.2. X-ray crystal structure :

$[Co_2(\mu\text{-}fp)_2(\mu\text{-}L)]\cdot 3H_2O\cdot EtOH$ (1). The molecular assembly consists of a neutral unit, three lattice water molecules and one ethanol molecule (Figure 1).The Co_2O_2 dian

core (Figure 2) of **1** is formed instantaneously from a unique bridging action of two phenolato O-donors of two 2-formyl phenolate (fp^-) templates in *anti*-orientation.

Generation of such intermediate species is possible from the binding of two 2-formyl phenolate units as unique chelating-*cum*-bridging ligands, not observed in routine synthesis from the use salicylaldehyde as standalone ligands. The symmetric bridging mode is achieved from the binding two fp^- causes the Co–O–Co angles to be similar at 99.58 (O3), 100.13° (O5) and the O–Co–O angles at 78.79° (Co1) and 78.11° (Co2). The Co···Co distance is 3.183 Å. The hexadentate N_2O_2 donor ligandbinds Co^{II} centers with tridentate NNO halves in *meridional* fashion around the piperazine bridge in *anti*-configuration and fulfils the distorted N_2O_4 octahedral environment. The N-Co-N and N-Co-O bite angles are 80.33, 89.31° (Co1) and 79.73, 88.43° (Co2). The *cis* [Co2 (78.11 - 108.78°); Co1 (78.79 - 104.73)] and the *trans* [Co2 (161.40-172.56); Co1 (164.23 - 174.06)] angles vary considerably from the ideal values. The planes (Co1/O3/O5 and Co2/O3/O5) intersecting at O3···O5 edge form an angle of 151.81° as a result of the folding imposed by piperazine ring N2···N3 = 2.747 Å. The Co–N_{pz} = 2.344 (Co1), 2.332 (Co2) Å are longer than Co–N_{im} = 2.056 (Co1), 2.061 (Co2) Å. The sums of the angles around the bridging O_{ph} atoms are 359.34 (O3) and 359.29° (O5) indicating planar geometries around them. The average Co–O_{ph} bridging distance (2.079 Å) is longer than terminal phenolate (1.99 Å) and shorter than terminal carbonyl (Co–$O_{carbonyl}$= 2.144 Å) distance. Co_2O_2 core reveals two pairs long (2.106 and 2.129 Å) and short (2.044, 2.038 Å) Co-O_{ph} distances on bridging and chelating sides respectively. The twist boat conformation of piperazine backbone identified from the torsion angles (φ_1) of N–C–C–N in the ring of 29.02 and 27.52°. Stereochemistry of the ethylene spacer within the piperazine ring is *gauche* as indicated from the Newman projection (Figure 3a). Intramolecular hydrogen bonding was observed between terminal phenolic oxygen and lattice water molecule (Figure 3b).

The X-ray structure of H_2L earlier established that in its free form it is present in conformation A (*chair* a-a lone pair) (Scheme 1) with a N···N distance of 2.89 Å and undergoes conformational isomerization to D. The centrosymmetric 2-formyl phenolate bridged intermediate allows only symmetrical coordination of the *twist-boat* (a-a) piperazine ring and allows centrosymmetric binding of the two tridentate halves of the ligand dianion.

Conclusion :

The conformation isomerism upon two cobalt ion coordination in bivalent state was scrutinized for semirigid piperazine backbone within the reported complex. We have been able to show a novel *cis*-coordination mode of *chair*-piperazine motif revealing an *equatorial-axial (e-a)* conformation for *basal* coordination around the initially formed double 2-formyl phenolate bridged stable Co_2 entity. This firstly formed motif obtained through template action of two 2-formyl phenolate bridges thus force a *twist-boat* conformation of piperazine backbone for coordination of two heterocycle nitrogen donors. This coordination did not able to register any ligand displacement reaction from the use of two 2-formyl phenolate clips. Carbonyl coordination to two Co^{II} centers is similar to the observed binding of urea to Ni^{II} center in metalloenzyme urease.

References :

1. O. Kahn, *Molecular Magnetism, VCH, New York,* **1993**.
2. Miller, J. S.; Drillon, M. *Magnetism: Molecules to Materials, Wiley-VCH, Weinheim*, **2002**.
3. Thompson, L. K. Directed Assembly of Metal-Cyanide Cluster Magnets. *Coord. Chem. Rev.*, **2002**, *193*, 233–234.
4. Beltran, L. M. C.; Long, J. R. Directed Assembly of Metal-Cyanide Cluster Magnets *Acc. Chem. Res.* **2005**, *38*, 32 334.
5. Ratilainen, J.; Airola, K.; Frohlich, R.; Nieger, M.; Rissanen, K. Synthesis of a tetradentate piperazine ligand and structural study of its coordination compounds. *Polyhedron.* **1999**, *18*, 2265–2273.
6. Airola, K.; Ratilainen, J.; Nyronen, T.; Rissanen, K. A linear open-chain piperazine-pyridine ligand and its meso-helic Co complex. *Inorg. Chim. Acta.* **1998**, *277*, 55-60.
7. Rissanen, K.; Breitenbach, J.; Huuskonen, J. An Unusual Copper(I) Complex of a New Macrocyclic Ligand. *J. Che Soc., Chem. Commun.* **1994**, 1265-1266.
8. Huuskonen, J.; Schulz, J.; Kolehmainen, E.; Rissanen, K. Photoresponsive Piperazine Macrocycles. *Chem. Ber.* 199 *127*, 2267-2272.
9. a) Schneider, H.J. Mechanisms of Molecular Recognition: Investigations of Organic Host-Guest Complexes. *Ange Chem., Int. Ed. Engl.*, **1991**, *30*, 1417-1436.
   b) Kant R. and Maji S.Recent advances in the synthesis of piperazine based ligands and metal complexes and th application. Dalton Trans., 2021, 50, 785-800.
   c) G. C. Paul, P. Sarkar and C. Mukherjee, Inorg. Chim. Acta, 2019, 486, 213–220.
   d) S. Muthuramalingam, S. Subramaniyan, T. Khamrang, M. Velusamy and R. Mayilmurugan, Chemistry Sele 2017, 2, 940–948.
   e) D. Basak and D. Ray, Inorg. Chim. Acta, 2020, 503, 119439.
   f) H. Mandal and D. Ray, Transition Met. Chem., 2018, 43, 571–577.
   g) S. Purkait, G. Aullón, E. Zangrando and P. Chakraborty, Dalton Trans., 2017, 46, 2184–2195.
10. Boiocchi, M.; Bonizzoni, M.; Fabbrizzi, L.; Foti, F.; Licchelli, M.; Taglietti, A.; Zema, M. The influence of the bo to-chair conversion on the demetallation of the nickel(II) complex of an open-chain tetramine containing a piperaz fragment. *J. Chem. Soc., DaltonTrans.* **2004**, 653-658.
11. Smekal, Z.; Travnicek, Z.; Mrozinski, J.; Marek, J. Synthesis, structure and magnetic properties of a trinuclear cya bridged complex $[Cu(bappz)(\mu\text{-}NC)Ni(CN)_2(\mu\text{-}CN)Cu(bappz)](ClO_4)_2$ (bappz = 1,4-bis(3-aminopropyl)piperazin *Inorg. Chem. Commun.* **2003**, *6*, 1395-1399.
12. Mukhopadhyay, U.; Bernal,A. Self-Assembled, Decameric Water Cluster Stabilized by a Cyano-Bridged Copper Complex. *Cryst. Growth Des.* **2006**, *6*, 363-365.
13. Mukhopadhyay, S.; Mandal, D.; Chatterjee, P. B.; Desplanches, C.; Sutter, J.-P.; Butcher, R. J.; Chaudhury, M. Bi- Trinuclear Copper(II) Complexes of a Sterically Constrained Phenol-Based Tetradentate Ligand: Syntheses, Structu and Magnetic Studies. *Inorg. Chem.* **2004**, *43*, 8501-8509.
14. Massoud, S. S.; Mautner, F. A. Synthesis, characterization, and crystal structure of 1,4-bis(3-aminopro piperazineperchloratocopper (II) perchlorate. Inorg. Chem. Commun. 2004, 7, 559-562. 1,4-bis (3-aminopro piperazineperchloratocopper (II) perchlorate. *Inorg. Chem. Commun.* **2004**, *7*, 559-562.
15. Chiari, B.; Piovesana, O.; Tarantelli, T.; Zanazzi, P. F.Exchange Interaction in Multinuclear Transition-M Complexes. 1. Synthesis, X-ray Structure, and Magnetic and Spectroscopic Properties of Di-p-methoxy-dichloro [piperazinebis (N-ethylenesalicylaldiminato)] diiron(III), $Fe_2L(OCH_3)_2Cl_2$. *Inorg. Chem.* **1982**, *21*,1396-1402.
16. Chiari, B.; Piovesana, O.; Tarantelli, T.; Zanazzi, P. F. Exchange Interaction in Multinuclear Transition-M Complexes.Nature of Metal-Metal Coupling in Dinuclear Iron (III) Systems Containing Fe-0-Fe-0 Bridging U *Inorg. Chem.* **1984**, *23*, 3398-3404.
17. Bera, M.; Ribas, J.; Wong, W. T.; Ray, D. A chair-piperazine bridged N,N-dimethylformamide coordin dicopper(II/II) complex obtained via solution transformation of heterocyclic imidazolidine spacer of a new lig *Inorg. Chem. Commun.*, **2004**, *7*, 1242-1245.
18. Chiari, B.; Piovesana, O.; Tarantelli, T.; Zanazzi,P. F. Exchange Interaction in Multinuclear Transition-M Complexes.Through-Bond Exchange Coupling in $Cu_2A(CH_3COO)_2{\cdot}2CH_3OH$ (A^{2-}=H Anion of N,N'-Bis (2 hydroxybenzhydrylidene) amino) ethyl) piperazine). *Inorg. Chem.* **1984**, *23*, 2542-2547.

19. Paital, A. R.; P. K.; Nanda, Das, S.; Aromi, G.; Ray, D. Unique Asymmetric (Cu^{II}_4) Double Stranded Helicate from a Hexadentate Piperazine-Based Ligand: Ligand Conformation Isomerism upon Coordination. *Inorg. Chem.* **2006**, *45*, 505-507.

20. Colacio, E.; Ghazi, M.; Kivekals, R.; Maria Moreno, J.Helical-Chain Copper(II) Complexes and a Cyclic Tetranuclear Copper (II) Complex with Single Syn-Anti Carboxylate Bridges and Ferromagnetic Exchange Interactions.*Inorg. Chem.* **2000**, *39*, 2882-2890.

21. Suen, M. C.; Keng, T. C.; Wang, J. C. One-dimensional structures of zinc(II) and cobalt(II) coordination complexes $[Zn(NCS)_2(PPz)]_n$ and $[CoCl_2(PPz)]_n$ (PPz=piperazine). *Polyhedron.* **2002**, *21*, 2705-2710.

22. Carlucci, L.; Ciani, G.; Proserpio, D. M.; Sironi, A. 2D Polymeric Silver(I) Complexes Consisting of Markedly Undulated Sheets of Squares. X-ray Crystal Structures of [Ag(ppz)](BF_4) and Pyrazine) [&(pyz)$_2$](PF_6) (ppz = piperazine, pyz = pyrazine).*Inorg. Chem.*, **1995**, *34*, 5698-5700.

23. Kondo, M.; Okubo, T.; Asami, A.; Noro, S.; Yoshitomi, T.; Kitagawa, S.; Ishii, T.;Matsuzaka,H.; Seki, K. Rational Synthesis of Stable Channel-like Cavities withMethane Gas Adsorption Properties: $[Cu_2(pzdc)_2(L)]n$(pzdc=pyrazine-2,3-dicarboxylate; L = a pillar ligand).*Angew. Chem. Int. Ed. Engl.* **1999**, *38*, 140-143.

24. Ganesan, S. V.; Natarajan, S.Synthesis and Structures of New Pyromellitate Coordination Polymers with Piperazine as a Ligand.*Inorg. Chem.*, **2004**, *43*, 198-205.

25. Niu, Y. Y.; Hou, H. W.; Wei, Y. L.; Fan, Y. T.; Zhu, Y.; Du, C. X.; Xin, X. Q. A linear piperizine-pyridine ligand and its Hg coordination polymer. *Inorg. Chem.Commun.*, **2001**, *4*, 358-361.

26. Xu, H.; Song, Y. L.; Hou, H. W. Crystal structures and third-order NLO properties in DMF solution of Co(II)-bpfp coordination polymers (bpfp = N; N′-bis(pyridylformyl)piperazine. *Inorg. Chim. Acta.* **2004**, *12*, 3541-3548.

27. Prudencio, M.; Pereira, A. S.; Tavares, P.; Besson, S.; Cabrito, I.; Brown, K.; Samyn, B.; Devreese, B.; Beeumen, J. V.; Rusnak, F.; Fauque, G.; Moura, J. J. G.; Tegoni, M.; Cambillau , C.; Moura, I. Purification, Characterization, and Preliminary Crystallographic Study of Copper-Containing Nitrous Oxide Reductase from *Pseudomonas Nautica* 617. *Biochemistry*, **2000**, *39*, 3899-3907.

28. Allinger, N. L.; Carpenter, J. G. D.; Karkowski, F. M. Conformational Analysis. XLII. Experimental Approaches to the Problem of the Size of the Lone Pair on Nitrogen. *J. Am.Chem. Soc.* **1965**, *87*, 1232-1236.

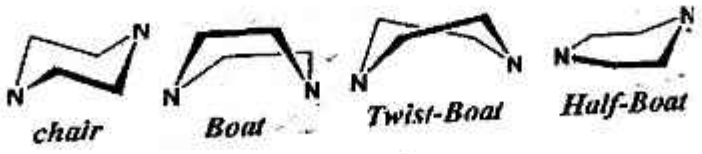
29. A. Altomare, M.C. Burla, M. Camalli, G.L. Cascarano, C. Giacovazzo,A. Guagliardi, A.G. Moliterni, G. Polidori, R. Spagna, J. Appl. Crystallogr. 32(1999) 115e119, https://doi.org/10.1107/S0021889898007717.

30. (a) G.M. Sheldrick, Acta Crystallogr. A 64 (2008) 112e122, https://doi.org/10.1107/S0108767307043930;
(b) G.M. Sheldrick, Acta Crystallogr. C71 (2015) 3e8, https://doi.org/10.1107/S2053229614024218.

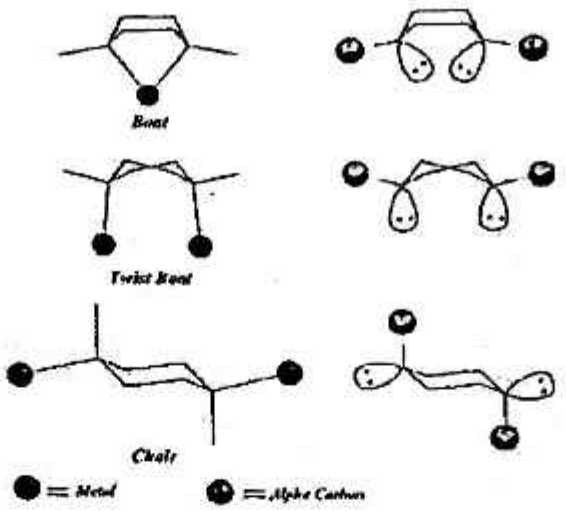
31. Chuburu, F.; Tripier, R.; Baccon, M. L.; Handel, H. Bis-Aminals of Linear Tetraamines: Kinetic and Thermodynamic Aspects of the Condensation Reaction. *Eur. J. Org. Chem.* **2003**, 1050-1055.

32. M. Ostermeier, C. Limberg, B. Ziemer.The Coordination Chemistry of Iron with the 1,4-Bis(2-pyridyl-methyl)piperazine Ligand.*Z. Anorg. Allg. Chem.* **2006**, *632*, 1287-1292.

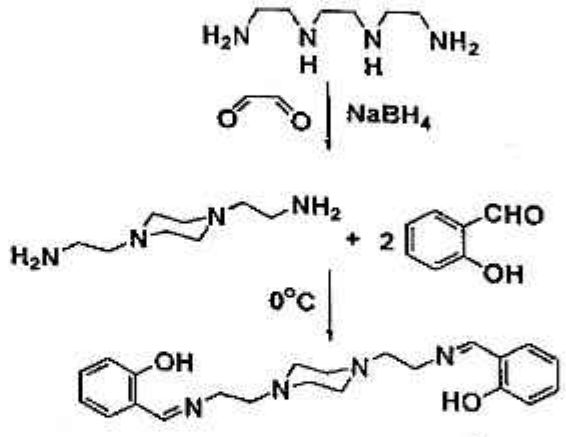
Figures and Tables



Scheme 1

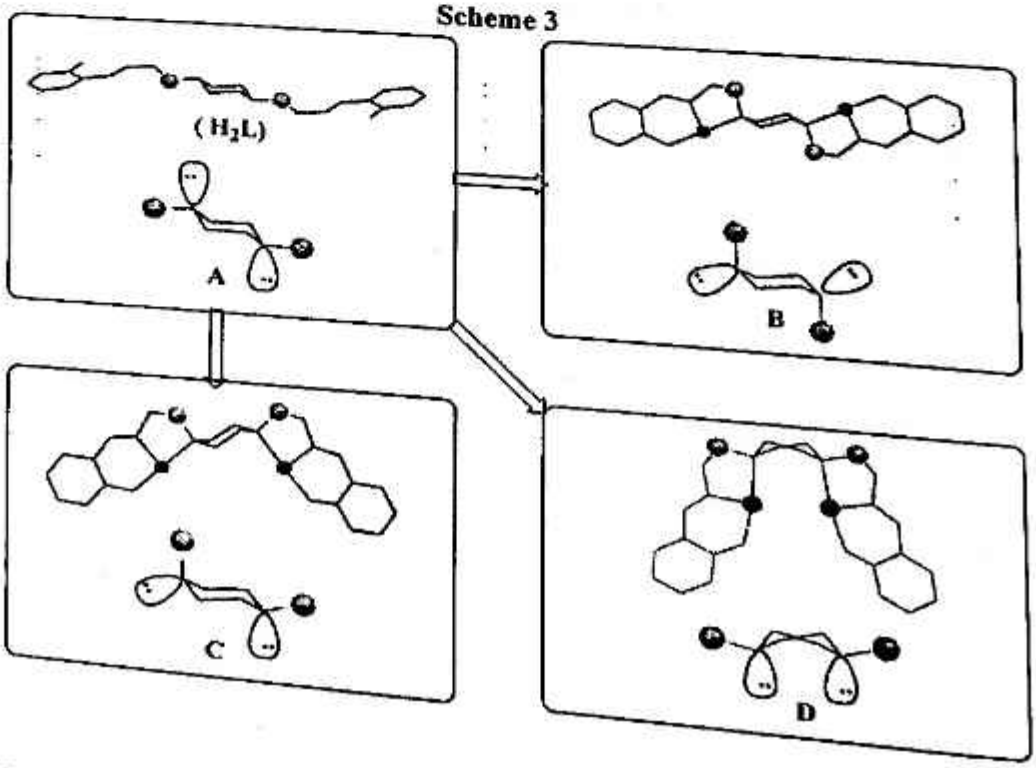


Scheme 2

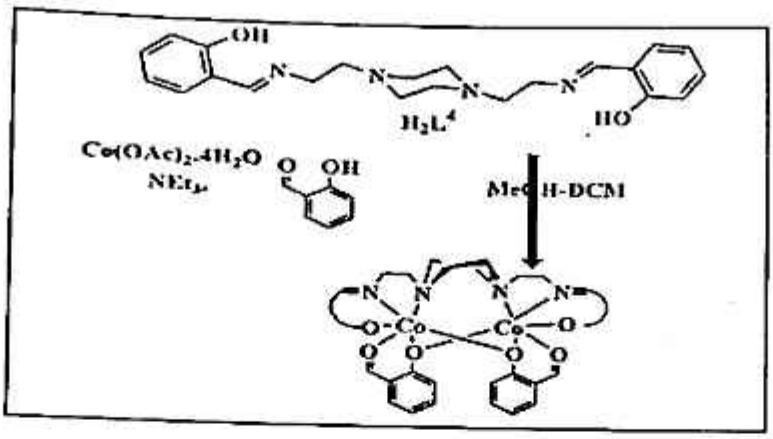


H_2L^4

Scheme 3



Scheme 4



Scheme 5

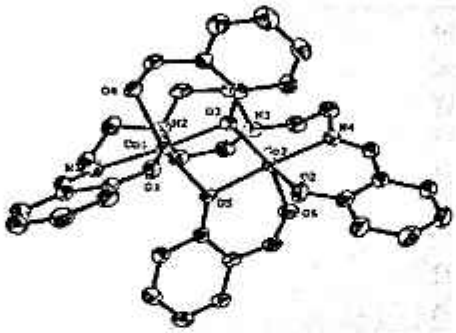


Figure 1. ORTEP of view of 1

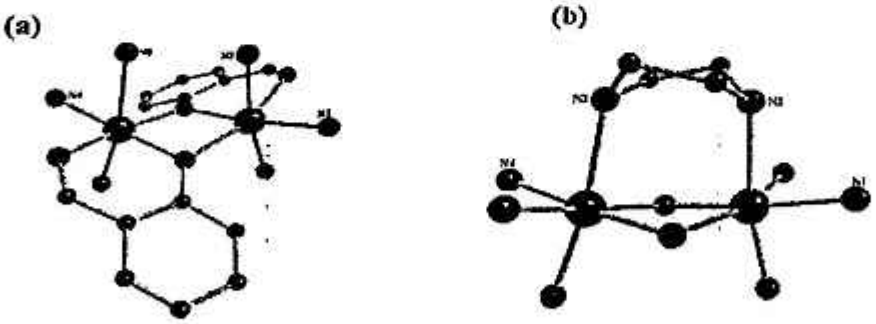


Figure 2. (a) The Co_2O_2 diamond core is presumably assembled as intermediate; (b) The core of complex 1 showing the fate of the piperazine backbone in *twist-boat* conformation

(a)

(b)

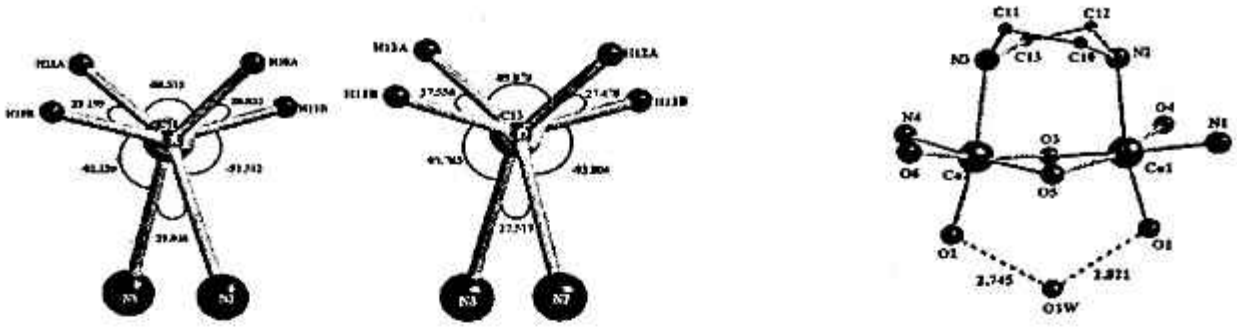


Figure 3. (a) Ethylene spacer within the piperazine ring is in *gauche*-conformation. (b) Hydrogen bonding interaction wi suitably poised lattice water molecule in supramolecular structure further stabilizes the dimeric structure.

Table 1. Crystallographic data for **1**

Molecular formula	$C_{76}H_{76}Co_4N_8O_{20}$
Molecular weight	1657.17
Crystal system	Monoclinic
Space group	$P\,2_1/c$
a (Å)	10.380(2)
b (Å)	19.536(4)
c (Å)	19.949(4)
α(°)	
β (°)	101.581(6)
γ (°)	U (Å^3) 3962.9(1)
D_c (g cm^{-3})	1.389
Z	2
F(000)	1712
Crystal size / mm	0.37 x 0.22 x 0.10
μ (mm^{-1})	0.897
θ Range (°)	2.08 - 26.56
R_1, wR_2 [$I > 2\sigma(I)$]	0.0749, 0.2071
hkl ranges	-12,13;-24,24;-24,24
Goodness-of-fit on	1.044
max, min (e Å^{-3})	+2.666, -0.512

$R_1 = \Sigma(\ ||F_o|-|F_c||\ )/\Sigma|F_o|$. $wR_2 = [\ \Sigma w(|F_o|-|F_c|)^2/\Sigma w(F_o)^2]^{1/2}$.

$w = 0.75/(\sigma^2(F_o) + 0.0010F_o^2)$.

Table 2. Selected bond lengths (Å) for **1**

Co(1)-O(1)	2.001(4)
Co(1)-O(3)	2.038(4)
Co(1)-N(1)	2.056(5)
Co(1)-O(5)	2.106(3)
Co(1)-O(4)	2.124(4)
Co(1)-N(2)	2.344(5)
Co(2)-O(2)	1.979(4)
Co(2)-O(5)	2.044(4)
Co(2)-N(4)	2.061(5)
Co(2)-O(3)	2.129(4
Co(2)-O(6)	2.165(4)
Co(2)-N(3)	2.332(5)

Table 3. Selected bond angles (°) for **1**

O(1)-Co(1)-O(3)	95.12(16)
O(1)-Co(1)-N(1)	89.3(2)
O(3)-Co(1)-N(1)	174.06(19)
O(1)-Co(1)-O(5)	95.98(16)
O(3)-Co(1)-O(5)	78.79(14)
N(1)-Co(1)-O(5)	104.74(17)
O(1)-Co(1)-O(4)	91.18(17)
O(3)-Co(1)-O(4)	86.61(15)
N(1)-Co(1)-O(4)	89.34(18)
O(5)-Co(1)-O(4)	164.23(16)
O(1)-Co(1)-N(2)	169.53(18)
O(3)-Co(1)-N(2)	95.12(18)
N(1)-Co(1)-N(2)	80.3(2)
O(5)-Co(1)-N(2)	88.18(16)
O(4)-Co(1)-N(2)	87.22(17)
O(2)-Co(2)-O(5)	93.79(17)
O(2)-Co(2)-N(4)	88.4(2)
O(5)-Co(2)-N(4)	172.56(17)
O(2)-Co(2)-O(3)	95.44(17)
N(4)-Co(2)-O(3)	108.78(17)
O(2)-Co(2)-O(6)	92.95(19)
O(5)-Co(2)-O(6)	84.81(16)
N(4)-Co(2)-O(6)	87.99(18)
O(3)-Co(2)-O(6)	161.40(17)
O(2)-Co(2)-N(3)	168.15(18)
O(5)-Co(2)-N(3)	98.00(17)
N(4)-Co(2)-N(3)	79.7(2)
O(3)-Co(2)-N(3)	88.21(16)
O(6)-Co(2)-N(3)	86.93(18)

The Art and Science of Adulteration

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Abstract :
Adulteration is an art by itself practiced since ages by human race following one or several rules. In this reviev an attempt has been taken to address the ways and causes of different kinds of adulteration of the authenti plant-based products of economic significance. Also, few classical and modern methods have been discusse that are employed to check the adulteration to maintain quality of plant-based drugs.

Keywords : Adulteration, intentional, non-intentional, powdered drugs, herbal products, substituent contaminants

Medicinal plants form a basis of drug source for traditional as well as homeopathy medicine In fact, approximately 70% synthetic drugs are also derived from plants. In India about 80% rural population depends on herbal medicine and/or indigenous sources of medicine. Almo 80% of the herbal products used in traditional medicine system as well as consumed common spices have medicinal plants as their sole sources of production. Hence, herb adulteration is one of the common malpractices in herbal raw-medicine as well as spice trad across the globe. According to a global survey by Ichim (2019), 27% of the herbal produc commercialized in marketplace has been found to be adulterated when tested against th labelled/claimed sources: comparatively highest rate of adulteration being observed Australia (79%), South America (67%), lower in Europe (47%), North America (33% Africa (27%) and the lowest in Asia (23%).

What is adulteration?

Adulteration is a practice of substituting the original crude drug partially or fully with oth spurious, inferior, spoiled or low graded drugs or entirely different drug similar in appearan or morphology to the original drug, substituted mostly with an intention of making prof Often these adulterated products do not match with the authenticated official sample (Sag 2014). Adulteration may be intentional or non-intentional. If the herbal products cont undeclared contaminant, substitute, and filler species, or none of the labeled species mentioned, which all may be accidental or intentional, economically motivated fraudulent, then those herbal products are said to be adulterated (Ichim, 2019).

Need for adulteration

India is one of the world's leading countries in the global trade of medicinal plants and is the largest grower of some herbal plants such as: Psyllium (*Plantago ovata*), Senna (*Cassia senna*) and Castor (*Ricinus communis*) Turmeric (*Curcuma longa*). India grows ten of the most widely distributed herbal medicines in the developing countries: *Allium sativum*, *Aloe barbadensis*, *Panax spp.*, *Glycyrrhiza glabra*, *Commiphora mukul*, *Azadirachta indica*, *Piper longum*, *Adhatoda vasica*, *Withania somnifera* and *Cyperus rotundus*, along with few other notable plants like *Tinospora cordifolia*, *Berberis aristata*, *Tribulus terrestris*, *Holarrhena antidysenterica* and *Boerhavia diffusa*, and also the species *Terminalia chebula*, *Terminalia bellirica* and *Emblica officinalis* (Shanmughanandhan et al., 2016). These herbal plants are important sources for herbal medicines used in the traditional medication system, specifically in Indian traditional medicine system comprising of Unani, Siddha and Ayurveda and also in Chinese traditional medicine systems and German medicine system popularly known as homeopathy medicine. This leads to an unending popularity of herbal drugs in global market, and due to this, their adulteration is gaining importance at commercial and marketing levels. Many a times, adulteration occurs when pharmaceutical companies manufacturing herbal products, procure materials from traders/suppliers who lacks specific knowledge in this field, or are untrained persons from rural / forest areas (Khan et. al., 2011).

Adulteration may be intentional or unintentional. Misidentification of drugs may be unintentional, where processed plant parts are morphologically undistinguishable or may be done intentionally by profit driven traders to substitute expensive herbs with low-graded look-alikes and this may be hazardous to human health (Khan et. al., 2011). According to a documentation by Sagar (2014), sometimes adulteration may be done due to reasons like: **(a) Uncertainty in identification of drugs:** Sometimes confusion may arise as to the original identity of the authentic drugs in that case, collectors with less taxonomic knowledge may mistakenly pluck wrong drugs, like, different species such as *Arliaquinquefolia*, *Ipomea sepiaria* etc. are considered as replacement for the herb Lakshmana; **(b) Costing of drugs:** Often the original drug becomes much costlier to afford, hence adulteration may be done by cheap identical drugs, like, Kumkuma or Kesar, Kumkum, Zafran, (Styles and Stigmas of aerial parts of flowers of *Crocus sativus* Linn.) are substituted and adulterated by Kusumbha or Kusum, (styles and stigmas of arial parts of flowers of *Carthamus tinctorius*), Rakta Chandana, Sandal Surkh, (hard wood powder of *Pterocarpus santalinus* Linn.) is substituted and adulterated by Red Capsicum, Lal Shimla mirch, (fruit powder of *Capsicum annuum*

Linn., *Capsicum baccatum* Linn. *and Capsicum frutescens* Linn.) as such Sveta Chandana Sandal Safed, (Hardwood powder of *Pterocarpus santalinus* Linn.) is substituted an adulterated by White Capsicum, Safed Shimla mirch, (Fruit powder of *Capsicum annuu Linn.,*) largely used in Ayurvedic and Unani compound formulation being costly herb and (

Non-availability of the required drugs : Sometimes the original and authentic drugs a hard to find or may become extinct due to several reasons, hence substitution may be done i those cases by other identical drugs, such as, substitution and adulteration for *Ashtvarga* pa (a group of 8 crude drugs - *Riddhi* or *Vriddhi*, *Kakoli*, *Kshirakakoli*, *Jibhaka*, *Rsabhak Meda* and *Meha meda*) which are endangered and rare drugs found in high altitude rang 2000 to above 4500-meter height Himachal and Himalaya Northern region of high altitud dense valleys.

Intentional and Unintentional Adulteration

According to Sagar (2014), a drug shall be considered adulterated if it consists any kind filthy, putrid or decomposed substances in whole or in parts.

Intentional adulteration

Generally, the drugs are adulterated by substitution with substandard commercial varieti inferior drugs or artificially manufactured commodities. The different types of adulteran found in market are given here (Sagar, 2014).

- ***Adulteration by using artificially manufactured substances***

In this type of adulteration, the original drugs are adulterated by material that a manufactured artificially, generally prepared in a way such that their general form a appearance resemble with original drugs. This is done usually for costlier drugs.

Few examples in this category are:

a) Cargo of ergot from Portugal was adulterated with small masses of flour dou molded to the correct size and shape and colored, first using red ink, and then i writing ink.
b) Honey is often substituted by artificial invert sugar.
c) Often paraffin wax is colored yellow and is being substituted for beeswax.
d) Compressed chicory is often used in place of coffee berries.
e) Bass-wood cut exactly the required shape of nutmeg is used to adulterate nutmeg.

- ***Adulteration by using inferior commercial varieties***

In this type, the original drugs are mostly substituted by using inferior quality drugs that may resemble the original drug in morphological characters, chemical constituents or therapeutic values. Few common examples in this category may be:

a) Hog gum or hog tragacanth may be used to adulterate tragacanth gum,
b) Mangosteen fruits are used to substitute Bael fruits,
c) Senna may be adulterated by using Arabian senna, obovate senna and Provence senna,
d) Ginger is often adulterated with cochin, African and Japanese ginger.

- ***Adulteration by using exhausted drugs***

Here, the active medicaments of the main drugs are extracted out and are used again artificially to enhance their effects by manipulation, usually for longer uses. This is usually done for the commodities that would retain its shape and appearance even after extraction, or the appearance and taste could be made to the required state by adding coloring or flavoring agents. This technique is frequently adopted for the drugs containing volatile oil, such as clove, Fennel, etc. As these are devoid of color and taste after extraction, the natural color and taste are usually manipulated with additives. Few well known examples may be:

a) Artificial dyes are used to recolor Saffron and red rose petals, after extraction.
b) Addition of aloes restores the bitterness of exhausted gentian.

- ***Adulteration by superficially similar inferior natural substance***

In this method, the substituents used may be morphologically similar but not having any relation to the genuine drugs in their constituents or therapeutic activity. Few documented examples are:

a) *Ailanthus* leaves are often substituted for *Belladonna, Senna* leaves,
b) Saffron is generally admixed with saff flower,
c) Peach kernels and apricot kernel are often used as fillers in almond packets.

- ***Adulteration by using the vegetative part of the same plant***

The presence of vegetative parts of the same plant along with the drug in excessive amount is also an adulteration. These often include parts of miniature plants growing along with the medicinally important plants, due to their color, odor and constituents. In a documentation, few examples are:

a) Epiphytes, such as mosses, liverworts and lichens that grow over the barks of plants also may occur in unusual amounts with the drugs,
b) Excessive number of stems are observed along with drugs like *Lobelia*, *Stramonium*, *Hamamelis* leaves, etc.

- ***Adulteration by Addition of toxic materials***

In this type of adulteration, the materials used for adulteration are toxic in nature and hazardous to human health as most of them are picked from market wastes and mixed with drugs.

a) A big mass of stone was found in the Centre of a bale of liquorice root.
b) lime stone pieces were found as fillers with *Asafoetida*,
c) lead shot found along with *Opium*,
d) amber colored glass pieces mixed in *Colophony*.

- ***Adulteration of powdered drugs***

Powdered drugs are found to be adulterated very frequently. Adulterants used in this case ar generally powdered waste products of a suitable color and density.

a) Powdered olive stones are substituted for powdered Gentian, liquorice or pepper
b) Dextrin is added in *Ipecacuanha*,
c) exhausted ginger is mixed in fresh ginger powder,
d) red and white sandalwood powders are added as fillers along with red and whi capsicum powders
e) powdered barks are adulterated with brick powders.

- ***Adulteration by Addition of synthetic principles***

Synthetically manufactured pharmaceutical chemicals are mostly used to increase market a therapeutic values of drugs. Most common examples are:

a) Citral is added as adulterant to lemon oil,
b) diabetes angel containing glyburide and phenformin,
c) sleeping buddha containing estazolam.

Unintentional adulteration

Unintentional adulteration may be due to the following reasons (Sagar, 2014):

- ***Confusion in vernacular names between indigenous systems of medicine and local dialects***

In Ayurveda, '*Parpatta*' refer to *Fumaria parviflora*. In Siddha, '*Parpadagam*' refer to *Mollugo pentaphylla*. Owing to the similarity in the names in traditional system of medicine, these two herbs are often interchanged or adulterated or substituted. Because of the popularity of siddha medicine in some parts of south India, traders in these regions supply *M. pentaphylla* as *Parpatta/Parpadagam* and the north Indian suppliers supply *F. parviflora*. These two can be easily identified by the presence of pale yellow to mild brown colored, thin wiry stems and small simple leaves of *M. pentaphylla* and black to dark brown -colored, digitate leaves with narrow segments of *F. parviflora*.

- ***Lack of knowledge about the authentic plant source***

Nagakesar is one of the important drugs in Ayurveda, whose authentic source is *Mesua ferrea*. However, market sample are adulterated with flowers of *Calophyllum inophyllum*, though the authentic plant is available in plenty throughout the western ghats and parts of the Himalayas, about which the suppliers are unaware of. Also, some restrictions in forest collection, may force them to adultery the products. Due to these reasons, *C. inophyllum* is sold as *Nagakesar*. Authentic flowers can be easily identified by the presence of two- celled ovary, whereas in case of spurious flowers they are single celled.

- ***Non availability of the authentic plant***

In European markets, authentic *Hypericum perforatum* is cultivated and sold. However, in India, availability of this species in very limited. Hence, the abundant Indo-Nepal species *H. patulum* is sold in the name of *H. perforatum*. Market sample is a whole plant with flowers, and it is easy to identify them taxonomically. Anatomically, stem transverse section of *H. perforatum* has compressed thin phloem, hollow pith and absence of calcium oxalate crystals. On the other hand, *H. patulum* has broader phloem, partially hollow pith and presence of calcium oxalate crystals.

- ***Similarity in morphology and/or aroma***

Mucuna pruriens is the best example for unknown authentic plant and similarity in morphology. It is adulterated with similar papilionaceae seeds, *M. utilis* (sold as white variety) and *M. deeringiana* (sold as bigger variety) being the popular adulterants. Apart from this, *M. cochinchinensis, Canavalia variso* and *C. ensiformis* are also sold in Indian markets.

Authentic seeds are up to 1cm in length with shining mosaic pattern of black and brown colo on their surface. *M. deeringiana* and *M. utilis* are bigger (1.5-2cm) in size. *M. deeringiana* i dull black, whereas *M. utilis* is white or buff colored.

- ***Careless collection by suppliers***

Some of the herbal adulterations are due to the carelessness of herbal collectors and suppliers A well-known example as documented by Sagar (2014) is: *Parmelia perlata* is use extensively in Ayurveda, Unani, Siddha, as well as in grocery. Market samples showed it t be admixed with other species (*P. perforata* and *P. cirrhata*). Sometimes, *Usnea sp.* is als mixed with them. Authentic plants can be identified by their thallus nature.

- ***Similarity in color***

It is well known that in course of time, drug materials get changed to or substituted with othe plant species. In the past, roots of *Ventilago madraspatana* were collected from weste Ghats, as the only source of *Ratanjot* which is however, not the practice now. *Arnebi euchroma var euchroma* is the present source. Due to similarity in yielding a red dye, *A euchroma* substitutes *V. madraspatana*. The description to identify these two is unnecessar because of the absence of *V. madraspatana* in local market. Whatever is available in th market, in the name of *Ratanjot*, is presently originated from *A. euchroma.*

- ***Several unknown reasons***

Vidari is another example of unknown authentic plant which being an important ayurvedi plant has been used extensively. Its authentic source is *Pueraria tuberosa*, and its substitute i *Ipomoea digitata*. However, market samples are not derived from these two. It is interestingl known that an endangered gymnosperm *Cycas circinalis* is sold in plenty as *Vidari*. Th adulterated materials are usually originated from Kerala, India. Although both the authenti plant and its substitute are available in plenty throughout India, the reason behind *C circinalis* becoming a major source for this drug is unknown. *P. tuberosa* can be easil identified by the presence of papery flake-like tubers, *I. digitata* by the presence of i concentric rings of vascular bundles and their adulterant *C. circinalis* by its leaf scars an absence of vessel elements.

Commonly adulterated herbal plants

List of experimental evidence-based existing substitutes/adulterants for few of the highly important medicinal plants are given below:

Sl. No.	Plant species	Substituent / adulterant	References
1)	*Boswellia serrata*	*Boswellia carteri / Garunga pinnata*	Alam (2008)
2)	*Santalum album*	*Erythroxylum monogynum*	Chembath et al. (2012)
3)	*Saussurea lappa*	*Aristolochia debilis*	Chen et al. (2008)
4)	*Cinnamomum sulphuratum*	*Cinnamomum species*	Dhanya and Sasikumar (2010)
5)	*Illicium verum*	*Illicium anisatum*	Dhanya and Sasikumar (2010)
6)	*Piper nigrum*	*Lantana camara, Embelia ribes*	Dhanya and Sasikumar (2010)
7)	*Papavar somniferum*	*Amaranthus paniculatas*	Dhanya and Sasikumar (2010)
8)	*Myristica fragrans*	*Myristica argentea, Myristica malabarica*	Dhanya and Sasikumar (2010)
9)	*Pimenta dioica*	*Myrtus tobacco, Lindera benzoin*	Dhanya and Sasikumar (2010)
10)	*Holarrhena pubescens*	*Wrightia tomentosa / Wrightia tinctoria*	Gahlaut et al. (2013)
11)	*Saraca asoca*	*Polyanthia longifolia*	Gahlaut et al. (2013)
12)	*Centella asiatica*	*Bacopa monnieri*	Jamil et al. (2007)
13)	*Swertia chirayta*	*Andrographis paniculata /Rubia cordifolia/Swertia species*	Joshi and Dhawan (2005)
14)	*Chlorophytum tuberosum*	*Chlorophytum arundinaceum/Chlorophytum borivilianum*	Katoch et al. (2010)
15)	*Glycyrrhiza glabra*	*Glycyrrhiza uralensis /Abrus precatorius*	Khan et al. (2009)
16)	*Cuscuta reflexa*	*Cuscuta chinensis*	Khan et al. (2010)
17)	*Echinacea purpurea*	*Echinacea angustifolia, Parthenium integrifolium*	Laasonen et al. (2002)
18)	*Decalepis hamiltonni*	*Hemidesmus indicus*	Padmalatha et al. (2012)
19)	*Aconitum heterophyllum*	*Cyperus rotundus*	Prakash et al. (2013)
20)	*Baliospermum montanum*	*Plumbago zeylanica*	Prakash et al. (2013)
21)	*Garcinia indica*	*Garcinia gummi-gutta*	Prakash et al. (2013)
22)	*Mesua ferrea*	*Nelumbo nucifera*	Prakash et al. (2013)
23)	*Ocimum basilicum*	*Ocimum sanctum*	Prakash et al. (2013)
24)	*Valeriana wallichii*	*Saussrea lappa*	Prakash et al. (2013)
25)	*Senna alexandrina*	*Senna auriculata*	Seethapathy et. al. (2014)

26)	*Senna tora*	*Sesbania sp.*	Seethapathy et. al. (2014)
27)	*Commiphora wightii*	*Boswellia serata*	Siddiqui (2011)
28)	*Asparagus racemosus*	*Asparagus gonoclados*	Singh et al. (2013)
29)	*Catharanthus roseus*	*Solanum melogena / Lycospermum esculentum*	Srivastava and Srivastava (1988)
30)	*Curcuma longa*	*Curcuma zedoaria*	V. A. Parvathy et al. (2015)
31)	*Sida rhombifolia*	*Sida acuta/Sida cordifolia*	Vassou et al. (2015)
32)	*Alpinia calcarata*	*Alpinia galanga/officinarum*	Zhao et al. (2001)

Various methods to check authentication of market available herbal products

The broadly available commercial technologies used for authentication of plant-based commodities include: physical methods, chemical/biochemical methods, immunoassays and the most recent DNA-based molecular tools.

Previously, the **classical approaches** of plant identification were mostly used involving the organoleptic method, micro- and macroscopic characters and chemical profiling. But advancement in **molecular techniques** has enabled researchers to use simple and cost effective rapid DNA analysis as a universally acceptable platform (Priyanka Mishra et.al 2015). These methods are comparatively the modern approaches till date.

- **Classical methods:** Thin Layer Chromatography (TLC), powder microscopy, determination and comparison of functional and physicochemical properties are the classical approaches that have been used since ages when molecular approaches were not evolved. These classical approaches are quite easier and cheaper compared to modern molecular methods. These methods are quite efficient for detecting the chemical or synthetic adulterants but complications may arise while detecting biological adulterants. Hence, though not so satisfactory in every case, still they are widely used to detect adulteration in primary fields where molecular methods cannot be utilized.

Thin Layer Chromatography:This is the most versatile, simplest and economical way to obtain chemical fingerprints of multiple herbal products and is commonly and shortly known as TLC. The Retention factor (R_f) value determined by this method is used to identify original constituents present in authentic samples and hence, serves as an efficient tool in detecting adulteration.In TLC, the identity and purity of the sample is determined by the comparison made with standard spot obtained by the standard crude drug under specific solvent system (Anubhuti et. al., 2011).Authentication of various commercially available crude drugs like *Foeniculum vulgarae, Curcuma longa, Plantago ovata, Zingiber officinale, Aloe barbadensis, Glycyrrhiza glabra*were tested by the TLC method against their respective

standards: Anethole; curcumin, demethoxycurcumin (DMC) and bisdemethoxycurcumin curcumin (BDMC); xylose and galactose; Resorcinol, Gingerol-1 and Gingerol-2; Barbaloin and Glycerrihitic acid (Fatima et. al. (2020).

Powder Microscopy : Now-a-days, there are a wide range of methods available to authenticate spices and other herbal drugs. These methods may range from simple morphological examination to physical and chemical analysis, and even DNA molecular techniques. But, due to cost, most of these methods cannot be utilized. Hence, powder microscopy serves as one of the most efficient, effective and practical method for primary authentication. This is a unique, valuable, rapid, cost-effective and simple assessment tool which plays an important role in the authentication of a wide range of spices and herbal products. This technique is quite impactful in case of detecting adulteration for those samples in which other methods are not feasible. According to Dattatreya et. al. (2010), adulterants in flour of legumes like, *Lathyrus sativus* (lathyrus), *Pisum sativum* (pea) or *Cicer arietinum* (Bengal gram) could only be checked by powder microscopy method because at present, there are no chemical methods by which adulteration in these flours can be detected. Adulterants in spices like turmeric, fennel, black pepper, cumin, paprika etc. and other herbal products can also be detected by this method (Osman et. al., 2019).

Functional Properties : These are yet another set of tests performed to detect adulteration in several commodities especially in spices. These tests may vary to some extent among various sample. But the most common ones applicable for almost all spices are : dispersibility, bulk density, moisture content, solubility and swelling power. All spices carry unique functional properties and any deviations in them in terms of the above-mentioned qualities can be reported to be adulterated.

Physico-chemical Properties : Chemical tests play an important role in detecting adulteration of spices and herbal drugs. Again, most of the tests in this case too vary among different samples with few common ones like: ash content, starch value etc.

According to research by Sen et. al., (2017), adulterants in few common spices, such as chilly, turmeric and coriander powders were detected by chemical tests. In chilli powders, detection of red lead salts, oil soluble coal tar, brick powder and Rodamine B were done by specific chemical tests. Similarly, in turmeric powders, detection of yellow lead salts, chalk, metanil yellow, aniline dyes and external starch were done while in coriander powders, dung powder and common salts were detected.

- **Molecular methods :** Given below are outlines of few well-known molecular techniques and their potential applications:

Sl. No.	Molecular techniques	Potential application	References
1)	Amplification refractory mutation system (ARMS) and multiplex ARMS (MARMS)	Allele-specific primer pairs were designed based on detected mutation site within sequence data of the target species and identification carried out using MARMS	Chiang et al. (2012), I et al. (2009), Qian e (2008), Wang et al. (20
2)	Amplified - fragment length polymorphism PCR (AFLP)	Genomic DNA is digested with pair of restriction enzyme followed by the ligation of adapters to the sticky end of the restriction fragments. Selective amplification of some of these fragments is carried out with two PCR primers that have corresponding adaptor and restriction site-specific sequences	Gowda et al. (2 Passinho-Soares et (2006)
3)	Arbitrarily primed (AP)-PCR and the direct amplification of length polymorphism (DALP)	The nucleotide sequences of one or more genetic loci (genes) are determined and the sequences that are characteristic of a given species are identified and sequenced	Cao et al. (1 Desmarais et al. (1998 et al. (2001)
4)	DNA barcoding	Uses short DNA sequences from the specified region of genome termed as "DNA barcode" for biological identification. It implies sequencing of a standard DNA locus as a tool for identifying species. An ideal DNA barcode should be easily retrievable with a single primer pair, be amenable to bidirectional sequencing and effectively provide high discrimination among species.	Mishra et.al. (2015)
5)	DNA microarray	Species-specific oligonucleotide probes were designed from 5S ribosomal RNA gene sequence and immobilized on silicon chip. Target sequences were amplified and fluorescently labelled by asymmetric PCR	Carles et al. (2005), S et al. (1998)

6)	DNA sequencing	Involves thermostable DNA polymerase and dideoxy nucleotide triphosphates to generate chain-termination sequence with a temperature-cycling format	Kretz et al. (1994)
7)	Intersimple sequence repeat (ISSR) and simple sequence repeats (SSR)	ISSR amplification is carried out using PCR primers complementary to two neighboring microsatellites. SSR are developed through the constructed genomic library enriched with repeated motifs. Isolation and sequencing of microsatellite containing clones are performed followed by designing of primer and PCR amplification using the designed primer pair	Sharma et al. (2008), Su et al. (2008), Tamhankar et al. (2009)
8)	Loop-mediated isothermal amplification (LAMP)	Amplification carried out under isothermal reaction conditions using allele-specific primers designed, based on the 18S ribosomal RNA gene sequence	Sasaki et al. (2008)
9)	Multiplex PCR	Specific PCR primers are designed and amplification carried out both in individual pairs and in combinations of many primers, under a single set of reaction conditions	Chiang et al. (2012), Jigden et al. (2010a, 2010b)
10)	PCR–short tandem repeats (STR)	Microchip electrophoresis method coupled with the PCR–short tandem repeats (STR) technique is developed	Qin et al. (2005)
11)	Quantitative real-time PCR (Q-PCR/qPCR)	Specific genomic locus of choice is employed with the different analysis applications of real-time PCR to exhibit differentiation	Xue et al. (2009), Xue and Xue (2008)
12)	Random amplified polymorphic DNA (RAPD) and sequenced characterized amplified region marker (SCAR)	Specific marker-defined polymorphic termini are sequenced, and primers are designed for specific amplification of a particular locus in targeted species	Cao et al. (2010), Devaiah and Venkatasubramanian (2008), Ghosh et al. (2011), Gupta and Mandi (2013), Ruzicka et al. (2009), Wang et al. (2001)
13)	Restriction fragment length polymorphism	PCR-amplified product of specific targeted gene is subjected to restriction digestion	Biswas et al. (2013), Lin et al. (2012),

	(RFLP)	with different restriction enzymes. Resulting DNA fragments are separated on agarose gel electrophoresis and transferred to membrane via blotting procedure followed by detection on X-ray film with the labelled probes	Watthanachaiyingcharo et al. (2010)
14)	Specific expression subset analysis (SESA)	SESA carried out on cDNA populations derived from the active part (therapeutically useful) and other major tissues of the target plant species, which serve as tester and driver, respectively. The ESTs obtained were further subjected to computational analysis	Shukla et al. (2013)

Authentication at the DNA level provides more reliability because, in contrast to othe macromolecules (proteins and RNA), DNA is more stable, is not affected by external factor and is found in all tissues. So, there is a potential need for the development of robust DN based markers for plant identification and authentication at commercial level (Sucher an Carles, 2008).

Among the several processes based on genomic levels, to overcome the difficulties c classical taxonomy, the DNA barcoding method proposed by Hebert et al. (2003a) have bee found to be most successful in checking authentication of herbal products as well as i identification of unknown species.

Bar coding analysis to check Authentication of available ayurvedic herbal drugs i the market

The region used for identification is termed as a DNA barcode, which constitutes a small pa (<1000 bp) of the genome and can be easily obtained. DNA barcoding is an oversimplifie solution to a complex problem providing a way to confirm the authentication of raw plan material and establish a level of quality assurance in market place (Mishra et. al., 2015, Li al., 2011b). In animals, the 50' end of cytochrome c oxidase 1 (CO1) from the mitochondri genome was considered a universal barcode marker, but in plants, it cannot be use preferably, due to its slow evolution and limited divergence, hence a similar general barcod for plants has remained elusive (Mishra et. al., 2015; Hebert et al., 2003b; Kress an Erickson, 2008). Hence, the search for plant barcode region gradually shifted toward chloroplast and nuclear genomes as it contains higher rates of substitution. During the la decade, major individual candidate regions matK, rbcL, trnH-psbA, ITS, trnL-F, 5S-rRN

and 18S-rRNA have been tested for use in plants with respect to their discrimination capacity. Due to differences in their efficiency, it was concluded that no single-locus plant barcode exists and the search for multilocus combinations was suggested and is still being sought. Two international initiatives working towards the development of DNA barcodes include the Consortium for the Barcode of Life (CBOL) and the International Barcode of Life (iBOL). The CBOL was established in 2004 for working towards the development of DNA barcoding as a global method for identification of flora and fauna constituting the earth's biodiversity. It suggested the combination of *matK* and *rbcL* as the potential plant barcoding region based on its universality and discriminating ability. The iBOL is the largest biodiversity genomics initiative ever undertaken, which maintains barcode reference library Barcode of Life Data systems (BOLD) and works through its constituent nodes comprising several nations clustered into separate working groups. (Mishra et.al., 2015).

DNA barcoding has been suggested as the path ahead in the postgenomic era for the identification/authentication of medicinal plants used in trade. However, it will be better to complement it with metabolomics along with need-based transcriptomics and proteomics analyses. The reason being that contamination in an herbal product may not always be at the plant species level. It could also be due to replacement of the traditionally prescribed plant part by a non-prescribed one of the same plant species or by a traditionally prescribed part of the right plant species collected in the wrong season. In both cases, the content of the active metabolites will be suboptimal (leading to compromised therapeutic activity) and it could be detected only through metabolite analysis. Thus, the success of the approach for authentication will depend on how DNA barcoding is combined with other tools depending on the nature of the problem being tackled (Mishra et. al., 2015).

Conclusion :

The adulteration of herbal products is distributed across the globe. The contaminations being mainly non-intentionally due to accidental contamination through plant misidentification or cross-contamination during processing as well as intentionally by fraudulent use of cheaper substitute and filler species adding up to product misrepresentation, poor packaging or inappropriate labeling of products (Ichim, 2019; Jordan et al., 2010; Osathanunkul et al., 2018). Adulteration and substitution of raw drugs have become a widespread problem in the global market mainly due to problems such as misidentification, poor availability of original drug due to deforestation, or may be due to fraud peddlers or illiterate traders. This has led in

deterioration of customer's faith as adulterated drugs often results in increased risks of health disorders. Moreover, increased substituents/contaminants in the herbal products reduces efficacy and therapeutic property of that drug, leading to the loss of the customers. The difficulties in plant identification and lack of information about active pharmacological principles, as well as variation in the process of cultivation/ collection, extraction and growth conditions along with genetic variability, lead to failure of herbal drug standards (Mishra et al., 2015). This results in reduced efficacy of the herbal remedy and contamination with toxic species, which poses serious health implications. This results in the lack of consumer confidence, leading to lower commerce and trade of natural health products (Seethapathy et al., 2014).

References :

1. Ahmed Galal Osman, Vijayasankar Raman, Saqlain Haider, Zulfiqar Ali, and Amar G. Chittiboyina, Ikhlas A. Khan (2019). Overview of Analytical Tools for the Identification of Adulterants in Commonly Traded Herbs and Spices. Journal of AOAC International, Vol. 102, March 2019. DOI: https://doi.org/10.5740/jaoacint.18-0389.
2. Akshatha M. Dattatreya, Divyashree K. Nanjegowda and Prema Viswanath. Microscopic detection of adulteration of Bengal gram (*Cicer arietinum*) flour with other legume flour based on the seed testa macrosclereids. J Food Sci Technol. 2011 Feb; 48(1): 114-119. Published online 2010 Nov 20. Doi: 10.1007/s13197-010-0168-0.
3. Alam, M.Z. (2008) Herbal Medicines. New Delhi: APH Publishing Corporation
4. Anubhuti P, Rahul S and Kant KC (2011). Standardization of fennel (*Foeniculum vulgare*), its oleoresin and marketed ayurvedic dosage forms. Int. J. Pharm. Sci. Drug Res., 3(3): 265-269.
5. Biswas, K., Kapoor, A. and Biswas, R. (2013) Authentication of herbal medicinal plant-Boerhavia diffusa L. using PCR-RFLP. Curr. Trends Biotechnol. Pharm. 7, 725–731.
6. Cao, H., But, P.P. and Shaw, P.C. (1996) Authentication of the Chinese drug "ku-di-dan" (Herba elephantopi) and its substitutes using random-primed polymerase chain reaction (PCR). Acta Pharm. Sin. 31, 543–553.
7. Cao, L., Li, S.X., Wei, B.Y., Huang, D., Xu, F. and Tong, Z.Y. (2010) Optimizing RAPD reaction system and authentic genuineness related genetic background of Fructus evodia. Chin. Tradit. Herb. Drugs, 41, 975–978.
8. Carles, M., Cheung, M.K., Moganti, S., Dong, T.T., Tsim, K.W., Ip, N.Y. and Sucher, N.J. (2005) A DNA microarray for the authentication of toxic traditional Chinese medicinal plants. Planta Med. 71, 580–584.
9. Chiang, C.H., Yu, T.A., Lo, S.F., Kuo, C.L., Peng, W.H. and Tsay, H.S. (2012) Molecular authentication of Dendrobium species by multiplex polymerase chain reaction and amplification refractory mutation system analysis. J. Am. Soc. Hortic. Sci. 137, 438–444.
10. Desmarais, E., Lanneluc, I. and Lagnel, J. (1998) Direct amplification of length polymorphisms (DALP), or how to get and characterize new genetic markers in many species. Nucleic Acids Res. 26, 1458–1465.
11. Devaiah, K.M. and Venkatasubramanian, P. (2008) Genetic characterization and authentication of Embelia ribes using RAPD-PCR and SCAR marker. Planta Med. 74, 194–196.
12. Dhanya K, Sasikumar B. (2010). Molecular marker-based adulteration detection in traded food and agricultural commodities of plant origin with special reference to spices. Curr Trends Biotechnol Pharm 4: 454–89.
13. Dhanya K, Syamkumar S, Siju S, Sasikumar B. (2011). Sequence characterised amplified region markers: A reliable tool for adulterant detection in traded turmeric powder. Food Res Int 44:2889–95.

14. Diao, Y., Lin, X.M., Liao, C.L., Tang, C.Z., Chen, Z.J. and Hu, Z.L. (2009) Authentication of Panax ginseng from its adulterants by PCR-RFLP and ARMS. Planta Med. 75, 557–560.

15. Gahlaut, A., Gothwal, A., Hooda, V. and Dabur, R. (2013) Rapd patterns of some important medicinal plants and their substitutes used in Ayurveda to identify the genetic variations. Int. J. Pharm. Pharm. Sci. 5, 239–241.

16. Ghosh, S., Majumder, P.B. and Sen, M.S. (2011) Species-specific AFLP markers for identification of Zingiber officinale, Z. montanum and Z. zerumbet (Zingiberaceae). Genet. Mol. Res. 10, 218–229.

17. Gowda, B., Chandrika, K., Prasanna, K.T. and Kirana, V.C. (2010) AFLP authentication of Embelia ribes burm.f. f and Embelia tsjeriam- cottam a. Dc. Int. J. Sci. Nat. 1, 58–60.

18. Gupta, D.D. and Mandi, S.S. (2013) Species-specific AFLP markers for authentication of Zanthoxylum acanthopodium and Zanthoxylum oxyphyllum. J. Med. Plants, 1, 1–9.

19. Ha, W.Y., Yau, F.C., But, P.P., Wang, J. and Shaw, P.C. (2001) Direct amplification of length polymorphism analysis differentiates Panax ginseng from P. quinquefolius. Planta Med. 67, 587–589.

20. Ichim MC (2019) The DNA-Based Authentication of Commercial Herbal Products Reveals Their Globally Widespread Adulteration. Front. Pharmacol. 10:1227. Doi: 10.3389/fphar.2019.01227

21. Jigden, B., Wang, H., Kyum, K.M., Kim, Y.J., Gyo, I.J. and Yang, D.C. (2010a) Authentication of the oriental medicinal plant Ligusticum tenuissimum (Nakai) Kitagawa (Korean Go-Bon) by multiplex PCR. Planta Med. 76, 648–651.

22. Jigden, B., Wang, H., Samdan, N. and Yang, D.C. (2010b) Molecular identification of oriental medicinal plant Anemarrhena asphodeloides Bunge ("Jimo") by multiplex PCR. Mol. Biol. Rep. 37, 955–960.

23. Joshi, P. and Dhawan, V. (2005) Swertia chirayita—an overview. Curr. Sci. 89, 635–640.

24. Kaneez Fatima, Shaukat Mahmud, Hina Yasin, Rana Asif, Kiran Qadeer and Iqbal Ahmad. Authentication of various commercially available crude drugs using different quality control testing parameters. Pak. J. Pharm. Sci., Vol.33, No.4, July 2020, pp.1641-1657. DOI link: doi.org/10.36721/PJPS.2020.33.4.REG.1641-1657.1.

25. Kretz, K., Callen, W. and Hedden, V. (1994) Cycle sequencing. PCR Methods Appl. 3, 107–112.

26. Lin, T.C., Yeh, M.S., Cheng, Y.M., Lin, L.C. and Sung, J.M. (2012) Using ITS2 PCR-RFLP to generate molecular markers for authentication of Sophora flavescens Ait. J. Sci. Food Agric. 92, 892–898.

27. Mishra, P., Kumar, A., Nagireddy, A., Mani, D.N., Shukla, A.K., Tiwari, R. and Sundaresan V. (2015) DNA barcoding: an efficient tool to overcome authentication challenges in the herbal market. Plant Biotechnol. J., Doi: 10.1111/pbi.12419

28. Newmaster SG, Grguic M, Shanmughanadhan D, Ramalingam S. (2013). DNA barcoding detects contamination and substitution in North American herbal products. BMC Med 11:222–35.

29. Osathanunkul, M., Osathanunkul, R., and Madesis, P. (2018). Species identification approach for both raw materials and end products of herbal supplements from Tinospora species. BMC Complement. Altern. Med. 18 (1), 111. Doi: 10.1186/ s12906-018-2174-0.

30. Passinho-Soares, H., Felix, D., Kaplan, M.A., Margis-Pinheiro, M. and Margis, R. (2006) Authentication of medicinal plant botanical identity by amplified fragmented length polymorphism dominant DNA marker: inferences from the Plectranthus genus. Planta Med. 72, 929–931.

31. Prakash, O., Jyoti, A.K., Kumar, P. and Manna, N.K. (2013) Adulteration and substitution in Indian medicinal plants: an overview. J. Med. Plants Stud. 1, 127–132.

32. Qian, L., Ding, G., Zhou, Q., Feng, Z., Ding, X., Gu, S., Wang, Y., Li, X. and Chu, B. (2008) Molecular authentication of Dendrobium loddigesii Rolfe by amplification refractory mutation system (ARMS). Planta Med. 74, 470–473.

33. Qin, J., Leung, F.C., Fung, Y., Zhu, D. and Lin, B. (2005) Rapid authentication of ginseng species using microchip electrophoresis with laser-induced fluorescence detection. Anal. Bioanal. Chem. 381, 812–819.

34. S. Khan, K. J. Mirza, F. Al-Qurainy, M. Z. Abdin (2011), Authentication of the medicinal plant Senna angustifolia by RAPD profiling. Saudi Journal of biological sciences (2011) 18, 287-292. Doi: 10.1016/j.sjbs.2011.03.001

35. Sagar PK: Adulteration and substitution in endangered, ASU herbal medicinal plants of India, their legal status, scientific screening of active phytochemical constituents. Int J Pharm Sci & Res 2014; 5(9): 4023-39. Doi: 10.13040/IJPSR.0975-8232.5(9).4023-39

36. Sasaki, Y., Komatsu, K. and Nagumo, S. (2008) Rapid detection of Panax ginseng by loop-mediated isothermal amplification and its application to authentication of Ginseng. Biol. Pharm. Bull. 31, 1806–1808.

37. Schena, M., Heller, R.A., Theriault, T.P., Konrad, K., Lachenmeier, E. and Davis, R.W. (1998) Microarrays: biotechnology's discovery platform for functional genomics. Trends Biotechnol. 16, 301–306.

38. Seethapathy GS, Ganesh D, Kumar JUS, Senthilkumar U, Newmaster SG, Ragupathy S, et al. Assessing product adulteration in natural health products for laxative yielding plants, Cassia, Senna, and Chamaecrista, in Southern India using DNA barcoding. Int J Legal Med. 2015;129(4):693–700.

39. Shanmughanandhan, D., Ragupathy, S., Newmaster, S. G., Mohanasundaram, S., and Sathishkumar, R. (2016). Estimating herbal product authentication and adulteration in India using a vouchered, DNA-based biological reference material library. Drug Saf. 39 (12), 1211–1227. Doi: 10.1007/s40264-016-0459-0.

40. Sharma, R.K., Gupta, P., Sharma, V., Sood, A., Mohapatra, T. and Ahuja, P.S. (2008) Evaluation of rice and sugarcane SSR markers for phylogenetic and genetic diversity analyses in bamboo. Genome, 51, 91–103.

41. Shukla, A.K., Mall, M., Rai, S.K., Singh, S., Nair, P., Parashar, G., Shasany, A.K., Singh, S.C., Joshi, V.K. and Khanuja, S.P.S. (2013) A transcriptomic approach for exploring the molecular basis for dosha-balancing property-based classification of plants in Ayurveda. Mol. Biol. Rep. 40, 3255– 3262.

42. Siddiqui, M.Z. (2011) Guggul: an excellent herbal panacea. Asian J. Pharm. Health Sci. 1, 36–39

43. Singh, A., Rai, V.P., Sing, M., Singh, A.K. and Sinha, B. (2013) Molecular diversity analysis of Asparagus racemosus and its adulterants using random amplified polymorphic DNA (RAPD). J. Med. Plant Res. 7, 1050–1056.

44. Sourish Sen, Partha Sarathi Mohanty and Suneetha V (2017). Detection of Food Adulterants in Chilli, Turmeric and Coriander Powders by Physical and Chemical Methods. Research J. Pharm. and Tech. 10(9): September 2017. ISSN 0974-3618 (Print), 0974-360X (Online).

45. Srivastava, G.N. and Srivastava, A.K. (1988) Pharmacognosy of Catharanthus roseus (L.) G. Don (Sadabahar) root and its adulterants. Pharm. Biol. 26, 33– 44

46. Su, H., Wang, L., Liu, L., Chi, X. and Zhang, Y. (2008) Use of inter-simple sequence repeat markers to develop strain-specific SCAR markers for Flammulina velutipes. J. Appl. Genet. 49, 233–235.

47. Tamhankar, S., Ghate, V., Raut, A. and Rajput, B. (2009) Molecular profiling of "Chirayat" complex using inter simple sequence repeat (ISSR) markers. Planta Med. 75, 1266–1270.

48. V. A. Parvathy, V. P. Swetha, T. E. Sheeja, and B. Sasikumar. (2015). Detection of plant-based adulterants in turmeric powder using DNA barcoding, Division of Crop Improvement and Biotechnology, Indian Institute of Spices Research, Kozhikode, Kerala, India. Pharm Biol, Early Online: 1–6 (2015) Informa Healthcare USA, Inc. DOI: 10.3109/13880209.2015.1005756.

49. Vassou, S.L., Kusuma, G. and Parani, M. (2015) DNA barcoding for species identification from dried and powdered plant parts: a case study with authentication of the raw drug market samples of Sida cordifolia. Gene, 559, 86–93.

50. Wang, H., Kwon, W.S., Yang, D.U., Kim, M.K., Sathiyamoorthy, S., Jin, H. and Yang, D.C. (2011) Development of a multiplex amplification refractory mutation system for simultaneous authentication of Korean ginseng cultivars "Gumpoong" and "Chungsun". Mitochondrial DNA, 22, 35–38.

51. Watthanachaiyingcharoen, R., Komatsu, K., Zhu, S., Vajragupta, O. and Leelamanit, W. (2010) Authentication of Coscinium fenestratum among the other menispermaceae plants prescribed in Thai folk medicines. Biol. Pharm. Bull. 33, 91–94.

52. Xiang, X.G., Zhang, J.B., Lu, A.M. and Li, R.Q. (2011) Molecular identification of species in Juglandaceae: a tiered method. J. Syst. Evol. 49, 252–260.

53. Xue, C.Y. and Xue, H.G. (2008) Application of real-time scorpion PCR for authentication and quantification of the traditional Chinese medicinal plant Drynaria fortunei. Planta Med. 74, 1416–1420.

54. Xue, C.Y., Li, D.Z. and Wang, Q.Z. (2009) Application of light cycler polymerase chain reaction and melting curve analysis to the authentication of the traditional Chinese medicinal plant Cimicifuga foetida. Planta Med. 75, 873–875.

55. Zhao, Z.L., Zhou, K.Y., Dong, H. and Xu, L.S. (2001) Characters of nrDNA ITS region sequences of fruits of Alpinia galanga and their adulterants. Planta Med. 67, 381–383.