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FERULIC ACID POLYMERS IN HEALTHCARE APPLICATIONS

Abstract

Ferulic acid polymers have importance in healthcare applications due to their multifunctional groups. Derivatives of the ferulic acids act as an antioxidant, against ultra violet radiation damage, and are used in the treatment of many other illnesses. The review mainly focuses on important applications of ferulic acid in drug delivery, wound healing, antioxidants, and the role of ferulic acid polymer to cure those diseases. Due to reliable properties, ferulic acids and their polymers are found alternative and useful components of drug delivery in many critical diseases with no toxic effect with less cytotoxicity. Polyferulic acid nanoparticles are used as an effective chemo drug carrier with additional anticancer effects on clinical colon cancer cells. In continuation of a large number of healthcare applications ferulic acid polymers including neuroprotective, and antidiabetic etc, they are also show some combined applications including food preservative and antimicrobial, Antioxidant and anti-microbial activity antioxidant and antifungal properties. In the presented review we have cited combined applications of ferulic acid polymers for their scientific importance.

Keywords: Ferulic acid polymers; drug delivery; antioxidant; and wound healing.

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I. INTRODUCTION

Naturally occurring compounds have considerable interest in biological applications, due to their easy availability and less adverse effect on a healthcare application. Due to its easy availability and multiple derivatives of ferulic acid polymer, it has shown a variety of applications in health care, including wound healing antioxidants, easy drug release, and others. Poly ferulic acid with high molecular weight shows biocompatibility and degradable properties thus poly ferulic acid becomes a useful compound for drug delivery applications [1-3]. Unpaired electrons present in free radicals cause damage to certain organs like DNA enzymes and lead to dangerous diseases like diabetes, cancer, autoimmune and neurodegenerative disorders [1]. Along with this free radicals undergo chain reactions, for many diseases, and accelerate oxidative strength, Atherosclerosis may lead to the death of patients. The single molecules of ferulic acid have various biological activities and the ability to react to stop free radical growth, thus here we thought to review the importance of ferulic acid polymers in healthcare applications [1].

In wound healing proliferation and repairing of tissue take place, collagen is found in the extracellular matrix and it is a useful component in the wound healing mechanism, Ferulic acid, and its polymers act as a natural component for the enhancement of collagen production in the body in wound healing [14]. To increase the solubility and stability of ferulic acid polymers and boost their cellular uptake, one strategy uses nanotechnology-based delivery systems, such as lipid-based nanoparticles, polymeric nanoparticles, or solid lipid nanoparticles.

The ferulic acid polymers can be shielded against deterioration by these nanocarrier systems, which can also increase their bioavailability and allow for targeted distribution to particular tissues or cells [15]. Co-polymers with ferulic acid in many cases found to be important in various healthcare applications, including food preservation, drug delivery, biosensor, and contact lens manufacturing. As a result of its antioxidant properties ferulic acid polymers act as the best component in photoprotective and protective skin locations thus it has importance in industries [16].

The biological activities of polymers used in healthcare applications can increase by incorporating functional groups on the polymer chain or adding plant extract. FA polymer has found improvement in thermal, mechanical, and biological properties [17]. FA polymers have biological importance but due to low solubility, Ferulic acid and polymer face problems in drug delivery applications. To overcome this difficulty, in most case, nano-particles has been used for drug delivery applications. Recently Maha Nasr and co-workers reported lipid nano-capsules of ferulic acids in cancer drug therapy [18]. The ferulic acid hydroxyl group act as a radical scavenger and inhibit the damage of cell and tissue, and also shows anti-inflammatory and anti-DNA damage properties. This review consists of some important and general healthcare applications of ferulic acid polymer.

II. APPLICATION OF FERULIC ACID POLYMERS

1. Tuberculosis Drug Delivery: Mariappan Rajana and co-workers 'ferulic acid co-polymer synthesized by ring-opening polymerization and usefully shown application towards Tuberculosis drug delivery. TB is one of the most dangerous diseases caused by Mycobacterium tuberculosis. Rifampicin (RF), inhibits DNA-dependent polymerize and acts as an antitubercular agent. The author has reported co-polymerization of Chitosan-on (ϵ -caprolactone) for the synthesis of CS-g-PCL via ring-opening polymerization in the microwave wave assistant method. Further grafting of ferulic acid was performed by using a coupling agent, at PH 7.4 in 1M acetic acid and 1M NaOH at a temperature of 45°C. So, they prepared 'CS-g-PCL/FA' Fig.1. The grafted copolymer was further converted to nano micelle and rifampicin was incorporated in the inner shell by ultrasonication [2]. Multiple functional groups such as carboxylic acids and hydroxy and methyl ether, allowed the modification of the main structure of ferulic acid, by which the properties can improved [3].

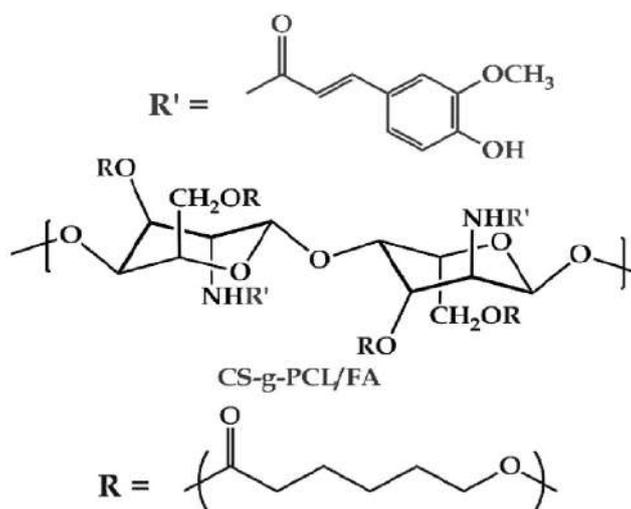


Figure 1: Chitosan-graft-poly(caprolactone)/(ferulic acid) polymer[2]

2. Wound Healing Applications: In disease diabetics Meletus due to the production of free radicals, wound healing has become a major problem. Claudia Carbone and a co-worker recently reported nanostructure lipid carriers of ferulic acid and Essential oil. A combination of ferulic acid and essential oil at homogeneous and with a small size of 150 nm, nano-stability, affects cytocompatibility, and promotes cell proliferation and migration [4]. Due to FA's antioxidant and antidiabetic properties, a nano-particle of Polylactic acid grafted on polyferulic acid was found useful in diabetic wound healing [5]. Brahmeshwar Mishra and co-workers reported Ferulic acid- poly (lactic-co-glycolic acid) (FA-PLGA) nanoparticle preparation using nanoprecipitation methods, followed by characterization using SEM and TEM. The average size of the nanoparticle was 240 nm [5].

- **Nanoprecipitation Method:** Poly (lactic-co-glycolic acid) was dissolved in acetone and drug material was added to this solution. Poloxamer 188 was dissolved in water. Thus organic phase containing polymer solution was injected into an aqueous solution through the syringe after 30 min. suspension was filtered through a 0.45 μ m membrane

to remove excess stabilizer. The nonmaterial was converted to gel, by using Carbopol 980 molecules. For that purpose, the nonmaterial was added to Carbopol 980 aqueous solution, and the suspension was stirred to gel swell [5].

- 3. Antiviral Applications:** Ferulic acid naturally occurring phenolic acid and has two different functional groups on the aromatic ring. Thus, FA has multiple applications including antioxidant, antiviral, and inhibitory action even if it shows applications in the food, agriculture, and cosmetic industries. The best source of ferulic acid is crop waste such as wheat bran, rice bran, etc. Ferulic acid is a versatile building block for various bio-polymers. In the year 2013, Kathryn E. Uhrich et al reported the ferulic acid biodegradable polymer with biological application and non-toxicity of polymer degradation. Aromatic hydroxyl carboxylic acids are mainly useful in developing biocompatible or biodegradable polymers.

Developing such types of polymer material is a more difficult process thus, polymerization takes a long time to build up. In a recent discovery, Desai and workers reported sulfated lignin in the sulfate group of Heparan sulfate was found active against the viral activity, author synthesized 4-hydroxy cinnamaldehyde-based carboxylate lignin by enzymatic oxidative coupling [6]. And tested in cellular assays of herpes simplex virus-1 (HSV-1) infection compared to sulfated lignin carboxylate lignin where they found carboxylate lignin was found to inhibit HSV-1 entry into mammalian cells ($IC_{50} = 8-56$ nM). Lignin is an organic complex biopolymer, the conditional part of lignin is phenylpropanoid with a hydroxyl group. Carboxylic acid lignin CD and FD obtained, peroxidase catalyzed oxidative coupling of caffeic and ferulic acid both at the basic pH = 8 in the dark. Naturally occurring phenol has various specific biological activities including antiviral, hepatoprotective, and vasodilatory actions. Vikas Pruthi and co-workers incorporated agro-waste Ferulic acid in bio-copolymer. The Natural ferulic acid was encapsulated in the electro-spun nanofibrous matrix of poly (D, L-lactide-co-glycolide)/polyethylene oxide. The author isolated ferulic acid from the Parthenium hysterophorus plant [7].

- **Electrospinning Process:** PLGA:PEO:1:1 in DCM/DMF solution. A solution blend of this polymer with 2% ferulic acid was prepared. The nanofiber of this blend was prepared by an electrospinning process with applied voltage (18 kV) and solution flow rate (0.5 mL/h). The characterization of nanofiber was done by using various spectroscopic techniques such as IR, DSC, and NMR, Based on the NMR study's author observed the shifting in chemical shift value of Ferulic acid encapsulated PLGA/PEO nanofibers. In the cytotoxicity of ferulic acid encapsulated PLGA/PEO nanofibers without ferulic acid does not show any cell growth while inhibition in cell growth is 71.3% in the case of nanofiber monitor in ferulic acid and ferulic acid encapsulated nanofiber [7]. Thus the cytotoxicity of ferulic acid nanofiber shown in Fig.2

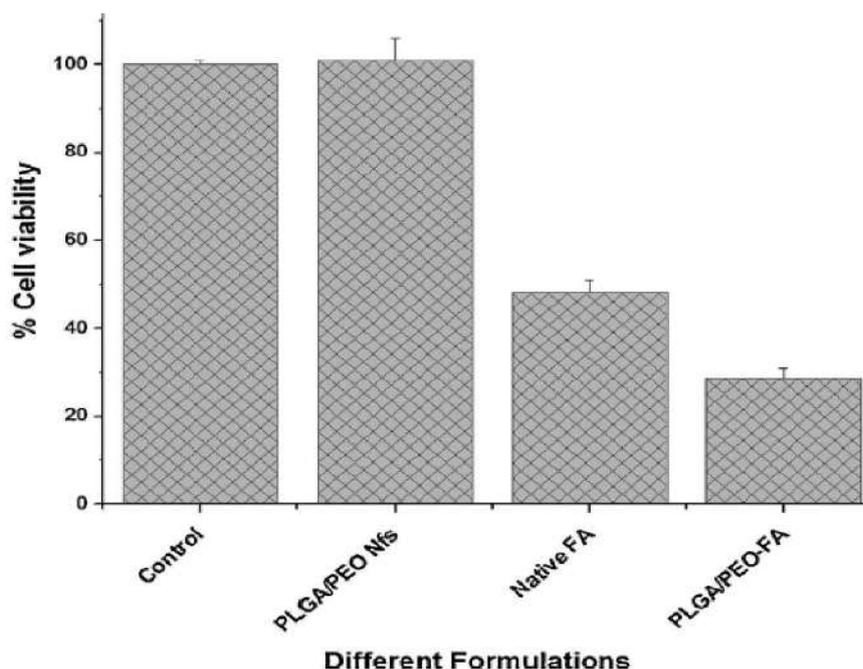


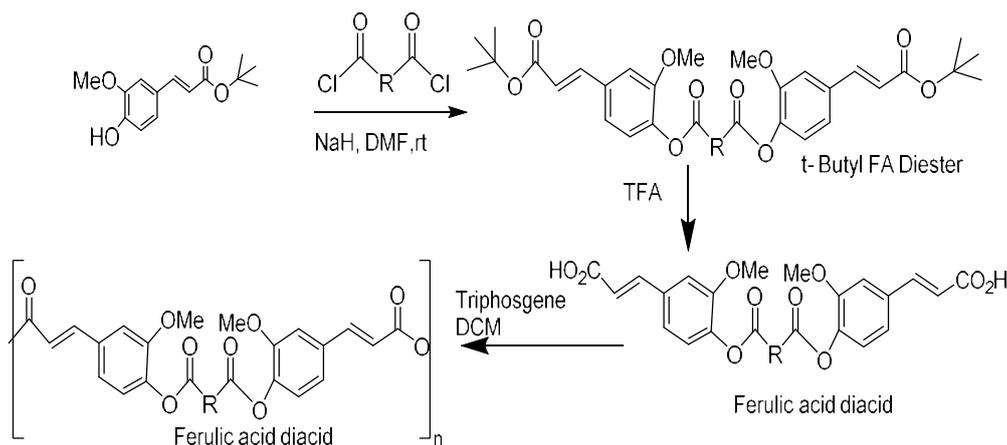
Figure2: Showing cytotoxicity of different material studies [7]

The average diameter for ferulic acid encapsulated PLGA/PEO nanofibers was recorded as 150 to 79.0 nm, and free radical scavenger activity of the nano-fiber was disclosed by using di(phenyl)-(2,4,6- trinitrophenol)iminoazanium (DPPH) assay [7].

- 4. Antioxidant :** Reactive oxygen species are essential for wound control and infection release for certain angiogenesis and cells. During a wound cellular damage takes place and thus, in this case, antioxidants are used for the removal of ROS, which can interact with wound healing. Removal of ROS done by using polyphenolic acids. Liu and co-workers reported functionality (methoxy hydroxy group) on polyphenols on aromatic ring unaffected affect the anti-oxidant properties. The author found that modification of a carboxylic acid with isocyanide found improvement in the antioxidant properties. Uncontrolled blood loss is the symptom, for trauma leads to death in hospitals due to microbial infection in trauma would cause death in patients [8]. Free radicals are found as pathogens for many diseases including cancer, aging, and atherosclerosis. Formulation and incorporation of antioxidants were found very difficult for the treatment of infectious. In the year 2017, Prabhas V. Moghe and co-workers, used a ferulic acid polymer as an antioxidant, in the treatment of inflammatory diseases, to atherosclerosis. The potential of degradable ferulic acid-based polymer nanoparticles to control macrophage foam cell formation by significantly reducing oxLDL uptake through the downregulation of scavenger receptors, The disease of atherosclerosis is due to the oxidation of lipoprotein which results in foam cell formation the phenolic polymers due to antioxidant properties useful in the treatment of atherosclerosis. The amphiphilic micro polymer as a nanoparticle with antioxidant properties has been developed, author reported polyhydride ester ferulic acids nanoparticles to use as lipoprotein antioxidants [9].

5. Drug Delivery Applications: Due to biocompatibility, ferulic acid is used in various biological activities including, anti-inflammatory, anticancer, antidiabetic, and pro-angiogenic applications. Purna Sai Korrapati and Balan Poornima reported that Cytosan-Polycarbonate nano-fiber was used for wound dressing and drug delivery applications [10].

Latex polymers have numerous varieties and various applications for industries. Latex polymers have multiple shapes in their morphological structure. Core-shell particle is one type of morphology used for the preparation of latex with various essential properties. It can be composed of a minimum of two polymers, this type of core latex shell has applications in drug delivery, control release, and nanostructured material for electrochemical applications. Sylvain Caillol and co-workers developed two-stage emulsion polymerization of 4-acetoxy-3-methoxy styrene (AC4VG) and n-butyl acrylate for the synthesis of biobased core-shell particles. Solution co-polymerization of AC4VG styrene and n-butyl acrylate was carried out in toluene under an environment and AIBN as initiators [11]. Ouimet and co-workers reported poly-ferulic acid (anhydride ester) synthesized by reaction of the corresponding acid chloride with ferulic acid ester compound upon hydrolysis obtained carboxylic acid with linked with ester linkage that was used for drug release application (Scheme 1) [12].



Scheme 1: Synthesis of dimeric ferulic acid polymer linking via linker

Scheme 1: Synthesis of dimeric ferulic acid polymer linking via linker [12]

To improve solubility to increase the efficiency of the ferulic acid polymers, the author used FA-loaded polymer nanoparticles in drug delivery. Polymerpolylactic acid and poly(lactic-co-glycolic acid) were used to prevent the cytotoxicity of drug carriers. A preliminary in vitro assay was performed on retinal pericytes and endothelial cells to verify the absence of blank carriers' cytotoxicity. FA-loaded NPs were subjected to purification studies and the physical-chemical properties were analyzed by photon correlation spectroscopy [13].

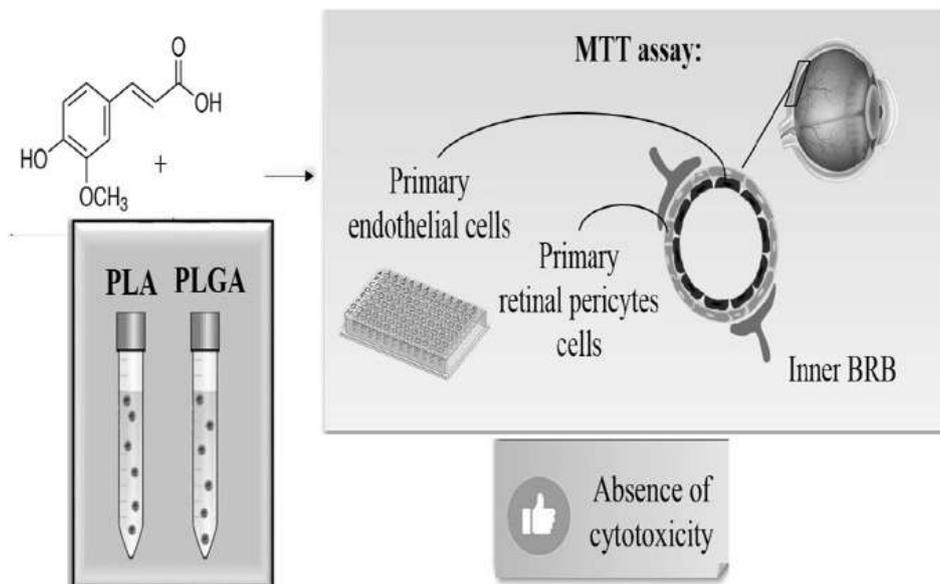


Figure 3: PLA and PLGA with ferulic acid for drug delivery[13]

Other ferulic acid polymers in different healthcare applications: A large number of applications have been reported for ferulic acid polymers and their composites some important applications are cited in Table 1.

Table 1: Applications of Ferulic Acid Polymers

SN	Different applications for ferulic acid polymers/composites	
	Ferulic acid polymers/composites	Applications
1	Chitosan scaffolds-ferulic acid (by simple solution method) (2023)	Biocompatibility and antioxidant [19]
2	Ferulic Acid and Glucose biosensing membrane (By electropolymerisation of ferulic acid) (2021)	Amperometric Glucose Biosensor [20]
3	poly(lactide) /poly(butylene adipate-co-terephthalate) ferulic acid blend (solvent casting) (2020)	Antibacterial in food packaging applications [21]
4	Poly(Ferulic Acid nanoparticles Nanocarrier (simple polymerization and nanoprecipitation) (2019)	Chemo drug delivery and clinical colon cancer therapy [22]
5	Arabinoxylan ferulate (AXF) with gelatin (GEL) (electrospun 2019)	Diabetic chronic wound dressing application [23]

III. CONCLUSION

Ferulic acid polymers and ferulic acid composites are best for healthcare applications. It is also helpful in drug delivery applications due to its biodegradability and less cytotoxicity in high molecular weight. Drug delivery and its effect on drug release in the presence of ferulic acid have been described in this chapter. Ferulic acid due to antioxidant and other important biological applications ferulic acid polymers are applicable such as wound healing anti-viral, cytotoxicity, and in the treatment of Tuberculosis. Thus the main functional groups present at para-position are carboxylic acid and phenolic hydroxyl group, which are involved most of the time in polymerization, thus, the presence of functional groups enhances the properties and alters the biological applications. In a recent literature report, Ferulic acid polymer nanoparticles have self-assembled properties that help in drug delivery applications. Thus in the future scientists may focus on these properties for many other ferulic acid polymers used in healthcare applications.

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Trend, Issues And Challenges Of Higher Education

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FULL PAPER

The national economy was pioneered by higher education. A country can expand by developing skilled labourers with a knowledge economy, which is facilitated by high-quality education, particularly in higher education. Owing to liberalization and globalization, there is a rise in competition from both developed and developing countries, and educational operations can be located anywhere in the world. Every country has its own educational policies, action plans, standards for accreditation, and methods for educational assessment in order to maintain the calibre of higher education. Since education is the foundation of all discipline and quality teacher education is the source of all discipline, nations must invest in teacher education to prepare its children to compete at the forefront of economic activity. The focus on precognition and adaptation to nationalization and globalization of education set apart the knowledge-based society. A quality education system is essential to closing the gap between members of different communities, castes, genders, and other groups, according to knowledge-based societies. Therefore, in order to transition from nationalization to globalization, it is imperative that higher education and teacher education be redirected in terms of goals, purposes, and approaches.

Indian Higher Education Scenario:

According to a survey, the higher education industry has grown dramatically since 1951. The number of colleges and universities rose from 28 to 677 and from 578 to 3800 between 1951 and 2014. Consequently, there are now far more teachers and students than ever before. The government's large investment in elementary and secondary education at the school level may be the reason why student enrolment has grown over time more than teacher enrolment. An increase in the number of schools and students enrolled, together with the mushrooming growth of higher education institutions As of the end of 2014, there were 38,000 colleges and 677 universities in India. But we still require more than 1500 universities to meet demand. In our

educational system, we observe an increase in the number of colleges and institutions as well as student enrolment. Most of these establishments have affiliated colleges with authorized and taught undergraduate courses. But when we compare this improved number to the growing population, we have to wonder if it's still getting better. The increase in the proportion of males and females enrolling in postsecondary education between 2010 and 2011. The fact that fewer women than men are enrolled is examined in the study. The data unequivocally shows that there is a 19% difference in research enrolment, which is followed by differences of 17% in undergraduate enrolment and 13% in graduate enrolment.

Primary Education vs. Higher Education in India:

It is imperative that a strong foundation be established before attempting to navigate the complexities of higher education. The primary issue of the nation is the millions of Indians who are unable to escape poverty due to a lack of elementary education. When a child turns five, they are eligible to start elementary school in the first grade. "Primary education" includes much more than just the "basic minimum" of a teacher, books, and a classroom; it also includes a child's everyday needs, like food and clothing, as well as a space to learn and develop. At the moment, the government supplies the bare minimum of furniture, teaching aids, textbooks, and teachers for schools.

In order for them to succeed in the real world in the future, they now also need to help kids develop their imaginations and find their hidden talents. If we are to provide the social mobility required to assist people in escaping poverty, then investment in public health and elementary education are essential. However, attending college won't make this problem go away. Upon finishing high school, also referred to as "10+2," a student is qualified to enrol in college. The goal for a five-year-old child should be elementary school, not secondary school, if their family makes less than the federal poverty line. Therefore, since universities are the target of such investment, children's standing will not improve if the government only makes higher education investments. By the time a child of poverty reaches the age of sixteen, their mentality has already been shaped. Therefore, there is no return on the government's investment in higher education. That's how secondary school and college differ from one other.

Issues of Higher Education in India:

India has experienced difficulty establishing a strong educational system since attaining independence. A number of administrations tried, but ultimately failed, to bring about a significant change in the nation's educational system using creative and practical means. For Indian students studying in the US, a number of challenges still exist. The Indian government is aware that higher education faces previously unheard-of difficulties in the contemporary world. According to the UGC, graduates

with a broad range of backgrounds will be expected to have a diverse range of skills, including those from business, the humanities, the natural sciences, social sciences, and the various professional fields of hospitality, tourism, agriculture, law, management, medicine, and engineering.

The Indian system of higher education is riddled with serious problems. A low student enrolment rate, obsolete teaching methods, deteriorating research standards, overcrowding and inadequate classrooms, disengaged pupils, and severe geographical, economic, gender, and racial disparities are a few of these. In addition to concerns about declining standards and insufficient funding, some private schools have come under fire for allegedly exploiting students from remote areas.

The following are some crucial points to talk about in relation to

- The main issue facing India's higher education system is that the quality of instruction is declining. The majority of educators lack sufficient training, and experience to carry out the responsibilities of their existing roles. Despite this, teaching languages in general and instruction languages in particular are taken for granted, which is unacceptable in the multilingual setting of a globalized society.
- The majority of academic institutions, whether funded or not, are governed by influential politicians who presently have significant roles on university governing boards. They assist political student organizations and have established their own youth cells. They use the children's excitement for political benefit. The students lose focus on their personal objectives as they begin to develop their political careers.
- Is this among the most troubling changes that the communities have experienced as a result of the present higher education system? The majority of students, or many of them, are unable to sustain themselves with the fundamental necessities of life. A number of factors, including rising costs, spending on luxury, population growth, food shortages, corruption, and selfishness, have made economic woes worse. When splitting their attention between a job and their college or university studies, students who work part-time jobs to pay for their education should do so. Nearly seventy-five percent of today's students are struggling financially. Earn while you learn initiatives are insufficient in assisting students in overcoming financial barriers.
- Geographically, the rich-poor, rural-urban structure has posed a serious challenge for educational institutions. Education has been provided by many colleges, universities, and technical institutes in a variety of formats and levels. Most of them are working in appalling conditions, but a small number of them are truly offering top-notch instruction. We are grateful to UGC for providing the list of these fraudulent academic institutions and phoney universities.



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- The main issue with India's higher education system is the caliber of the teachers. The vast majority of teachers are not qualified or experienced enough to fulfill the demands of their jobs. The lack of values exhibited by the teachers employed by Higher Education Institutions lowers the standard of instruction.
 - The second-largest higher education system in the world, the Indian system serves millions of students from all socioeconomic backgrounds and meets the educational requirements of fostering a supportive learning environment in higher education establishments. Undoubtedly, India is currently facing numerous challenges associated with destitution, joblessness, and the erosion of ethical and spiritual principles. However, the problems and difficulties that India's higher education system has encountered during the last few decades are listed below.
 - Compared to men, women are far less literate. The attitudes of conservative culture keep girls out of college. Every member of the family would be educated if women pursued education. Women's enrolment at HEIs has been steadily rising recently.
 - More points equal success for governments. English is increasingly used as a proxy for intellect. As a result, parents nowadays are not as interested in using vernacular education. Government schools are increasingly being considered as the final option because of the perception of lower quality.
 - Another significant issue facing higher education is privatization. It is best to privatize higher education.
 - The Indian education system needs more funding. Over the last few years, many positive developments have been made in this area, and if these developments continue, India may soon be able to overcome its current difficulties.
 - The government must push schools to help kids reach their full potential and not ignore their ideas since the world needs innovative thinkers.
 - These problems with the Indian educational system lead a lot of youngsters to decide to study overseas. The relevant authorities need to address them, and students need to decide whether to stay in India to further their education and use their knowledge to strengthen the nation.

Suggestions for Improving Quality of Higher Education:

- The teaching and academic programs, research and scholarship, staff, students, buildings, facilities, equipment, community services, and the academic environment are all factors that contribute to an educational institution's quality. It also mandates that, while taking into consideration the national cultural values and circumstances, higher education should be distinguished by its international features, including interactive networking, knowledge sharing, teacher and student mobility, and international research collaborations. Universities renowned

for their partnerships include Jawaharlal Nehru University, University of Mumbai, and University of Delhi. The same should be done by other universities.

- External experts should perform academic and administrative audits in colleges annually to ensure quality in all facets of academic activities. The self-financed colleges ought to apply for accreditation and meet the necessary criteria. Colleges and universities should acknowledge the importance of providing high-quality education and present an action plan to raise standards in these settings.
- Traditionally, research, innovation, teaching, human resource development, and continuing education have been the main ways that Indian universities have advanced and transmitted knowledge. Another role that is becoming more and more important is international cooperation. The global village is witnessing an increasing emphasis on international cooperation and action to find appropriate answers to problems that have global dimensions, and higher education is one of them. This is due to the increased development of transportation and communication.
- Higher education approaches must also be suitable for the demands of learning to do, learn to be, and learn to become. The current demands of education are for student-centred learning and the use of dynamic teaching strategies. Lecture-based teaching strategies will need to make way for strategies that emphasize independent study, one-on-one conversations between instructors and students, and engaging seminars and workshops. Students can study from specialists who are seated far away thanks to ICT-based distance learning techniques.
- The world is about to enter the Information Age, and advances in technology, communication, and information sharing will create new, affordable avenues for reaching young people who want to pursue higher education and those who require continuing education to keep up with the rapidly changing nature of the workforce, the explosion of information, and the need for lifelong learning. At the core of higher education is knowledge, which is an essential tool for the advancement of social justice, political democracy, and individual enlightenment.
- The decrease in public funding over the past two plan periods has had a significant impact on standards since, on the one hand, non-salary items and staff emoluments are becoming more expensive, and, on the other, resources are becoming less. In order to mobilize resources for higher education, effective methods must be implemented. Additionally, the fee structure must be based on the student's ability to pay. so that highly subsidized and totally subsidized education can be provided to pupils at lower economic levels.
- The latest technologies present a plethora of chances for advancement in every field. Opportunities for socio-cultural advancements, better learning, better health, and better service delivery are all presented by it. While there is a need to increase

the nation's capacity for innovation, the focus should be on enhancing the current capabilities in light of the growing awareness of the relationship between research innovation and growth.

- Students and business alike anticipate the provision of specialized courses to ensure that they receive the finest possible education and are prepared for the workforce. To enable the offering of specialized programs to students, vocational and diploma courses must be made more appealing. Teachers and researchers should be given incentives in order to lure younger people to these fields of study.
- To guarantee that curricula and skills meet requirements, a connection between industry and academia is required. In order to ensure that academics are employable and that good jobs are realized with the understanding that knowledge + skills + global professional skills = good jobs, skill development is extremely important.
- Every human endeavour in our evolving learning society will require the input of specialists, which will bring the higher education industry as a whole into sharp relief. The nation must get ready to invest an increasing amount in higher education while also taking steps to improve, diversify, and enhance its research and higher education programs, even though the responsibility of achieving Education for All will continue to be given top priority.
- A person can only have a vision of their future life and career based on their knowledge; only then can they set a broad aspiration for themselves; only then can someone lead a fascinating life, work at a job they are satisfied with, and achieve extraordinary things in the world. Thus, the provision of career-oriented courses is necessary.

Five Trends in Higher Education:

1. Career-Focused Learning Flourishes in Modernized, Stackable Formats

Colleges and universities focus on modernizing academic programs to meet the demand for more targeted, modular learning that connects to future jobs.

2. Debt-Free Education Captures Attention

With student loan forgiveness spotlighting the high cost of a college degree, institutions look to help students fund their education without taking on significant debt.

3. Institutions Rework Financial Models and Revenue Streams to Attain Sustainability

With tuition revenue becoming less reliable, colleges and universities invest in alternative approaches to ensure long-term financial stability via new sources of income.

4. Inclusion and Support Services Build Connection, Acceptance, and Success

A strong link between student belonging and persistence drives institutions to ramp up student-centered support and success services to ensure every enrollee is mentally, socially, and academically prepared for college life.

5. Increased Marketing Spending Puts Pressure on Quantifiable Results

As investments in marketing rise, institutions increasingly focus on how to quantify their marketing results.

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