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Digital divide and empowerment of farm women

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Abstract

This paper delves into the intricate nexus between the digital divide and the empowerment of farm women in rural India, elucidating the often-overlooked contributions of these women to agriculture. Despite their pivotal role, entrenched patriarchal norms and limited access to resources hinder their economic agency. The United Nations Food and Agriculture Organization under-scores the potential 20–30% global farm yield increases with gender-equitable resource access. The Indian government's "Digital India" initiative aims to bridge this gap, yet its success pivots on empowering farm women digitally. The paper navigates the challenges posed by the digital divide—ranging from inadequate internet connectivity to high technological costs—identifying them as barriers to farm women's participation in the digital landscape. Strategies for empowerment, such as enhancing internet connectivity, providing digital literacy, and developing agricultural applications, are expounded. Drawing on studies from Nigeria and India, the impact of the digital divide on farm women's economic activities and decision-making is scrutinized. The abstract underscores the imperative of targeted collaborative efforts to surmount the digital gap, crucial for propelling sustainable and inclusive rural development and realizing gender equality in agriculture.

Keywords: Agricultural applications, Digital divide, Digital empowerment, Digital literacy, Farm women, Gender equality, Inclusive growth, Rural development.

Introduction

In rural India, women are essential to all economic activities, including agriculture, whose day begins prior to sunrise and lasts past sunset. These are India's female farmers, whose views are frequently ignored because of their gender and who

battle to define their identity at the grassroots level due to patriarchal traditions and gender socialization. Women have made important contributions to agriculture not just in India but all throughout the world. According to the UN's Food and Agriculture Organization, women might improve farm yields by 20–30% if they had equal access to productive resources as men. This might increase agricultural output globally in poor nations by up to 4%, which would result in a 12–17% decrease in the number of hungry people worldwide, or between 100–150 million people.

In order to mainstream agricultural women and give them direct access to information about better agricultural practices, an inclusive strategy is required from policy to implementation. Without empowering people who are living on India's last frontier, the empowerment of Indian women will fall short.

ICTs and their growth are considered to aid societies and countries in establishing a solid and sustainable production capacity and a respectable standard of living, both of which are essential for the country's economic success. Because of its profound impact on global economic growth and jobs, digitization has established itself as a game-changer. The government of India has launched a flagship program called "Digital India" in order to transform the nation into a knowledge economy and digitally empowered society by utilizing various e-governance initiatives in order to ensure the bridging of the digital divide and the promotion of inclusive growth. This is done in recognition of its prominent status in this highly competitive world and the larger positive impact that it can have on the Indian economy and its population. With a focus on the three pillars of safe and secure digital infrastructure, digital service delivery, and citizen digital literacy, Digital India intends to make all citizens able to access government services online through improved online infrastructure and increased internet connectivity. The "Digital India Programme" places a lot of emphasis on the empowerment of citizens through the development of digital competence, but the program's goals can only be achieved once farm women are proficient in the many facets of the digital world.

It is past time to make a concerted effort to foster an environment that will empower women farmers at the grassroots level by giving them access to technical and financial information about agriculture as well as a well-established identity. They require immediate access to data on enhanced agriculture techniques and connections to markets. In the current digital age, it's also crucial to consider the information and communication tools that can enable female farmers to access marketplaces, which are typically seen as being dominated by men and may not be accessible to them physically. A true social and cultural barrier is emerging due to a lack of access to such technology and a reluctance or inability to interact with this kind of communication, which is potentially just as significant as the incapacity to read and write.

The digital divide is a term that refers to the gap between those who have access to digital technologies and those who do not. This gap exists not only in terms of access to digital devices but also in terms of the skills and knowledge required to use these devices effectively. The digital divide has significant implications for various populations, and one group that is particularly affected by it is farm women.

Farm women face unique challenges in accessing and using digital technologies. In many rural areas, internet connectivity is limited or non-existent, making it difficult for farm women to access information and services online. Even when internet access is available, farm women may lack the skills and knowledge necessary to use digital technologies effectively. Additionally, the cost of digital devices and services may be prohibitively high for many farm women.

The digital divide has significant implications for farm women's economic and social well-being. Access to digital technologies can enable farm women to access markets, find information on crop prices and weather patterns, and connect with other farmers and agricultural experts. Without access to these technologies, farm women may be at a disadvantage in the marketplace and may be unable to access critical information and resources.

The digital divide in Indian society

Due to the rapid development and distribution of digital media over the last two decades, access to this medium has become crucial to being an active player in our contemporary society. In most developed countries, computers and mobile phones have become indispensable to how people communicate, work, and learn. It is a well-known fact that digitalization has had an intense impact on society and has also influenced the lives of people immensely. In India, the benefits of digitalization have apparently been seen in every corner of society, generating great change in society. However, it is also a reality that the unequal access to information and communication technologies has led to a massive digital divide in society. The perceived divide between those who have access to the most recent information technologies and those who do not is discussed. According to research, there are numerous elements along racial, economic, ethnic, and educational lines that contribute to this digital gap. Ownership and access do not always correlate to users of the technology because many people with access are not proficient users or are unable to get information efficiently.

Concepts of empowerment and digital empowerment

Empowerment is described as "the process of gaining mastery over one's self and one's environment in order to fulfill human needs," with a focus on people's capacity to improve their lives and inspire others. A process of reflection and action can help marginalized groups become more aware of their condition, and they can then take steps to change their reality. “Such empowerment can increase people's capacity for strategic decision-making and give them the tools and know-how to live more fulfilled lives." Empowerment can be achieved through a process of building self-esteem that can come from skill attainment and learning, increasing a sense of worth, and in so doing, helping to enhance social capital. It is a term that describes the different ways in which members of different communities can interact effectively. This can vary from chatting with neighbours or engaging in recreational activities to participating in environmental organizations and political parties. It also allows for the acquisition of new sources of information and support; thus, bridging social capital is considered important for social development. Access to the internet and the development of content production skills open up a plethora of new forms of interaction by enhancing individuals’ social capital. It offers chances to communicate with a global audience and, most significantly, gives the previously voiceless and

underprivileged a voice in a public setting in a way that has never been possible to this extent before.

The concept of digital empowerment has been defined by various authors in different ways. In essence, digital empowerment combines the words "digital" with "empowerment." Digital refers to electrical technology that creates, stores, processes, and records data that is represented by words and images that are written in binary code, also known as bits, which is made up of combinations of the digits 0 and 1. While empowerment refers to the various strategies that people from various communities might use to communicate successfully, this can vary from person to person based on socio-economic and political situations.

Empowering farm women through digital technologies

Empowering farm women through digital technologies can involve several strategies. These strategies include:

Improving internet connectivity

Governments and private organizations can work to improve internet connectivity in rural areas, including through the development of wireless networks and the use of satellite technology. Community broadband networks, which provide high-speed internet access to rural communities, can also be developed.

Providing digital literacy training

Farm women may lack the skills and knowledge necessary to use digital technologies effectively. Governments and organizations can provide digital literacy training programs to help farm women develop these skills. These programs can include basic computer skills training as well as more advanced training on the use of digital technologies for farming and other agricultural activities.

Developing agricultural applications

There are a growing number of agricultural applications available that can provide farm women with access to critical information and resources. Governments and organizations can work to develop and promote these applications, ensuring that they are accessible and relevant to the needs of farm women. These applications can include weather forecasting, crop monitoring, and market information.

Supporting women's groups

Women's groups and organizations can provide a support network for farm women, helping to connect them with other farmers and agricultural experts. These groups can also provide training and support on the use of digital technologies.

The role of digital empowerment in bridging the digital divide

Janssen and Stoyanov (2012) described the digital empowerment of individuals based on their competency to use digital devices and applications. Digital competence involves more than knowing how to use devices and applications; it is intricately connected with skills to communicate using ICT as well as information management skills. Additionally, a balanced attitude towards technology as well as specific knowledge and attitudes about legal and ethical issues, privacy, and security are necessary for the wise and healthy use of ICT. Meanwhile, they generated twelve digital competence areas that describe how much a person is digitally competent in the present ICT

generation. The twelve digital competence areas are summarized in Table 1.

In addition to Table 1, Figure.1 given above illustrates how the various digital competence areas relate. It provides a schematic representation of the results and reflects the kaleidoscopic nature of the ideas generated by experts, which comprised a mixture of competences, proficiency levels, purposes, technologies, and domains (application areas).

Table 1 Twelve digital competence areas identified by Janssen and Stoyanov (2012).

Digital competence area	Description
1. General knowledge and functional skills	The digitally competent person knows the basics (terminology, navigation, functionality) of digital devices and can use them for elementary purposes.
2. Use in everyday life	The digitally competent person is able to integrate technologies into the activities of everyday life.
3. Specialized and advanced competence for work and creative expression	The digitally competent person is able to use ICT to express his/her creativity and to improve his/her professional performance.
4. Technology mediated communication and collaboration	The digitally competent person is able to connect, share, communicate, and collaborate with others effectively in digital environments.
5. Information processing and management	The digitally competent person uses technology to improve his/her ability to gather, organize, analyze and judge the relevance and purpose of digital information.
6. Privacy and security	The digitally competent person has the capacity to protect personal data and take appropriate security measures.
7. Legal and ethical aspects	The digitally competent person behaves appropriately and in a socially responsible way in digital environments, demonstrating awareness and knowledge of legal and ethical aspects on the use of ICT and digital content.
8. Balanced attitude towards technology	The digitally competent person demonstrates an informed, open-minded, and balanced attitude towards Information Society and digital technology. The digitally competent person is curious, aware of opportunities and new developments, and is comfortable to explore and exploit them.
9. Understanding and awareness of role of ICT in society	The digitally competent person understands the broader context of use and development of information and communication technology.
10. Learning about and with digital technologies	The digitally competent person actively and constantly explores emerging technologies, integrates them in his/her environment and uses them for lifelong learning.
11. Informed decisions on appropriate digital technologies	The digitally competent person is aware of most relevant or common technologies and is able to decide upon the most appropriate technology according to the purpose or need at hand.
12. Seamless use demonstrating self-efficacy	The digitally competent person confidently and creatively applies digital technologies to increase personal and professional effectiveness and efficiency.

It also represents how the various digital competence areas identified through the online consultation can be considered 'building blocks', which are not necessarily mutually exclusive. Vertically presented blocks like, for instance, 'Legal and ethical aspects' are considered to be relevant across everyday use, more specialized use, and up to decisions regarding the appropriateness of technologies. There is both intra- and inter-block variance in proficiency levels. As one progresses upward from the central blocks, proficiency levels seem to increase. Among the areas of digital competence, learning about and with technologies, informed decisions on appropriate technologies, and seamless use of technologies exhibit higher proficiency levels. 'Core' competences related to digital technology usage in everyday life and at more advanced levels connected to creative expression and/or work are bolstered on the one hand by technology-mediated communication and collaboration competences and competences relating to information processing and management on the other hand.

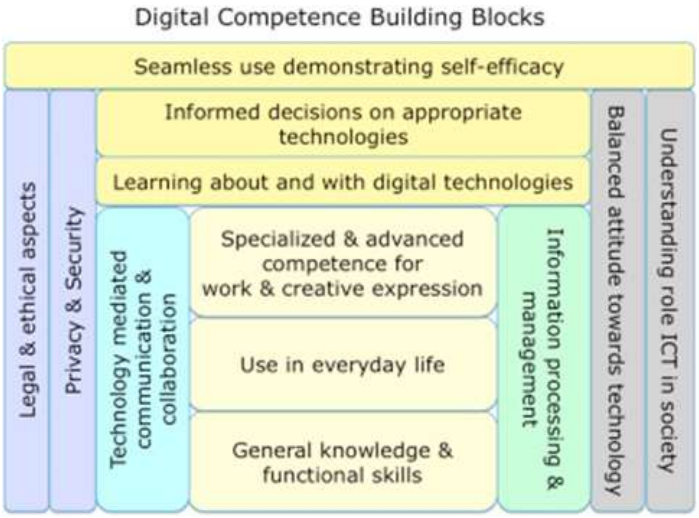

Figure 1 Areas of digital competence: experts' collective view.
Source: Janssen and Stoyanov (2012)

The above-mentioned digital competence areas involve the basic and direct application of digital technology, which must be substantiated by awareness and skills related to other competences so as to have wider implications for digital technologies. These 'supplementary' yet significant competences comprise awareness of legal, ethical, privacy, and security aspects, the ability to act in a judicious manner, and an understanding of the role of ICT in society while maintaining an equilibrated view towards technology. Ultimately, at a higher level of observation and consolidation, digital competence includes a variety of competences that render a digitally competent person capable of assessing both his or her own digital competences and the digital environment. This level of digital competence assists in better decision-making for self-development and

improvement of one's personal digital environment, which finally culminates in a level of proficiency where the digitally competent person becomes self-efficient in the unhindered and consistent use of digital technologies.

Impact of the digital divide on farm women

The impact of the digital divide on farm women can be significant. Without access to digital technologies, farm women may be unable to access critical information and resources that can help them improve their economic and social well-being. They may also be at a disadvantage in the marketplace, as they may not have access to the same market information as their male counterparts. The digital divide can also perpetuate gender inequalities, as men may have greater access to digital technologies and the opportunities they provide.

Studies have shown that the digital divide has significant implications for farm women. A study by Braimoh (2017) found that women in rural Nigeria were less likely to use the internet than men and that the gender gap in internet use was larger in rural areas than in urban areas. A study by Mukherjee et al. (2019) found that women in rural India faced significant barriers to accessing digital technologies, including lack of awareness, lack of skills, and lack of resources.

Several studies have also explored the impact of digital technologies on farm women's economic and social well-being. A study by Dzisi and Diko (2020) found that women who had access to mobile phones and the internet were more likely to participate in market activities and earn income from their farming activities. Another study by Ezzat and Abdelhady (2020) found that women in Egypt who had access to digital technologies were more likely to participate in decision-making within their households and communities.

Conclusion

The digital divide is a significant barrier for farm women, limiting their access to critical information and resources that can help them improve their economic and social well-being. However, there are several strategies that can be used to empower farm women through digital technologies, including improving internet connectivity, providing digital literacy training, developing agricultural applications, supporting women's groups, and providing financial assistance. Governments, organizations, and individuals all have a role to play in bridging the digital divide and empowering farm women. It is important that these efforts are focused on the specific needs and experiences of farm women and that they are developed in collaboration with women's groups and organizations. Overall, bridging the digital divide is essential for achieving gender equality in agriculture and rural development. By empowering farm women through digital technologies, we can improve their economic and social well-being, increase their participation in decision-making processes, and promote sustainable and inclusive rural development.

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Pharmacological and formulation studies on growth hormone: *in-vivo* and *in-vitro*

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Abstract

Human growth hormone (HGH), also known as somatotropin, Growth hormone is indicated in many diseases, like Prader-Willi syndrome, chronic renal insufficiency, Tuner syndrome, AIDS-related wasting, idiopathic short stature in children, and the accumulation of fat in adults with lipodystrophy. A number of carriers have been utilized to carry drugs to target tissues, which include immunoglobulins, serum proteins, synthetic polymers, lipid vesicles, microspheres, niosomes, etc. In this study, in-vivo somatotropin was estimated by ultraviolet spectroscopy, and blood plasma showed an absorption maximum at 214 nm. In-vitro preparation of niosomes by hand shaking method, reverse phase evaporation method, and ether injection method. The niosomal formulation of somatotropin has proven to be highly effective in inducing growth as compared to the existing marketed formulations of somatotropin. As a result, growth hormone can now be synthesized by Escherichia coli bacteria as a result of the successful application of recombinant DNA technology. Therefore, this hormone is now beginning to become available in sufficient quantities for treatment purposes. The niosomal formulation of somatotropin has proven to be highly effective in inducing growth as compared to the existing marketed formulations of somatotropin.

Keywords: Growth hormone, Niosomes, Noisome, Pharmacokinetic data, Somatotropin.

Introduction

Hormone is a substance of intense biological activity that is produced by specific cells in the body and transported through circulation to act on its target cells. Hormones regulate body functions to bring about a programmed pattern of life events and maintain homeostasis in the face of a markedly variable external and internal environment (Brahmanakar and Jaiswal, 2018).

Growth hormone

It is a 191 amino acid, single-chain peptide with a molecular weight of 22000. Growth hormone (GH) promotes the growth of all

organs by inducing hyperplasia. There is a proportionate increase in the size and mass of all parts, but in the absence of gonadotropins, sexual maturation does not take place. The growth of the brain and eye is independent of growth hormone (Rebenson and Lee, 2009). It promotes the retention of nitrogen and other tissue constituents; more protoplasm is formed. Positive nitrogen balance results from increased uptake of amino acids by tissues and their synthesis into proteins. Growth hormone promotes the utilization of fat and spares carbohydrates. The uptake of glucose by muscles is reduced while its output from the liver is enhanced and fat is broken down. Excess production of growth hormone is responsible for gigantism in childhood and acromegaly in adults. Hyposecretion of growth hormone in children results in pituitary dwarfism (Toadd et al., 2007). It has also been tried in children with constitutionally short stature with encouraging results. Commercial interests are promoting it for accelerating growth in children without growth hormone deficiency.

An ideal dosage form of drug therapy for any disease is the one that immediately attains the desired therapeutic concentration of drug in plasma at the site of action and maintains constant concentration for the entire duration of treatment. The frequency of administration of the dose of any drug depends upon its half-life, or mean residence time (MRI), and its therapeutic index. In most cases, the dosing interval is much shorter than the half-life of the drug, resulting in a number of limitations associated with such a conventional dosage form (Vyas and Dixit, 2017).

1. Poor patient compliance increases the chances of missing the dose of a drug with a short half-life, for which frequent administration is necessary.
2. A typical peak-valley plasma concentration-time profile is obtained, which makes attainment of a steady-state condition difficult.
3. The unavoidable fluctuations in the drug concentration may lead to under-medication or over-medication as the C_{35} values fall or rise beyond the therapeutic range. 4. The fluctuating drug levels may lead to the precipitation of adverse effects, especially for a drug with a small therapeutic index, whenever over-medication occurs (Khandare et al., 2016).

There are two ways to overcome such a situation:

1. Development of new, better, and safer drugs with long half-lives and large therapeutic indexes.
2. Effective and safer use of existing drugs through concepts and techniques of controlled and targeted drug delivery systems.

Design of controlled drug delivery systems

In recent years, research has focused on the development of new drug delivery systems (Rothstein, 2010).

- Sustain drug action.
- Localize drug action.
- Target drug action

Carrier Systems for Drug Delivery

A number of carriers have been utilized to carry drugs to the target organ or tissue, which include immunoglobulins, serum proteins, synthetic polymers, lipid vesicles, microspheres, erythrocyte reversible

micelles,pharmacosomes, niosomes, etc. (Kiwada et al., 2008).

1. **Cellular Carriers**: resealed erythrocytes, serum albumin, antibodies, platelets, and leukocytes.
2. **Polymer-based systems:** signal-sensitive, mucoadhesive, bindable, soluble synthetic polymer carriers, dendrimer
3. **Macromolecular carriers:** Proteins, serum albumin, glycoproteins, neoglyeoproteins, and artificial viral envelopes. Glycosylated water-soluble polyamines poly-lysine. Monoclonal antibodies Immunological Fab fragments, antibody-enzyme complex
4. **Colloidal carriers:** Vesicular system: liposomes, pharmacosomes, virosomes, and immunoliposomes.
   Microparticulate system Microparticles, nanoparticles, nanocapsuies, nanospheres, and solid lipid nanoparticles.

Rothstein et al. concluded that a controlled-release formulation of somatotropin has been attempted to reduce the necessity of the multiple injections given to the patients. It has been generally known that protein molecules dissolved in an aqueous medium are precipitated upon contact with a water-miscible organic solvent (Stafford et al., 2016).

Material and Methodology

Quantitation of Somatotropin: Somatotropin was estimated in vivo by ultra violet spectroscopy, and in blood plasma, it showed an absorption maximum at 214 nm. Standard curves were prepared for the concentration range of 2–20 ug/mL in PBS pH 7.4 buffer. Standard curves were also prepared in blood (plasma), and urine observations were reproducible, and the curves showed excellent linearity.

Preparation and in-vitro characterization: Niosomes were prepared by the hand shaking method, the reverse phase evaporation method, and the ether injection method. The prepared materials were evaluated for size distribution, entrapment efficiency, and release characteristics. The effect of type of lipid and leakage on storage was investigated. Among the methods used, the ether injection method showed higher entrapment efficiency for all types of tweens and spans used, while among the tweens used, the tween showed the highest entrapment, probably due to the higher encapsulated aqueous niosomes available for the drug. The size distribution of niosomes prepared by the handshaking method showed a regular increase in the mean size of vesicles as the surfactants of higher HLB were used. Niosomes prepared using tween 80 (H.L.B., 4.3) were 347 micrometers and tween 20 (H.LB. 86) were 7.36 um. The in-vitro release was studied using dialysis. The release of drugs from vesicles was sustained and prepared into a free drug solution. Slower release was observed in niosomes prepared using tween 40 and tween 60 as compared to those prepared using tween 20 and tween 80, which may be due to their high transition temperature and thus supposed to be less permeable using tween 40 as surfactant. The effect of lipid composition and lipid concentration was investigated on the in-vitro characteristics of niosomes prepared by hand. Niosomes prepared using pure surfactant showed higher entrapment and greater mean vesicle size (8.1 um); the interaction of cholesterol reduced both entrapment efficiency (12.3%) and mean vesicle size (4.8 um). The incorporation of dicetyl phosphate

further reduced the entrapment efficiency to 10.9% and the mean vesicle size to 3.87 um. Release rate studies revealed pure surfactant vesicles to be most permeable; intercalation of cholesterol is suppressed by its membrane stabilizing effect. Incorporation of DCP further reduced the release, and an almost-near correlation was observed between the concentration of lipid and entrapment efficiency. Drug leakage was studied in niosomes stored at room temperature and in cold places. Niosomes prepared by the injection method showed lower leakage as compared to those prepared by the shaking method and the reverse phase evaporation method.

In-vivo **Evaluation:** Based on their promising in vitro characteristics, niosomes prepared by the hand shaking method using tween 40, cholesterol, and a D.C.P. ratio of 1:3:5 was selected to investigate their *in vivo* behavior. The plasma drug profile of noisome-entrapped somatotropins displayed higher and sustained plasma mg levels as compared to the free drug solution. Half-life was increased from 30 min to 96 min, AUC from 5.62 to 77.94 ughrs-' ml, while the volume of distribution decreased from 961.5 ml to 423.7 ml and total body clearance from 3.3316 liters to 0.1835 liters hrs."

Table 1. Concentration of Somatotropins injection and optimized formulation in blood.

Sl. No.	Time (hr)	Concentration of somatotropin in blood			
		Somatotrophin injection		Optimized formulation	
		ng/ml	Log conc.	ng/ml	Log conc.
1.	0.85	11.2	1.048	10.8	1.542
2.	0.28	6.9	0.8426	41.3	1.618
3.	0.50	4.4	0.6327	30.8	1.4788
4.	0.75	1.1	0.0647	21.6	1.3440
5.	1.2	1.4	0.0787	18.9	1.2852
6.	2.0	1.3	0.0765	13.6	1.2138
7.	3.0	1.6	1.021	7.8	0.8999
8.	5.0	1.8	0.0952	3.8	0.5486

Stability studies

The leakage of somatotropin out of vesicles on storage was determined, and the suspension was prepared using surfactant, cholesterol, and D.C.P. in ratios of 1:3:5 (FD_8) Niosomes prepared by the hand shaking method, the ether injection method, and the reverse phase evaporation method were stored for drug studies. Niosomes prepared by the above methods were dialyzed and then stored in capped vials at

a. Room temperature (25.2°C)
b. in the refrigerator (4-6°C)

Results

The spectrophotometric method was selected for in vitro analysis of somatotropin in a phosphate-buffered saline (pH 7.4) solution. It was selected because of its specificity, sensitivity, reproducibility, feasibility, simplicity, rapidity, and accuracy. The test for identification of the drug was found to be

positive. Scanning in the UV range of 200–300 nm showed an absorption maximum at 214 nm of the drug solution in P.B.S. (7.4). The curve was found to obey Beer's law in the concentration range studied (2–20 ng/mL). Table 1 shows the standard curve of somatotropin in P.B.S. (pH 7.4) buffer by spectrophotometry. The calibration curves for quantitation of somatotropin in blood (plasma) and urine were prepared by spectrophotometry to be used in *in-vivo* studies.

Table 2. Pharmacokinetic data of somatotrophin injection and optimized formulation.

Sl. No	Parameter	Somatotrophin injection	Optimized formulation
1.	T1/2 (Min)	30.0	96.0
2.	Ks (Hrs)	2.31	0.433
3.	Vd (ML)	961.5	423.7
4.	AUC (µghrs ml^{-1})	5.84	80.96
5.	CLT (liter hrs^{-1})	3.3316	0.1835

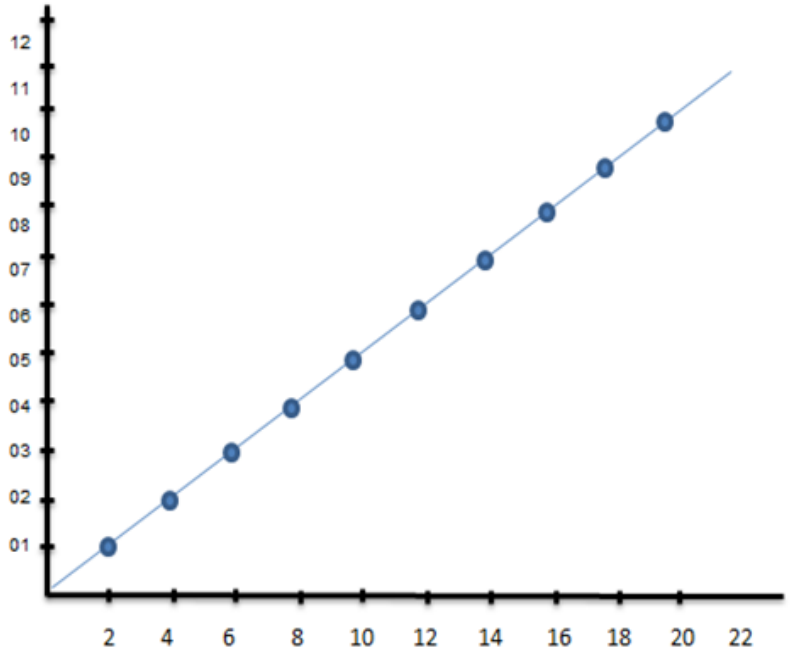

Fig 1. Standard Curve of Somatotropin in P.B.S (PH-7.4) Buffer.

Discussion

Niosomes were repaired by the hand shaking method (HSM), reverse phase. The evaporation method (R.E.M.) and ether injection method (E.I.M.) in the hand shaking method (Malhotra and Jain, 2016) by dried lipid film with an aqueous phase result in the formulation of niosomal dispersion. In the reverse phase evaporation method, water in an ether emulsion is sonicated; the evaporation of

ether causes reversal of the emulsion phase and, through the intermediate gel state, the formation of niosomal dispersions (Chauhan and Lawrence, 2018). In the ether injection method, lipids dissolved in ether are injected into a hot aqueous solution, where the evaporation of ether leaves behind a lipid bilayer encapsulating the aqueous phase. In the lipid mixture, tween and spans were used as nonionic surfactants (Baillie et al., 2015). Since the non-ionic surfactant tween 80 and span 60 have the highest phase transition temperature of 50 °C, all vesicle preparations were carried out above 50°C in the ether injection method; the aqueous phase was maintained at 40+2 °C; and in the hand shaking method, hydration of film was carried out at 40+2°C (Roberts and Azain, 2015). Vesicles were prepared from 250/mol of lipid containing surfactant, cholesterol, and dicetyl phosphate (D.C.P.) in the molar ratio of 1:3:5 (FD_8) (Allen et al., 2011). This ratio was chosen because it was found to have better *in-vivo* performance if non-ionic surfactant, cholesterol, and D.C.P. were used in the ratio 1:3:5 (FD_8) than any other composition (British Pharmacopoeia, 2011). D.C.P. was included in bilayer composition to impart a negative stage because negatively charged niosomes have been reported to be more efficient for drug delivery and have shown better *in-vivo* growth activity than positively charged or neutral niosomes (Resolw and Willard, 2009). The niosomes prepared by ether injection and reverse-phase evaporation methods exhibit higher entrapment efficiency than the hand shaking method. The difference is presumably due to the type of vesicles formed by each method. The uniflagellar structures formed by the ether injection method and the reverse phase evaporation method represent a more efficient surfactant than the multilamellar structures formed by the hand shaking method. Among the types of surfactants used, tween60 always showed the highest entrapment in niosomes prepared by any method. The physicochemical properties of the drug might be well correlating with the H.L.B. value of tween 60; entrapment efficiency depends upon the encapsulated volume, which was high in niosomes prepared using tween 60 (Sesalet and George, 2007).

In-vivo: The performance of a drug delivery system is the most important criteria in its development as a clinically acceptable dosage form. Preliminary in-vivo studies are carried out on laboratory animals such as rats, mice, hamsters, monkeys, etc. Observing the pharmacological response by analyzing the drug in the body can lead to in-vivo evaluations. Drugs can be analyzed in the organs to ascertain the ability of a system to achieve compartmental utilization of the drug in target tissue, which will reduce the concentration in non-targeted healthy tissues (Cook et al., 2016). While determining the blood level would ascertain the ability of the system to prolong the action of the drug, niosomes prepared by the hand shaking method using span, cholesterol, and D.C.P. in the molar ratio 1:3:5 (FD_8) was selected for *in-vivo* studies on the basis of their promising *in-vitro* performance. The blood levels of niosome-entrapped drugs after administration of a bolus injection were compared with those obtained from a plain drug solution (Hansen et al., 2006). The drug was analyzed in the blood by spectrophotometry. Albino rats (Sprague-Dawle strain) of either sex weighing 40–50 g was used in the study. The rats were procured, conditioned, and maintained on laboratory rat feed (Eppard et al., 2016).

Blood somatotropin level: blood samples were analyzed by spectrophotometry. The blood samples were centrifuged, plasma collected, mixed with 0.1 ml of 0.25 NaH_2PO_4 buffer, and extracted with 6.0 ml of ethyl acetate. After centrifugation at 5000 rpm for 5 min, 3 ml of the organic layer was evaporated at 55°C. The residue was redissolved in water (triple distilled) and estimated spectrophotometrically (Moallem et al., 2015). The optimized formulation of somatotropin increased its life from 30 minutes to 96 minutes. Area under the curve (AUC) from 5.84 to 80.96 ml-1 to 423.7 ml and total body clearance (LT) from 3.3316 liters to 6.1865 liters increase in half-life and decrease in clearance blisher the efficiency of niosomes in sustaining the action of drugs (Polidori et al., 2018).

The control group shows a moderate growth rate, while the animals with the marketed formulation of somatotropin showed a sharp growth rate, as evident from their weight gain. Groups administered with niosomal formulations exhibit a tremendous growth rate, which may be attributed to the fact that niosomal formulations are able to deliver the drug in a controlled manner over a prolonged period of time. Thus, the niosomal formulation of Somatotropin has proven to be highly effective in inducing growth as compared to the existing marketed formulations of Somatotropin (Fernandez et al., 2019).

Conclusion

In the past, it has been difficult to obtain sufficient quantities of human growth hormone to treat patients with growth hormone deficiency, except on an experimental basis, because it has had to be prepared from the human pituitary gland. Human growth hormone can now be synthesized by Escherichia coli bacteria as a result of the successful application of recombinant DNA technology. Therefore, this hormone is now beginning to become available in sufficient quantities for treatment purposes. Dwarfs who have a pure growth hormone deficiency can be completely cured. Also, human growth hormone might prove beneficial in other metabolic disorders because of its widespread metabolic functions.

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Phytochemistry, medicinal uses of the common food mung bean (*Vigna radiata*)

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Abstract

The seeds and sprouts of green gram (Vigna radiata), a popular food, contain ample nutrients with biological properties. This review offers an understanding of the nutritional worth of green grams and their sprouts, discussing chemical components that have been isolated in recent years, such as flavonoids, phenolic acids, organic acids, amino acids, carbohydrates, and lipids. Additionally, we also summarize fluctuating changes in metabolites during the sprouting process and associated biological properties, including antioxidant, antimicrobial, anti-inflammatory, anti-diabetic, blood pressure-lowering, lipid metabolism regulation, blood pressure-lowering, and anti-cancer effects, etc., with the aim of providing scientific proof for improved utilization of this commonly consumed food as a remedy.

Keywords: Antioxidant, Medicinal value, Mung bean, Nutritional value, Phytochemistry, *Vigna radiata*.

Introduction

With increasing clinical evidence suggesting that plant-based foods offer numerous potential health benefits, their consumption has been steadily rising at a rate of 5%–10% annually (Tham et al., 1998). Moreover, various global health organizations have

recommended an increase in the intake of plant-based foods to improve well-being and prevent chronic diseases (Espin et al., 2007).

The mung bean (*Vigna radiata*) has been traditionally consumed as a staple food in China for over 2,000 years. It is widely recognized for its detoxifying properties and is used to refresh the mind, alleviate heatstroke, and reduce swelling during the summer. In the book Ben Cao Qiu Zhen, the mung bean was documented to have beneficial effects on gastrointestinal issues and skin hydration (Min, 2001). The seeds and sprouts of mung beans are also commonly used as a fresh salad vegetable or staple food in India, Bangladesh, Southeast Asia, and Western countries (Fery, 1990). As a dietary choice, mung beans provide a well-rounded nutritional profile, including protein and dietary fiber, as well as significant amounts of bioactive phytochemicals. The high levels of proteins, amino acids, oligosaccharides, and polyphenols in mung beans are believed to be the primary contributors to its antioxidant, antimicrobial, anti-inflammatory, and antitumor properties, as well as its involvement in lipid metabolism regulation (Kanatt et al., 2011; Randhir et al., 2004; Vanamala et al., 2006; Anjum et al., 2011).

In recent times, research has indicated that the sprouts of mung beans following germination display more noticeable biological properties and a greater abundance of secondary compounds as the relevant biosynthetic enzymes become active during the initial stages of germination. Consequently, germination is believed to enhance the nutritional and medicinal attributes of mung beans (El-Adawy et al., 2003). The proficient utilization of mung beans, as supported by scientific experimentation, will prove advantageous for their utilization as a health food, medication, and beauty product (Golob, 1999). In this current analysis, we summarize the nutritional worth, chemical constituents, and changes in metabolites during the sprouting procedure, as well as the pharmacological effects and clinical uses of mung beans. This will offer a deeper comprehension of the potential applications of this common food.

The nutritional value of mung beans as a common food

Mung beans are a legume crop or pulse used primarily as dried seeds and occasionally as forage, green pods, and seeds for vegetables (Tomooka, 2002). Dried seeds may be eaten whole or split, cooked, fermented, or milled and ground into flour. Mung beans can also be made into products like soups, porridge, confections, curries, and alcoholic beverages. In western cultures, mung bean sprouts are popularly used as a fresh salad vegetable (Lambrides and Mungbean, 2007).

Importantly, mung beans are composed of about 20%–24% protein. Globulin and albumin are the main storage proteins found in mung bean seeds and make up over 60% and 25% of the total mung bean protein, respectively. Therefore, due to its high protein content and digestibility, consumption of mung beans in combination with grains can significantly increase the quality of protein in a meal (Wang et al., 2004; Kudre et al., 2013). Mung bean protein is rich in essential amino acids, such as total aromatic amino acids, leucine, isoleucine, and valine, as compared with the FAO/WHO (1973) reference. However, compared with the reference pattern, mung bean protein is

slightly deficient in threonine, total sulfur amino acids, lysine, and tryptophan (Mubarak, 2005). Moreover, the proteolytic cleavage of proteins during sprouting leads to a significant increase in the levels of amino acids.

Mung legumes contain a higher amount of carbohydrates (50%–60%) compared to soybeans, and the main type of carbohydrate present is starch. Because of their abundance in starch, mung beans have traditionally been used for making starchy noodles, known as muk in Korea. Oligosaccharides, which include raffinose, stachyose, and verbascose, found in raw or poorly processed legumes, can cause flatulence when consumed. Although these oligosaccharides are also present in mung beans, they can be dissolved in water and eliminated through proper soaking, sprouting, or fermenting. The energy provided by mung beans and sprouts is lower than that of other grains, which is advantageous for individuals with obesity and diabetes (Zheng, 1999). Furthermore, trypsin inhibitors, hemagglutinin, tannins, and phytic acid present in mung beans have been reported to possess biological functions that aid digestion and detoxification (Lin and Li, 1997).

In addition to a high amount of protein and low-calorie content, mung beans also contain different enzymes and abundant trace elements. For instance, superoxide dismutase (SOD) obtained from the mung bean can be chemically altered and transformed into an SOD oral solution. This chemically modified SOD can evade destruction by stomach acid and pepsin, thereby prolonging its lifespan and making it suitable for human oral uptake (Lin and Li, 1997).

Overall, regular consumption of mung beans could regulate the microbiota of enterobacteria, decrease the absorption of harmful substances, decrease the risk of high cholesterol levels and heart disease, and prevent cancer (Kruawan et al., 2012).

Chemical constituents

In recent years, flavonoids, phenolic acids, organic acids, and lipids have been discovered in the seeds and sprouts of mung beans. These compounds have been found to play a role in the medicinal properties of the beans.

Flavonoids

Flavone, isoflavone, flavonoid compounds, and isoflavonoid compounds (compounds 1–44) are the significant metabolites found in the mung bean (Prokudina et al., 2012; Wang et al., 2008). Most flavonoids have multiple hydroxyl substitutions and can be classified as polyphenols with evident antioxidant activity. Vitexin (apigenin-8-C-β-glucopyranoside) and isovitexin (apigenin-6-C-β-glucopyranoside) have been reported to be present in mung bean seeds at approximately 51.1 and 51.7 mg g^{-1}, respectively (Li et al., 2012; DongKwan et al., 2008). Flavonoids are involved in stress protection (i.e., oxidative and temperature stress), early plant growth, signaling (i.e., legume nodulation), and defense against insect and mammalian herbivores (Koes et al., 1994).

Phenolic acids

Phenolic compounds are secondary compounds primarily produced through the PPP, shikimate, and phenylpropanoid

pathways (Randhir et al., 2004). These compounds are important bioactive phytochemicals, and their presence in wild plants has led to an increase in the use of wild plants as food sources (Estomba et al., 2006; Singh et al., 2009).

A total of twelve phenolic compounds have been identified in mung bean seeds and sprouts (Sosulski and Dabrowski, 1984; Sawa et al., 1999). Mung beans have high levels of total phenolics and total flavonoids, which contribute to their ability to scavenge the DPPH radical, inhibit tyrosinase, and exhibit antiproliferative and alcohol dehydrogenase activities. These properties make mung beans a potential substitute for prescription drugs and a preventive or therapeutic agent for human diseases (Kim et al., 2012).

Others

Mung beans and sprouts have also been discovered to contain natural acids and fats. Twenty-one natural acids, such as phosphoric and citric acid, and 16 fats, including γ-tocopherol, were identified as the main constituents of mung beans using gas chromatography/mass spectrometry (GC/MS) (Bowles, 1990).

Dynamic changes in metabolites

Under both biotic and abiotic stress, the physiology of plants undergoes significant alterations. The activation of defense mechanisms, including those involving proteinase inhibitors, results in a response that shields the plant from these types of pressures (Jom et al., 2011). As part of this response, the production of secondary metabolites with diverse health advantages has been observed (Bowles, 1990; Kessler and Baldwin, 2002). However, even in the absence of stress, healthy plants can also be prompted by stress stimulators to artificially generate secondary metabolites. Focused examinations have revealed that the sprouting of mung beans is accompanied by a range of noteworthy changes in the contents of metabolites, such as reduced concentrations of antinutrients (Kataria et al., 1989) and increased levels of free amino acids (Mubarak, 2005; Kataria et al., 1989; Kavas and Sedef, 1991; Abdel-Rahman et al., 2007; Kirchhoff, 2002).

Sprouting significantly decreases the levels of reducing sugars and starches by 36.1% and 8.78%, respectively (Mubarak, 2005). Interestingly, until 60 h of incubation, levels of the monosaccharides fructose and glucose increase dramatically in the sprouting material. However, significant decreases in the levels of both sugars have been observed during the final sprouting stage from 60 to 75 h. The concentration of the disaccharide sucrose increases within the first 24 hours but rapidly declines after the initial sprouting phase (El-Adawy et al., 2003; Mubarak, 2005; Bowles, 1990). Moreover, raffinose and stachyose are completely eliminated during sprouting. The decrease of sucrose in the latter stages of sprouting may be due to the absence of raffinose, resulting in the breakdown of sucrose for energy supply (Mubarak, 2005).

In comparison to grains, mung beans have higher levels of protein (Kirchhoff, 2002). As previously explained, the breakdown of proteins during sprouting results in a notable rise in the quantities of most amino acids. Furthermore, targeted analysis has revealed elevated levels of free amino acids in

sprouted mung beans and lentils (Kavas and Sedef, 1991; Chau and Cheung, 1997).

Gentistic acid, cinnamic acid, and p-hydroxybenzoic acid are the main phenolic acids of metabolites that are present throughout the sprouting process (Amarowicz et al., 2009). Within the first day of incubation, the concentrations of caffeic acid, ferulic acid, and shikimic acid are relatively low in mung bean seeds. However, after the initial soaking and early germination phases, mung bean samples show significantly increasing amounts of these compounds (Singh et al., 2009). Furthermore, the concentrations of gallic acid, chlorogenic acid, and coumarin increase dramatically in the germination material until day 3 or 4, and catechin concentrations increase during the final stage of mung bean sprout development (i.e., on the eighth day of incubation) (Sosulski and Dabrowski, 1984).

The overall concentrations of natural acids also increase during sprouting. Phosphoric acid and citric acid are two of the main natural acid byproducts. A clear and continuous rise in lactic acid is observed, while malic acid and citric acid reach their highest points after only 24 hours of incubation (Bowles, 1990).

Fatty acid methyl esters (FAMEs) are primarily formed through the transesterification of the raw lipid extract and indicate the presence of mung bean triglycerides. Within the initial 24 hours of incubation, changes in the levels of most FAMEs are relatively minimal. However, after the initial soaking and early germination phases, mung bean samples show significant decreases in the levels of FAMEs. In contrast, the levels of γ-aminobutyric acid in mung bean sprouts are increased throughout sprout development and may be particularly important for human nutrition due to its health-enhancing effects (Bowles, 1990; Moumita et al., 2010).

Proteinase blockers are proteins or peptides capable of impeding the catalytic activities of proteolytic enzymes that play crucial roles in biological systems, controlling proteolytic processes, and participating in defense mechanisms against a wide range of insects, fungi, and other disease-causing microorganisms (Lawrence and Koundal, 2002). During the initial 5 days of sprouting, there is a gradual decline in the levels of extractable trypsin blockers in mung bean seeds (Lorensen et al., 1981). The hemagglutinin activity of mung bean seeds has also been documented to decrease by approximately 84.4% after 3 days of sprouting (Messina, 1999).

Biological activities

In ancient texts, mung beans were widely recognized for their ability to remove toxins from the body. Mung bean protein, tannin, and other compounds called polyphenols are believed to bind with organophosphorus pesticides, mercury, arsenic, and other heavy metals, aiding in the elimination of waste from the body (Zhang, 1988). Mung beans have also been found to possess antioxidant, antimicrobial, and anti-inflammatory properties. Additionally, mung beans have been shown to have benefits for diabetes, hypertension, lipid metabolism, blood pressure regulation, and cancer prevention, among other effects. These different characteristics of this functional legume are explained further below.

Antioxidant effects

The proteins, polypeptides, polysaccharides, and polyphenols from the seeds, sprouts, and hulls of mung beans all display potential antioxidant activity. The antioxidant abilities of mung bean protein hydrolysate (MPH) have been documented as 0.67 and 0.46 μmol Trolox equivalent (TE)/mg protein, as measured by oxygen radical absorbance capacity-fluorescein (ORACFL) and Trolox equivalent antioxidant capacity (TEAC) assays, respectively. Freeze-drying in lactose excipient decreases the antioxidant capacity of MPH to 0.48 μmol TE/mg protein in the ORACFL assay but does not modify the results of the TEAC assay (Wongekalak et al., 2011).

MP_1 and MP_2, derived from the aqueous extract of mung beans, are two acid heteropolysaccharides with 9.9% and 36.4% uronic acid content, respectively. The primary composition of MP_1 (molecular weight: 83 kDa) is mannose, while MP_2 (molecular weight: 45 kDa) consists of rhamnose and galactose. MP_2 demonstrates higher activity in scavenging hydroxyl radicals, whereas MP1 exhibits greater reducing power and stronger scavenging capacity for superoxide and DPPH radicals, as well as more significant inhibition of the self-oxidation of 1,2,3-phentriol than MP_2 (Lai et al., 2010).

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During the germination process, sprout extracts display higher levels of total phenolics, total flavonoids, and DPPH radical scavenging activity compared to seed extracts (Kim et al., 2012). Furthermore, the antioxidant activity of mung bean sprouts reaches its peak on either the first or second day, depending on the method of analysis used (i.e., β-carotene assay or DPPH assay, respectively) (Randhir et al., 2004).

The DPPH scavenging activity (SA) of mung bean broth (MBS; 20 mg/mL) is roughly 145% of that of tea broth (5 mg/mL) and 195% of that of vitamin C solution (0.15 mg/mL), indicating that the DPPH-SA of 100 g mung bean is comparable to that of 36.3 g dried green tea and 1462 mg vitamin C. Vitexin and isovitexin are the primary antioxidant components in mung beans (Cao 2011). Vitexin inhibits DPPH radicals by approximately 60% at 100 μg/mL and effectively prevents UV-induced skin cell death (Kim et al., 2005).

Antimicrobial activity

The utilization of phytochemicals as natural biocides, which are known as antimicrobial agents, is gaining popularity. Enzymes, peptides, and polyphenols derived from mung beans have demonstrated both antimicrobial and antifungal properties. Tests for antifungal activity are typically conducted using the inhibition crescents method, while

tests for antimicrobial activity are carried out using either the deferred plate method or the agar-diffusion method (Wang et al., 2009; Wang 2009).

A non-specific lipid transfer peptide (nsLTP; molecular weight: 9.03 kDa) with antimicrobial and antifungal properties was isolated from mung bean seeds. Interestingly, nsLTP exhibits antifungal effects on *Fusarium solani*, *F. oxysporum*, *Pythium aphanidermatum*, and *Sclerotium rolfsii*, and antibacterial effects on *Staphylococcus aureus* but not Salmonella typhimurium (Wang et al., 2004).

Mungin, a novel cyclophilin-like antifungal protein isolated from mung bean seeds, has activity against the fungi *Rhizoctonia solani*, Coprinus comatus, Mycosphaerella arachidicola, *Botrytis cinerea*, and *F. oxysporum*. Mungin also has inhibitory activity against α- and β-glucosidases, suppressing [3H] thymidine incorporation by mouse splenocytes (Ye, 2000).

In 2005, a chitinase (30.8 kDa) with antifungal activity was isolated from mung bean seeds. The protein has a pI of 6.3, as determined by isoelectric focusing, and an estimated specific activity of 3.81 U/mg. The enzyme shows optimal activity at pH 5.4 and is stable from 40 to 50°C. Importantly, chitinase shows antifungal activity on *R. solani*, *F. oxysporum*, *M. arachidicola*, *P. aphanidermatum*, and *S. rolfsii* (Wang et al., 2005).

Furthermore, aside from the aforementioned antimicrobial and antifungal properties, polyphenolic extracts derived from mung bean sprouts have also been demonstrated to exhibit efficacy against Helicobacter pylori, a prevalent bacterial infection in the human population that leads to gastroduodenal ailments (Randhir et al., 2004).

Anti-inflammatory activity

In Asia, mung beans have been utilized in various cuisines and in traditional remedies to address poisonous intoxication, heat stroke linked to thirst, irritability, and fever; these advantageous effects of mung beans are believed to be connected to the inflammatory response (Lee et al., 2011).

Scientists have examined the anti-inflammatory impacts of mung bean ethanol extracts on lipopolysaccharide (LPS)-stimulated macrophages. The extract predominantly contained polyphenols, gallic acid, vitexin, and isovitexin and significantly reduced the activity of murine macrophages by inhibiting pro-inflammatory gene expression without causing harm to cells (Yeap et al., 2012). Additionally, a study demonstrated that all pro-inflammatory cytokines, including interleukin (IL)-1β, IL-6, IL-12β, tumor necrosis factor (TNF)-α, and inducible NO synthase (iNOS), were significantly decreased in cells treated with 3.7 mg/mL polyphenols. These findings suggested that the ethanol extract had immense potential to alleviate the clinical symptoms of diseases associated with inflammation, such as allergies and diabetes (Bellik et al., 2012).

The immunomodulatory effects of mung bean aqueous extracts and individual compounds on PBMCs have also been assessed using BrdU immunoassay, secretion of IFN-γ and IL-10, and identification of responding cells using flow cytometry. The findings revealed that 20 μg/mL genistein,

phytic acid, and syringic acid stimulate a Th1-biased immune response by significantly reducing IL-10 secretion and enhancing IFN-γ secretion. The research concluded that various non-nutritive components of mung beans, including flavonoids, acids, and plant hormones, likely play a crucial role in modulating human immune function (Cherng et al., 2007).

Antidiabetic effects

Research has also explored the antidiabetic properties of extracts from mung beans. In a 2008 study, the antidiabetic effects of extracts from mung bean sprouts and mung bean seed coats were examined in male KK-Ay mice and C57BL/6 mice with type 2 diabetes. These extracts were given orally to the KK-Ay mice for a period of 5 weeks, and the mung bean sprout extracts (2 g/kg) and mung bean seed coat extracts (3 g/kg) reduced levels of blood glucose, plasma C-peptide, glucagon, total cholesterol, triglycerides, and blood urea nitrogen (BUN). Additionally, both treatments significantly improved glucose tolerance and increased levels of insulin immunoreactivity (Yao et al., 2008).

Phenolic antioxidants and L-DOPA can be increased in mung bean extracts through solid-state bioconversion (SSB) by R. oligosporus, with the aim of enhancing health-related functionality. α-Amylase is responsible for breaking down starch during digestion, which is important for regulating postprandial blood sugar levels. A study in 2007 by Randir and Shetty examined the inhibition of α-amylase and H. pylori in bioprocessed extracts and connected these effects to the management of diabetes and peptic ulcers, respectively. The potential inhibition of α-amylase in the tested sprout extract was moderately high in the early stages (days 0–2) and increased during days 4–10, which was linked to a higher phenolic content (Randhir and Shetty, 2007).

Lipid metabolism accommodation

The regulation of lipid metabolism by mung beans has been extensively established. In a preliminary investigation, rabbits with hyperlipidemia were given a 70% combination of mung bean meal and mung bean sprout powder. The combinations influenced the overall cholesterol and β-lipoprotein levels, relieving the symptoms of coronary artery diseases (Li, 1981). Furthermore, in more recent research, normal mice and rats were administered mung bean extracts for 7 days, and total cholesterol was significantly reduced in both types of rodents. This impact was believed to stem from the phytosterol content of mung beans, which was comparable to blood cholesterol, facilitating the prevention of cholesterol biosynthesis and absorption (Zhang and Cai, 1995).

Antihypertensive effects

Large doses (600 mg peptide/kg body weight) of unprocessed sprout extracts, dehydrated sprout extracts, and enzyme-digested sprout extracts have been demonstrated to significantly decrease systolic blood pressure (SBP) in rats after being administered for 6–9, 3–6, or 3–9 hours, respectively. Similar alterations were observed in the plasma angiotensin I-converting enzyme (ACE) activity of these mung bean extracts. A prolonged (1-month) intervention study was conducted, which included treatment with freshly ground

sprout powder, dehydrated sprout powder, and concentrated extracts of the sprouts. The findings indicated that the sprout powders were not as effective as concentrated sprout extracts. The SBPs of rats treated with concentrated extracts of fresh and dehydrated sprouts were significantly reduced during the intervention period from weeks 1–4 and weeks 2–4, respectively (Hsu et al., 2011).

Antitumor effects

Mung beans have been demonstrated to display antitumor effects through various distinct mechanisms. The genetically engineered plant nucleases R-TBN1 and R-HBN1, akin to nucleases derived from pine pollen and mung beans, were discovered to be efficacious against melanoma tumors and were approximately 10-fold more powerful than bovine seminal ribonuclease (RNase). Because of their comparatively low cytotoxicity and elevated effectiveness, these genetically engineered plant nucleases seem to be stable biochemical agents that can be focused on as potential antitumor cytostatics (Matousek et al., 2009).

Furthermore, mung beans have been demonstrated to display antiproliferative properties, as evaluated by the MTT assay using a cell culture system in vitro. Mung beans demonstrate antiproliferative effects that vary according to the dosage, as observed against CAL27, a cell line of tongue squamous cell carcinoma, as well as various other cancer cell lines such as DU145, SK-OV-3, MCF-7, and HL-60 cells (Xu and Chang, 2012).

Another study analyzed the impacts of trypsin inhibitors derived from mung beans (known as LysGP33) on the spread and growth of human colon cancer cells (SW480 cells). In this investigation, the consequences of the purified GST-LysGP33 active portion on the movement of SW480 cells were assessed using wound healing experiments. The findings indicated that at the 24-hour mark, the GST-LysGP33 active fragment at a concentration of 10 μmol/L influenced cell migration. By the 72-hour mark, cells treated with GST-LysGP33 displayed a roughly 50% reduction in wound healing compared to the control group (Zhao et al., 2012).

Antisepsis effects

The aqueous extract from the outer layer of mung beans (MBC) has demonstrated protective effects against sepsis both in laboratory settings and in living organisms. This effect was achieved by inhibiting the activity of high mobility group box 1 (HMGB1), a protein found in the nucleus of cells that has recently been identified as a late mediator of life-threatening systemic inflammation. This discovery has led to the development of a wider range of potential treatments for sepsis. It was observed that the MBC extract reduced the release of HMGB1 and various chemokines in cultures of immune cells in a dose-dependent manner. When administered orally to animals, MBC significantly increased the survival rate from 29.4% in the control group (mice given a saline solution) to 70% in the experimental group that received the MBC extract (Zhu et al., 2012). Chlorogenic acid (56) has also been found to have protective effects against sepsis by inhibiting late mediators of the condition. In murine peritoneal macrophages, chlorogenic acid suppressed the release of HMGB1 induced by endotoxins in a concentration-dependent manner. Furthermore, administration of chlorogenic

acid reduced the accumulation of HMGB1 in the body and prevented mortality caused by endotoxemia and polymicrobial sepsis (Lee et al., 2012).

Conclusion

The mung bean [*Vigna radiata* (L.) Wilczek] is one of the most significant short-term, summer-growing legumes and is cultivated widely throughout tropical and subtropical regions. As we have discussed in this overview, mung beans have extensive applications in the agriculture, health food, pharmaceutical, and cosmetics industries. Mung bean seeds and sprouts are excellent examples of functional foods that reduce the risk of various diseases. Moreover, the seeds and sprouts have health-enhancing effects in addition to their nutritional value.

During the germination process of the mung bean, its chemical constituents undergo a series of biochemical reactions. One such reaction is the production of small active compounds from large molecules, promoting absorption and utilization. Another change observed during germination is the formation and accumulation of many categories of active substances, such as polyphenols, saponins, vitamin C, etc. Therefore, we believe that these alterations in the chemical composition of mung beans during germination will result in significant and important modifications in the pharmacological activities of mung beans as well.

Investigation into the chemical components and biological effects of mung bean seeds and sprouts has furnished a strong theoretical foundation for the progress and utilization of mung beans. Coupled with the examination of the metabolites of these chemical components, exploration of the physiological roles of these compounds is essential for the further development of this area. Consequently, forthcoming research can concentrate on the isolation and refinement of novel substances with physiological activity in agriculture, nutritional supplements, beauty products, and medical applications.

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Present Scenario of Household Food and Nutritional Security

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ABSTRACT

This paper provides a nuanced analysis of the current state of household food and nutritional security in India, examining historical perspectives, policy interventions, and the pivotal role of agriculture. Despite notable strides in reducing severe undernutrition, seasonal food insecurity persists in specific regions, necessitating targeted strategies. Emphasizing the integral connection between agriculture and food security, the paper advocates for increased production, resource efficiency, and gender-inclusive policies. Noteworthy attention is given to the role of women in agriculture and the existing gender disparities. The importance of household food security as a precursor to nutritional well-being is underscored, prompting recommendations for nutrition-oriented agriculture, food diversification, and tailored interventions for vulnerable populations. Furthermore, the abstract highlights the imperative of enhancing food quality and safety measures and advancing nutrition education. The conclusion calls for collaborative efforts from policymakers, researchers, and stakeholders to address the multidimensional challenges and ensure sustainable solutions in the dynamic landscape of food and nutrition security.

Keywords: Agriculture, Food quality, Gender disparities, Household food security, Nutrition education, Nutrition, Policy interventions, Sustainable solutions, Vulnerable populations.

Introduction

India, with 2.5 per cent of the global land mass and 16 per cent of the global population, recognized the importance of human resources as the engines powering national development and gave high priority to the improvement of the health and nutritional status of the population. Article 47 of the Constitution of India states that "the State shall regard raising the level of nutrition and standard of living of its people and improvement in public health among its primary duties." India's Five-Year Plans enunciated the policies, laid down multi-pronged strategies, outlined multi-sectoral programs to improve food security and the nutritional status of the population, laid out the goals to be achieved in a specified time frame, and provided the needed funds to implement the interventions. As a result of all these interventions, famines and severe food insecurity are no longer a threat, but even today, seasonal food insecurity is seen in different pockets of the country. There has been a substantial reduction in severe grades of undernutrition and micronutrient deficiencies and some improvement in the nutritional status of all segments of the population.

Agriculture and food security are inextricably linked. These factors influence women and men in their choice of crops and levels of potential productivity. Agriculture, whether domestic or international, is the only source of food, both for direct consumption and as raw material for refined foods. Agricultural production determines food availability.

India has been at the forefront of developing national food and nutrition databases, undertaking research studies and surveys, and documenting the ongoing agriculture, food, nutrition, and health transitions. Indian scientists have substantially contributed to the global efforts to review the ongoing transitions, evolve appropriate definitions of food security, make recommendations regarding human nutrient requirements, and develop appropriate standards for assessment of nutritional status. The country has also utilized the evolving knowledge and invested in evidence-based intervention programs to:

(i) improve the food and nutrition security of the citizens,

(ii) ensure that the ongoing food supplementation programs provide sufficient food to meet the energy and nutrient gap in vulnerable segments of the population, and

(iii) nationalize and improve ongoing nutrition interventions aimed at prevention, early detection, and effective management of undernutrition and overnutrition.

Women account for a great proportion of the agricultural labor force, produce the majority of food grown, and perform most of the unpaid care work in rural areas; yet, they do not enjoy equality with men when it comes to assets, land, food, nutrition, work opportunities, education, and participation in decision-making (FAO, 2016; World Bank. 2020).

The term "food security" refers to the ability of a country or region to assure an adequate

food supply for its current and projected population. Food security was measured by food grain production to ward off famine, improve availability and access to food at an affordable cost, meet energy requirements, and prevent chronic undernutrition among the ever-growing population. Over decades, there has been increasing recognition that, though there has been a reduction in severe acute food insecurity, dietary intake in large segments of the population does not meet energy (hunger) and micronutrient (hidden hunger) requirements, and consequently, undernutrition and micronutrient deficiencies are widespread. As defined by the State of Food Insecurity (Food and Agriculture Organization of the United Nations, 2002), "Food security is a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. This definition encompasses a whole lot of pre-requisites for food security and brings into focus the linkage between food, nutrition, and health.

Those whose access to an adequate diet is conditioned by seasonality are food insecure and are generally called seasonally food insecure. Individuals who normally have enough to eat but become food insecure in the face of disasters triggered by economic, climatic, and civil shocks (war and conflict) are transitorily food insecure. The "at all times" element of the food security definition makes risk and associated vulnerability an important element of the food security concept.

Nutrition-Oriented Agriculture and Food Diversification

Household food security is a precondition to achieving nutrition security. To improve households and communities' situations, the efficiency of existing resource utilization should be improved. At the same time, conserving and, where possible, enhancing the productive capacity of the resources can be an aim. The strategy should involve sound land-use planning and subsequent implementation of actions at the community and household level to match demands with the potentials of both the land and its people (FAO 1996).

Increased production and diversification of food need to be promoted in such a way as to offer particular benefit to the rural poor. Measures should include targeted interventions to increase the productivity of small-scale farmers, such as production incentives, the development of an efficient marketing infrastructure for food products, and improved seeds. In addition, more research input would be required to improve the food production situation in rain-fed and disadvantaged areas, for example, areas where shifting cultivation is practiced. To ensure a proper impact of food production and diversification programs, nutrition and agricultural measures have to be accompanied by effective extension services, credit availability for men and women, and encouragement in using inputs such as fertilizer and improved seeds. Technology combined with investment in people—especially education for men and women farmers, particularly in nutrition and health—can show high rates of return.

In some rural areas, the overriding nutritional problems are not just associated with the shortage of food but also with a lack of jobs

and income. Poor households are more likely to contain malnourished members. Women and children are often the most severely affected. Producer incentives and new technologies that increase production and employment in the agricultural sector, including the establishment of small- and medium-scale food processing facilities, can help augment incomes, alleviate poverty, and improve food security at the household level. Incorporating nutritional considerations into production policies and programs can avoid some of the negative effects sometimes associated with new technology. The health and nutrition risks of technological change must be mitigated through appropriate technology design. There is substantial scope for agricultural, public health, and nutrition workers and researchers to collaborate on improving the design of agricultural programs.

Selected agricultural interventions to improve household food security

Improvement of staple food production is necessary to ensure the sufficiency of staple foods (such as rice, sorghum, maize, etc.) throughout the year. Measures recommended are ones to improve production, such as irrigation systems, terraces, up-land farming systems, etc. Interventions in the fields of land entitlements and management of water supply for agricultural production are also included here. The introduction of improved and more productive seeds, improved soil management, encouragement of seed marketing, and the implementation of essential infrastructure may become necessary. In up-land areas, measures to improve cultivation techniques, including mixed cropping systems and improved seed varieties, could increase productivity. Promotion of food diversification to increase production of nutritious food items, with special emphasis on fat-, protein-, and micronutrient-rich foods. Examples are the increased production of *mung*, soy, and various other beans or seeds (sunflowers, sesame, peanuts), as well as various kinds of green, leafy, or yellowish-colored vegetables to increase consumption of iron and vitamin A. Products have to be selected according to the production potential of the area, the preferences of the population, and the predominant nutrition deficiencies found in the area. Specific measures can be implemented in upland as well as in lowland areas, home gardens, or village gardens. Fruit tree production is a valuable investment to improve the quality of diet in the long term.

Increase production of food from animals; animal raising programs, including the introduction of new and more productive breeds; vaccination programs; and fodder production. Raising big animals (cows, buffaloes, etc.) is mainly seen as a measure to increase household income, while raising poultry can contribute directly to food consumption within the family. Fish raising is also a valuable measure where appropriate places and water are available. However, measures to be implemented at the community and household levels are not independent from higher levels; they need political commitment, support, and structures through which the measures are implemented.

Food production in urban areas

Feeding the growing population of cities in developing countries has become a major

concern during the past decade. Food supply coming from rural areas is and, in the future, will continue to be the basis for ensuring food security in cities. But agriculture in and nearby cities has to play a very important complementary function to:

- Increase agricultural production by using available land, water, and waste resources.
- Improve the quality and quantity of food supply (more food and fresh food rich in micronutrients, introduction of home gardens, or poultry raising).
- Improve the socio-economic situation by creating jobs and income from food production, especially for poor population groups.
- Contribute to the sustainable development of urban areas and prevent food crises among large population groups.

Food quality and safety

Acceptable levels of food quality and safety can be achieved by implementing and monitoring quality assurance measures along the entire food chain. Food control measures are diverse and complex. The technical dimensions involved are different for nearly every food product, for the various technologies used in food preparation, processing, and manufacturing, and for the many types of facilities in which food is produced. The various measures range from good agricultural and veterinary practices at the farm level to good manufacturing and good hygienic practices applied in food processing. In view of the many concerns of consumers and the scope and dimensions of food quality and safety problems, technical assistance is often needed. Governments are expected to ensure that the food industry produces safe food and that the risks to human health and economic fraud or unfair trade practices are minimized (World Health Organization, 2023).

Like many developing countries, most of us do not have access to the latest information related to new technologies and may lack technically trained staff, equipment, methods, and facilities to analyze food for contaminants, toxins, chemical or drug residues, or microbiological contamination. In some countries, the legal framework related to food quality and safety needs to be revised, and the regulations governing food standards are lacking or outdated. Food control infrastructure may be weak and may not have sufficient financial support. In India, there is an urgent need for improved regulatory food inspection and laboratory services, the development of food control enforcement programs, and the administration and coordination of food control activities. As many developing countries rely on food exports for foreign exchange, we must have a particular interest in strengthening national food control systems, harmonizing national food regulations with international standards, and establishing import and export food inspection and certification systems to ensure conformity with the World Trade Organization's agreements regarding sanitary and phytosanitary measures and technical barriers to trade (Whitehead 1999, FAO, Food and Nutrition Division).

Nutrition, education, and communication

Promoting better eating habits and positive health behaviors is one of the most challenging tasks in overall efforts to improve nutrition. In addition to access to a variety of safe and affordable foods, people also need accurate information as to what constitutes a healthy diet and how to meet their nutritional needs. Besides education, strategies to promote healthy diets must include motivation and the creation of opportunities for people to change their behavior while recognizing individual preferences, lifestyles, and constraints of time and resources (FAO/WHO, 1992). Dietary guidelines give an individual the recommended dietary allowances. They are most useful to serve as the basis and provide the guiding principles for the dissemination of nutrition education messages. More recently, the central government and private organizations have issued dietary guidelines, reflecting growing concern about the prevention of diet-related non-communicable diseases.

Conclusion

In conclusion, the present paper provides a comprehensive overview of the current status of household food and nutritional security in India, examining the historical context, policy interventions, and the role of agriculture in shaping the nation's nutritional landscape. Despite substantial progress in mitigating severe undernutrition and micronutrient deficiencies, challenges such as seasonal food insecurity persist in certain regions. The paper underscores the crucial link between agriculture and food security, emphasizing the need for increased production, diversification, and efficient resource utilization. The role of women in agriculture is highlighted, drawing attention to existing gender disparities in access to assets, land, and nutrition. Recognizing that household food security is a prerequisite for nutritional well-being, the paper advocates for strategies such as nutrition-oriented agriculture, food diversification, and targeted interventions to address the unique needs of vulnerable populations. Additionally, the importance of enhancing food quality and safety measures, along with nutrition education and communication, is underscored. The conclusion emphasizes the multidimensional nature of the challenges at hand and calls for concerted efforts from policymakers, researchers, and stakeholders to forge sustainable solutions that ensure the health and well-being of the population in the dynamic landscape of food and nutrition security.

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Therapeutic properties of milk from goats (*Capra hircus*)

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Abstract

The goat (Capra aegagrus hircus) is an economically accessible animal and was the first animal to be domesticated. The ample nutritional and health benefits of goat milk are the paramount factors that drew consumers to use goat milk and milk products as functional foods. The superior digestibility of goat milk is the key factor that led to the extensive usage of goat milk as an alternative to cow milk for infants who suffer from the shortage of mother's milk. Goat milk demonstrated positive health effects, viz., immunomodulating, immunity boosting, anti-allergic, antiatherogenic, anti-carcinogenic, antimicrobial, anti-inflammatory and anti-mucousal, lactose intolerance, dengue viral fever overcoming, heart health, nutrient uptake enhancing, prebiotic supplementing and ultra-nourishing.

Keywords: Anti-allergy, Dengue viral, Goat milk, Immunity, Medicinal value, Therapeutic properties.

Introduction

The goat (*Capra aegagrus hircus*) is an economically accessible animal and was the first animal to be domesticated. Their extensive adaptability to unfavourable climatic or geographical conditions and low cost of maintenance have made them a flexible species of livestock for marginalized and landless farmers. Hence, goat milk has been suggested as an alternative source of milk for infants due to its similar composition to human milk and its improved nutraceutical properties (Kumar et al., 2016). Furthermore, factors such as amino acid composition, protein secondary structures, and the chemical properties of goat's milk significantly reduced the potential for allergic reactions compared to cow's milk (Clark and García, 2017).

Data Collection Methods

A thorough search of the existing literature was conducted using a range of scientific databases, including Biological Abstracts, CABI, Cochrane Library, Google Scholar, PubMed, Research Gate, Science Direct, Science Hub, and Scopus. The search terms used included Anti-allergy, Dengue viral, Goat milk, Immunity, Medicinal value, Therapeutic properties and others. The author also gathered relevant data from primary and secondary sources. Consequently, this review focuses on the collection on the latest information related to the therapeutic properties of milk from goats (*Capra hircus*).

Therapeutic properties of goat milk

Immunomodulating properties

The immunomodulatory properties of goat milk can be attributed to the compounds like peptides and oligosaccharides that were reported to modulate host inflammatory cytokines (Daddaoua et al., 2006). Milk can trigger innate and adaptive immune responses in the human body that can help fight inflammation (Jirillo and Magrone, 2014). Lara-Villoslada et al. (2006) stated that oligosaccharides from goat's milk reduce inflammation in the intestines of rats and aid in the healing of damaged colonic mucosa. In a live mouse model, goat milk protein blocked the NF-κB p65 and p38 MAPK signaling pathways which subsequently reduced the gene expression of different pro-inflammatory indicators. Also, goat whey increased the expression of proteins such as mucins and occludin proteins that increase gut barrier properties (Araujo et al., 2017).

Immunity boosting properties

Selenium is one of the key components of the immune system's functionality. A small amount of selenium is found in cow's milk, but a significant amount of the same is found in goat's milk. Hence, goat milk and its products act as immunity boosters and are able to protect an individual from illness.

Many types of cells are involved in the innate and adaptive immune responses, with T-lymphocytes (T-cells), Natural Killer (NK) cells, and B-lymphocytes (B-cells) as the main players. Even though immunoglobulins (Ig) have a comparable structure, slight variations within the primary immunological categories (IgG, IgM, IgA, IgD, and IgE) are linked to a range of biological characteristics, and IgG and IgA make up the bulk of serum immunoglobulins. A number of factors influence our immune health, and nutrition in particular is the main determinant of the body's immune response.

Even if goat milk might not be a perfect alternative for people with cow milk allergies, very recent studies have shown immunomodulatory effects from goat milk in both *in vitro* and human studies. Recently, researchers investigated the effects of goat milk on human blood cells in terms of nitric oxide (NO) and cytokine release. The results demonstrated that goat milk was able to activate NO release from blood cells as well as trigger cytokine production (IL-10, TNF-a, and IL-6). The release of NO may potentially have protective effects on the milk consumer's cardiovascular system and also exhibit antibacterial properties, thereby reducing the risk of infections.

Anti-allergic properties

Anti-allergic and improved digestibility characteristics Allergy to milk proteins, particularly cow's milk, is an unfavourable reaction to milk consumption that is

inherently immunomodulatory and categorized as IgE-mediated, non-IgE-mediated, or mixed (Fiocchi et al., 2010; Koletzko et al., 2012). Cow milk allergies are commonly observed during the first 3 years of human life. This is because the presence of α-S1-casein, β-casein, and β-lactoglobulin in milk leads to allergic reactions (Ruiter et al., 2006). The N and C-terminal peptides of cow's α-S1-casein (16–35 aa and 136–155 aa) have a greater affinity for IgE, while the epitopes 17–36, 39–48, 69–78, 93–102, 109–120, 123–132, 139–154, 159–174, and 173–194 were identified as IgE ligands in children (Vila et al., 2001). In contrast, studies have indicated that the utilization of goat milk has resolved between 30 and 40% of the cases (Haenlein, 2004). Haenlein (2004) reported that 40–100% of allergic patients were sensitive to cow's milk proteins and were able to tolerate goat's milk proteins. The genetic variation that exists in the proteins between the different species supports the potential usage of goat milk as a substitute for cow's milk during allergic conditions. Moreover, the consumption of goat's milk has been demonstrated to trigger natural and acquired immune reactions in the human body, while simultaneously preventing the activation of monocytes in the host caused by endotoxins (Jirillo and Magrone, 2014).

The better digestibility of goat's milk in comparison with cow's milk is related to the differences in the fatty acid (FA) composition. The smaller size of the fat globules in goat milk is one of the factors that increases its digestibility. In addition, the proportion of small-sized casein micelles is higher in goat's milk than that of cow's milk, which explains the better digestibility of goat's milk and its dairy products (Park et al., 2007). Goat milk contains a relatively lower amount of α-s casein and often has more αs2 than αs1-casein. Furthermore, the β-casein and kappa-casein are present in higher quantities in goat milk compared to cow milk, resulting in the formation of a less firm gel. This characteristic is advantageous for improved digestibility (Lad et al., 2017).

An allergy is defined as an altered or abnormal tissue reaction following exposure to a foreign antigen (McCullough, 2003). It is well known that proteins are essential for body functions like growth, development, and repair. They are the most common antigens. Infants are most commonly sensitive to proteins, with about 2–6% incidence (Lara-Villoslada et al., 2004). Some research shows that cow milk intolerance is often due to alpha-s-1 casein. It is interesting that the level of alpha-s-1 casein in goat milk is 89% lower than that of cow milk. As a result, it causes fewer allergies; goat milk has demonstrated advancements in colic, minor gastrointestinal issues, bronchial asthma, and dermatitis compared to cow milk, particularly for individuals with sensitivities to cow milk (McCullough, 2003).

Goat milk provides more immunological advantages by decreasing specific markers linked to allergic responses (Lara-Villoslada et al., 2004) in mice compared to cow milk, like the cytokine interleukin-4 (IL-4) and antigen-specific immunoglobulin G1 (IgG1), essential markers in hypersensitivity reactions. IgG1 attaches to mast cells and stimulates degranulation (the initiation of an allergic response), leading to an increase in histamine levels and subsequent allergic symptoms. This response to cow milk differed from goat milk, which did not elicit an allergic reaction. It is demonstrated that there are disparities in IgG1 (A) and

histamine (B) production when cow milk is administered compared to goat milk.

Goat milk proved its anti-allergy benefits upon drinking when a similar trial in children with cow milk protein allergies was conducted. Drinking cow milk had significantly higher levels of the inflammatory marker tumour necrosis factor-α (TNF-α) than those who consumed goat milk. TNF-α is a primary mediator of adverse reactions to cow milk protein, including gastrointestinal distress, respiratory distress, and cutaneous symptoms such as eczema. Furthermore, apart from the absence of inflammatory reactions linked to the intake of goat milk, individuals who consumed goat milk also exhibited elevated levels of the anti-inflammatory cytokine IL-10. This cytokine hinders the production of pro-inflammatory cytokines like TNF-α and is believed to play a role in immune suppression, thereby preventing responses to cow milk antigens. The findings highlight the contrasting impact of cow's milk and goat's milk on these markers of allergenicity.

Antiatherogenic properties

Goat's milk is abundant in medium-chain triglycerides (MCT), which encompass fatty acid esters of caproic, caprylic, and capric fatty acids. These MCT have demonstrated a cholesterol-lowering impact in rat models (Alferez et al., 2001) and also hinder the accumulation of cholesterol in tissues (Babayan, 2009). Consumption of goat's milk stimulates the release of nitric oxide (NO) by blood cells, which subsequently enter the bloodstream through the lymphatic pathway. This prompts vasodilation and exerts a protective effect on the heart and arteries. Additionally, goat's milk contains lower levels of xanthine oxidase, an enzyme that serves as an indicator of inflammation and contributes to heart disease (Alférez et al., 2001). Moreover, several studies have also suggested the ACE inhibitory potentiality, anti-oxidative property, and cholesterol-lowering ability of goat milk-derived peptides and fats (Ibrahim et al., 2017; Moreno-Montoro et al., 2017), therefore indicating their possible role in controlling coronary artery diseases (CVD).

Anti-carcinogenic properties

The anti-carcinogenic properties of goat milk have been studied against mammary and colon cancer in animal models as well as *in vitro* in human melanoma, colorectal, and breast cancer cells (Ceballos et al., 2009; Johansson, 2011). The mechanism by which conjugated linoleic acid (CLA) inhibits tumour development is not fully understood. Additionally, several lactic acid bacteria that are isolated from goat milk have also been reported to demonstrate anticancer effects (Mittu and Girdhar, 2015), therefore suggesting the use of goat milk-derived LAB for the preparation of fermented milk products that impart the same therapeutic properties that the bacterial strains possess.

Goat milk has a high content of conjugated linoleic acid (CLA) (Jirillo et al., 2010). Anticarcinogenic properties of CLA have been reported against mammary and colon cancer (Liew et al., 1995) in animal models, as well as *in vitro* models of human melanoma (Shultz et al., 1992), colorectal, and breast cancer. The mechanism by which CLA inhibits tumour development is not fully understood, although perturbation of the eicosanoid-dependent cell signalling systems, anti-oxidative effects, and disturbance of the receptor-mediated actions of oestrogen have all been suggested by fermented goat milk (Jirillo et al., 2010).

Antimicrobial properties

The overall inhibitory impact of milk is generally higher than the combined antimicrobial effects of immunoglobulin and other defense proteins, such as lactoferrin, lactoperoxidase, lysozyme, and other peptides. Therefore, the cooperative effect of naturally occurring proteins and peptides provides the antimicrobial effect. In this context, lactoperoxidase has been discovered to possess inhibitory activity against a wide range of pathogens, including Vibrio cholera, Salmonella typhi, Klebsiella pneumoniae, Shigella dysenteriae, and Staphylococcus aureus (Moreno-Montoro et al., 2017). Similarly, several antimicrobial peptides like isracidin and lactoferricin from goat milk have been isolated and have been effective against several disease-causing and spoilage organisms (Atanasova and Ivanova, 2010).

Anti-inflammatory and anti-mucousal properties

Cow milk may be responsible for the allergens because of its protein fractions, while goat milk is not. On the other hand, along with these, cow milk contains a higher content of fat than goat milk, which may increase mucous buildup. Goat milk does not provoke discomfort in the digestive tract because the magnitude of the fat droplets in goat milk is one-ninth the magnitude of cow milk fat droplets.

Goat milk plays a pivotal role in nearly all physiological responses and exerts antioxidant and anti-inflammatory impacts in the organism. This is significant as inflammation is the organism's main reaction to infection, and oxidation has been associated with the emergence of numerous ailments, including cancer. Furthermore, other factors, such as the maintenance of a healthy intestinal microflora with the help of probiotics and prebiotics (Also contained in goat milk), are essential for protecting against the negative effects of pathogenic infections and allergies (Shea et al., 2004).

Lactose intolerance properties

Goat milk contains a slightly lower lactose content than cow milk. Lactose intolerance is caused by a deficiency of lactase, which digests the milk sugar Lactose. In patients suffering from lactose intolerance, unhydrolyzed lactose passes to the large intestine. In the large intestine, this unhydrolyzed lactose is fermented by microbes, leading to gas formation and the release of free fatty acids, which cause gastrointestinal disturbances such as diarrhoea, abdominal pain, and flatulence (Russell et al., 2011). Anecdotal report indicates that goat milk is simple to process due to its gentler coagulation. The casein profile of goat milk allows lactose to pass through the large intestine more quickly and prevents the symptoms of lactose intolerance (Robinson, 2001). However, goat milk is not recommended for patients suffering from lactose intolerance. Along with its digestibility, it explains why patients with lactose intolerance can enjoy goat milk without any repercussions.

Haenlein (2004) stated that therapy with goat milk generally resolves 30–40% of difficult instances of childhood cow milk hypersensitivity, which may be greater in certain circumstances (One study demonstrates enhancements in 89 per cent of 55 children treated with goat milk).

The inability to metabolize lactose (essential milk sugar) leads to lactose intolerance, which is a gastrointestinal disorder. Goat milk is an alternative source for people with lactose intolerance. Although goat milk has lactose, it has been

hypothesized that the superior digestibility of goat milk relatively masks its intolerance effect (Johansson, 2011); however, it needs to be further studied. Goat milk is more thoroughly and readily assimilated than cow milk, resulting in a smaller amount of undigested waste in the colon to ferment and trigger the unpleasant symptoms of lactose intolerance (Haenlein, 2004; Aliaga, 2010).

Dengue viral fever Overcoming properties

Dengue fever is the most prevalent major health issue (viral illness) in India. *Aedes aegypti* transmits the virus to humans (Neuberger et al., 2016). Treatment of dengue fever typically involves the consumption of goat's milk and dairy products as they are abundant in selenium (Se) (13.7 ng/mL). However, the selenium (Se) content in the milk is influenced by various factors such as diet, climate, and breed (Singh and Sharma, 2016; Zhang et al., 2018). A deficiency of selenium has been linked to a decrease in platelet count, which is a crucial indicator of the onset of dengue fever. Selenium has an anticoagulant effect, while a deficiency of selenium is primarily associated with thrombotic or pro-clotting effects (Mahendru et al., 2011).

Heart health properties

Low-density lipoprotein (LDL) is an atherogenic lipoprotein that transports cholesterol from the liver to the blood vessels and is often called "The bad cholesterol". The "good" cholesterol is the high-density lipoprotein (HDL), which transports cholesterol from the vessels to the oxidative modification of LDL (ox-LDL), which plays a pivotal role in atherosclerosis progression. This implies that antioxidants, which could inhibit LDL oxidation, should be effective in suppressing atherosclerosis (Lindqvist, 2008).

Proteins in goat milk are important sources of the angiotensin-converting enzyme (ACE), antihypertensive peptides, and inhibitory peptides. They are able to control microbial infections and also provide disease defense.

Minor milk proteins include immunoglobulins, lactoferrin, transferrin, proteose peptone, ferritin, calmodulin (a calcium-binding protein), prolactin, and folate-binding proteins. Non-protein nitrogen (NPN) in human and goat milk is higher than that in cow milk. Taurine in goat milk, which is obtained from the sulfur-containing amino acid, has significant metabolic roles, just like carnitine, a vital nutrient for newborns. The mineral and vitamin content of goat milk is mostly higher than that of cow milk (Park et al., 2007).

Goat milk is better than cow milk in monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), and medium-chain triglycerides (MCT). These are beneficial for cardiovascular conditions. Along with these, goat milk has a lower level of cholesterol than cow milk (Haenlein, 2004). Because of the balanced fatty acid profile of goat milk, it helps prevent atherosclerosis, heart attacks, strokes, and other heart complications. The high potassium content of goat milk reduces blood pressure.

Goat milk demonstrates a hypocholesterolemic impact. The consumption of goat milk decreases plasma triglycerides and therefore has a beneficial influence on lipid metabolism (Lopez-Aliaga et al., 2005). Goat milk is said to lower the overall cholesterol level and

maintain sufficient triglycerides and transaminases (glutamate oxaloacetate transaminase (GOT) and glutamate pyruvate transaminase (GPT)—markers for liver poisoning). This renders goat milk valuable in managing and preventing coronary heart diseases (CHDs).

Nutrient uptake enhancing properties

As the chemical composition of goat milk is much closer to that of human milk, it easily assimilates into the body. Therefore, it enhances the bioavailability of the nutrients present in it. The authors reported that goat milk consumption increases the uptake of Iron and Copper in the digestive tract.

Prebiotic supplementing properties

Goat milk has the same high level of oligosaccharides as human milk and cow milk. It is well known that these act as prebiotics in the gut and improve the health of the digestive tract (Raynal-Ljutovac et al., 2008). They are responsible for the beneficial bacteria, i.e., *Bifidobacteria*, in the intestine. *Bifidobacteria* exert a wide range of health benefits, including immune stimulation, prevention of pathogenic infections, anticarcinogenic activity, and cholesterol-lowering activity, in addition to improving lactose maldigestion (Russell et al., 2011).

Ultra-nourishing properties

The goats are recognized as bioorganic sodium animals, while cows are referred to as calcium animals in naturopathic medicine, Bioorganic sodium is a crucial element in maintaining mobile and flexible joints. Goat milk provides 35% of the calcium that we need in a cup. Additionally, just one cup of goat milk can fulfill up to 20% of our daily riboflavin requirements. Along with phosphorous, goat milk also contains high levels of potassium and Vitamin B_{12}.

Goat milk enhances the availability of Zn, a mineral with antioxidant capacity (Zago and Oteiza, 2001). The improved nutritive utilization of goat milk fat (Alferez et al., 2001) results in a lower substrate for lipid peroxidation, which in turn reduces the production of free radicals in this type of milk. This explains why the group of animals consuming goat milk had lower levels of TBARS. The habitual consumption of goat milk, even during Fe-overloading feeding regimes, may positively impact genomic stability, possibly due to the high availability of Mg and Zn (Diaz-Castro et al., 2009), as well as its superior fat quality (Alferez et al., 2001). Magnesium metabolism plays a role in enhancing genomic stability through the following mechanisms: DNA is constantly damaged by external mutagens and internal processes. To keep mutation frequencies low, cells have developed various DNA repair systems. Nucleotide excision repair is primarily responsible for removing DNA damage caused by external mutagens, and Mg is an essential cofactor in all steps of this repair process. Additionally, endogenous DNA damage is mainly repaired through base excision repair (BER) (Hartwig, 2001).

Conclusion

The ample nutritional and health benefits of goat milk are the paramount factors that drew consumers to use goat milk and milk products as functional foods. The composition of goat milk does not reveal greater variations as compared to cow milk, whereas it shares few similarities with human milk composition. Besides, the superior digestibility of goat milk is the key factor that led to the extensive usage of goat milk as an alternative to cow milk for

infants who suffer from the shortage of mother's milk. In addition, several studies conducted on in vitro and in vivo animal models have demonstrated positive health effects, viz., anticancer, anti-inflammatory, antiatherogenic, anti-allergenic, and so on. According to the reviewed literature, goat milk has the potential to act as nutraceuticals in combination with conventional medical treatment. However, further clinical trials are needed to explain their therapeutic benefits.

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The vital role of growth hormone in control of the COVID-19 pandemic era

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Abstract

The COVID-19 pandemic is a worldwide pandemic challenge that started in China and spread to almost all countries. The causative virus was identified as highly contagious and, until now, significantly difficult to contain. Global epidemiological distribution has raised several questions whose answers could help us understand the behavior of the virus and consequently lead us to possible means of limiting its spread. Growth hormone (GH) secretion declines by approximately 15% for every decade of adult life in people after 30 years of age. Data from highly affected rural areas suggest a more aggressive course in the elderly, a double-time affection of males more than females. The deficiency of GH is a common sign in all susceptible patient groups. The role of GH in the exclusive epidemiological outline of the COVID-19 pandemic is vital so that it might help in the early identification and management of high-risk rural groups as appropriate.

Keywords: Coronavirus, COVID-19, Diabetes Mellitus, Growth Hormone, Hypertension, Respiratory Disease, Rural Health.

Introduction

COVID-19 originated in China as a result of a novel Corona RNA virus in December 2019 (Dong *et al*. 2020). The disease is a severe acute respiratory syndrome (SARS) caused by a betacoronavirus called SARS-CoV-2, which affects the lower respiratory tract and manifests as pneumonia in humans (Peng *et al.*, 2020; WHO, 2020c). Despite rigorous global efforts to elaborate preventive measures, the infection caused by COVID-19 continued to increase in many countries around the world (WHO, 2020a; WHO, 2020b). In the early months of 2020, there was a rapid global

expansion of the coronavirus disease COVID-19. On March 11, 2020, the World Health Organization (WHO) declared a worldwide pandemic (Funatsu *et al*. 2006). To reduce transmission through respiratory droplets, most countries imposed social distancing and lockdowns**.** Millions of Indians residing in rural areas bear an increasing burden from the COVID-19 pandemic, caused by viral transmission and death rates outpacing those of rural and urban communities. Kumar *et al*. (2020) argues for the need to take immediate steps to control the spread and its aftereffects and to use this opportunity to strengthen and improve the primary health care system in rural India.

Growth hormone is a small protein molecule that contains 191 amino acids in a single chain and has a molecular weight of 22,000 (Khudaiberdiev, 2022). Also called somatotropic hormone or somatotropin**, i**t causes the growth of all the tissues of the body that are capable of growing. It indorsed increased sizes of the cells and increased mitosis, with the development of greater numbers of cells and specific differences of cells, for example, bone growth cells. Genetics and nutrition are the two most important factors; however, growth promoters can enhance the competence of the human body.

Growth hormones provide numerous functions for healthy body performance, including enhancing production and productivity. They energize skeletal growth, and protein anabolism in many tissues increased protein synthesis and decreased the oxidation of proteins. Also, enhance the availability of fat by stimulating the breaking down of triglycerides and maintaining blood glucose within the normal range. For this reason, the development of human GH has had good effects on society (Paramasivam *et al.,* 2022). GH is primarily responding to body weight, fat formation, and feed conversion (Mo *et al.,* 2022).

The socioeconomic impact of the COVID-19 pandemic increased the thirst for a solution that allows the safe facilitation of restrictive health measures. Largely, most of the crucial efforts exerted by research are directed toward creating a proper vaccination or efficient medical treatment for the virus. However, preventive measures based on understanding the epidemiology of the disease can also be important in attenuating its spread (Rajkovic *et al.,* 1994).

This article reviews the role of growth hormones during COVID-19 disease. Elkarow and Hamdy (2020) reported that the results were dependent on the updated epidemiological observations of the COVID-19 pandemic and the identified levels of growth hormone (GH) in different risk factors of the patients, as well as the outcome of GH on the immune system.

Why elderly people are at a higher risk?

The World Health Organization (WHO) reported that the disease affected elderly people much more than young people and children. The observed pattern was not common in most infectious diseases, which normally affected those age groups who were supposed to be still in the stage of building up their immunity. For many communicable diseases, young adults and children are at higher risk, for instance, in the pandemic in recent history. During the Spanish flu pandemic in 1918, children and young adults were at the highest risk (Reid, 2005). In contrast, the Chinese Center for Disease Control and Prevention reports that children under 19 years of age

constitute 2% of the total number (72,314) of COVID-19 patients recorded by February 20, 2020. A small percentage of patients aged under 19 years have suffered severe (2.5%) (WHO, 2020). Instead of this, the severity and case fatality of COVID-19 progressively increased with the advancement in age. The increase in severity with age has been reflected in the case reports in the groups of 50–60 years mean age (Verity *et al*., 2020). There is probably a lacking factor in the older patient, which makes them more vulnerable to the disease severity. Growth hormone (GH) levels decline in the serum as humans age. After the 3rd decade of life, there is a progressive decline of GH secretion by approximately 15% for every decade of adult life. Combined measurements of daily GH secretion demonstrate that secretion peaks at puberty at about 150 μg/kg/day and then decreases to approx. 25 μg/kg/day by age 55 (Merriam and Hersch, 2008). The pediatric age group usually exhibits atypical clinical manifestations of COVID-19, which are mainly mild compared with those of adult patients (Gotzinger *et al*. 2020; Mehta *et al*. 2020), and the occurrence of pediatric severe and life-threatening forms is very deficient (Leger *et al*. 1996). Children with comorbidities, including chronic kidney and lung disease, diabetes, obesity, malignancy, immune disorders, heart disease, and congenital malformations, are more likely to suffer from the severe form of COVID-19 (Gotzinger *et al*., 2020). Fascinatingly, infants (less than 12 months) exhibited a more severe form of the disease than other pediatric age groups. GH levels were recorded high in the mid-term fetus and at birth and then started to decline in the first weeks and more slowly over the next few months, reaching prepubertal levels by around the age of 6 months (Leger *et al*. 1996). Current records suggest that children could get infected but were less symptomatic with low-case fatalities. The real incidence of infection in children may be disclosed through large screening studies involving serological tests. Regulation of the GH/IGF-I axis depends on the integrity of the hypothalamus, pituitary, and liver. During aging, the leading factor that contributes to the decline of GH/IGF-I includes changes in the somatotrophs from growth hormone-releasing hormone (GHRH) and somatostatin (SS). Other vital factors, such as body composition, exercise, diet, and sleep, played a significant role in the age-related weakening of the GH level. Phenotypic comparisons between aging and adult growth hormone deficiency syndrome combined with this decrease in GH/IGF-I with aging have raised the question of whether aging is a GH-deficient state (Sherlock and Toogood, 2007). It was worth observing that the reported curve of COVID-19 morbidity and mortality equaled well the pattern of decline of GH levels throughout the life of human subjects.

Potential risk factors for the severity of covid-19 illness

COVID- 19 disease severity and mortality were reported to increase with a few risk factors, such as morbid obesity, hypertension, diabetes, respiratory disorders, excessive alcohol intake, and chronic liver and kidney disease (Gupta *et al*. 2020).

Morbid Obesity

Morbid obesity occurs when the body mass index (BMI) exceeds 35. It constitutes a risk factor for SARS-CoV-2 severity, which requires intensive attention to preventive measures in susceptible individuals (Simonnet *et al*. 2020). In

morbid obesity, there is markedly decreased GH secretion. Furthermore, for both adults and children, the greater the BMI, the lower the GH response to provocative stimuli (Alvarez *et al*. 2002). In obesity, both the spontaneous and stimulated pulsatile patterns of GH secretion controlled by the hypothalamus are blunted. The accumulation of truncal obesity and particularly visceral adipose tissue mass were found to be a stronger negative determinant of GH secretion compared to other factors, such as age, sex, or generalized obesity (Vahl *et al.,* 1996; Clasey *et al.,* 2001). The deficiency of GH effectively heightened insulin resistance and visceral obesity by increasing cortisol production in key target tissues, including the liver and adipose tissue (Stewart *et al*. 2001).

The corticosteroid hormone action has been determined in the peripheral tissues through the activity of 11-beta-hydroxysteroid dehydrogenases (11-beta-HSD). Two isozymes of 11 beta-HSD interconvert hormonally active cortisol (F) and inactive cortisone (E). 11beta-HSD type 1 principally activated F from E in the liver and adipose tissues, while 11beta-HSD type 2 inactivated F from E in the kidney and placental tissues. GH acting via IGF-1 inhibits 11beta-HSD1, resulting in a shift in cortisol metabolism favoring cortisone production (Gelding *et al*. 1998). Patients with truncal obesity but without evidence of hypopituitarism had a relative GH deficiency, which excited the low-dose of GH treatment in this group by obstructing cortisol generation within omentum fat, which could offer an effective therapeutic approach (Stewart *et al*. 2001).

Diabetes Mellitus

Diabetes mellitus (DM) is associated with enhanced severity and mortality of COVID-19 (Huang *et al*. 2020). Although GH excess, such as in patients with acromegaly, predisposes to diabetes, studies report that there is a significantly increased prevalence of DM in adult GHD patients compared with the general population (Abs *et al*. 2013), particularly in those with additional risk factors, such as a family history of diabetes mellitus. The association between GHD and diabetes can be largely described by adverse body compositions in patients with GHD. Increased abdominal obesity seen in GHD patients is likely a contributor to the decreased insulin sensitivity observed in some patients (Allen *et al.,* 2016; Feldt-Rasmussen *et al.,* 2000). GH is an important regulator of glucose levels, and adult patients with GHD are reported to have impaired glucose metabolism, insulin resistance, and fasting hyperglycemia (Giovannini *et al.,* 2015; Kim and Park, 2017).

Hypertension

Hypertension is another risk factor for COVID-19 disease. Patients with raised blood pressure were found to have a 2-fold increased risk of death from COVID-19 compared to normotensive patients (Chao *et al*. 2020). Adult GHD, cardiovascular and cerebrovascular morbidity, and mortality are higher, and this increased risk can be largely attributed to hypertension (Daniel and Merriam, 2012). The beneficial effect of GH on cardiovascular risk factors in a patient with hypopituitarism may be an indirect effect via an alteration in cortisol metabolism (Stewart *et al*. 2001). Studies have described a close relationship between the GH/IGF-1 axis and the renin-angiotensin-aldosterone axis (RAS). GH stimulates RAS, as demonstrated by increasing levels

of angiotensinogen, aldosterone, and plasma renin activity in humans (Ho and Weissberger, 1990). Angiotensin-Converting Enzyme 2 (ACE2), a cell membrane receptor in different target tissues, including the lung, catalyzed angiotensin II conversion to angiotensin-(1–7). The ACE2/angiotensin-(1–7)/MAS axis counteracts the negative effects of the RAS, thus playing an important role in maintaining the physiological and pathophysiological balance of the body (Santos *et al*. 2018). However, up-regulation of the ACE2/Angiotensin-(1-7)/Mas receptor axis had been recorded in the heart and kidney of growth hormone receptor knock-out mice. On the other side, down-regulation of the ACE2/angiotensin-(1-7)/MAS receptor axis had been recorded in the heart and kidney of transgenic mice overexpressing growth hormone (Muñoz *et al.,* 2014). SARS-CoV-2 entered host cells via the ACE2 receptor, which was expressed in various human organs, and the spike glycoprotein of SARS-CoV-2, which bonded to ACE2, represented a potential target for developing specific drugs and vaccines. Besides the direct viral effects and inflammatory reactions associated with COVID-19 pathogenesis, ACE2 down-regulation that follows COVID-19 infection and the consequent imbalance between the RAS and ACE2/angiotensin-(1–7)/MAS may also contribute to multiple organ injury in COVID-19 (Ni *et al*., 2020). Whether adult GHD leads to overexpression of ACE-2 in vivo is not yet established by clinical studies.

Respiratory Disease

It is reported that GH levels and response to GHRH are decreased in patients with bronchial asthma. Low levels of the hormone are associated with corticosteroid and salbutamol-treated asthmatic patients (Lanfranco et al. 2010). The obese patients with obstructive sleep apnea syndrome (OSAS) validate a peculiar reduction of both spontaneous and stimulated GH secretion coupled with reduced IGF-I levels. Endocrine abnormalities are more marked than those observed in the non-apneic obese subject and are likely to be due to the effect of hypoxia and sleep fragmentation on hormone secretory patterns. GH/IGF-I axis activity interruption causes metabolic alterations, which are not only common in OSAS but also increase the risk of cardiovascular issues and mortality. The serum levels of IGF-1 are significantly lower in patients with acute exacerbations of COPD (AECOPD) than in other COPD patients and then increase relatively at the time of recovery (Corbo *et al.,* 2014.; Kythreotis *et al.,* 2009). However, serum levels of IGF-1 at admission and discharge of AECOPD patients in hospitals are lower compared to those of healthy subjects. Furthermore, emphysematous patients appear to have significantly lower IGF-1 levels than those with chronic bronchitis, both on admission and at discharge (Ottesen *et al*. 2001).

Endocrine and neuroendocrine hormone systems are influenced by the immune system (Tong et al., 2022). GH has an important role in the development of the immune system and causes enhanced growth of the thymus gland. GH improves thymic functions, including thymocyte proliferation and migration, placing this molecule as a potential therapeutic adjuvant in immunodeficiency conditions associated with thymocyte decrease and loss of peripheral T cells (Savino et al. 2002). This gland is responsible for the production of immune cells called T cells, the mediators of cell-mediated immunity. GH is also produced by lymphoid organs (Salehzadeh et al., 2022), for example, the thymus, spleen, and immune cells. Clinical

studies have suggested significant activities of GH in immune regulation, and the GH receptor is expressed in different sub-populations of lymphocytes. GH stimulates the proliferation of T and B cells and immunoglobulin formation. Thus, it enhances the maturation of myeloid progenitor cells and becomes able to modulate cytokine responses. Lower circulating levels of IGF1 are linked with the incidence and mortality of adult respiratory distress syndrome (ARDS) in patients. These results support the activity of the IGF pathway in ARDS. Having an immune-regulatory effect in addition to their anabolic effects, GH and IGF-1 may act to protect the host from lethal bacterial infection as well. Hormones promote the maturation of myeloid cells, stimulate phagocyte migration, prime phagocytes for the production of superoxide anions and cytokines, and enhance opsonic activity.

Conclusion

The current pandemic highlights some characteristic distribution of the severity of the disease COVID-19 that seems to be matched with a comparative deficiency or resistance of growth hormone in some groups of patients. Spread the knowledge to the medical practitioner so that it may add to the effort to understand and consequently overcome the pandemic. There is a further need to study the role of GH in the exclusive epidemiological outlines of the COVID-19 pandemic so that it can help in the early detection and management of high-risk groups. The randomized controlled trial would help to clarify the possible prophylactic role of growth hormone supplements in those groups of patients to reduce immunity and decrease the severity and/or mortality of COVID-19 until an efficient vaccine is available on the market not only in the country but worldwide.

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For whole books Author(s), year. Title. (Ed.). Edition if any, Number of pages. Publisher, address.

Snedecor G W and Cochran W G. 1994. Statistical Methods, 6th edn, 491p. Iowa State University Press, Ames.

For chapters from books Author(s), year. Title. book title, editors (editors), Publisher, address. Page-page.

Clark J A and McArthur A J. 1994. Thermal Exchanges. Livestock Housing.1edn, pp. 97-122. (Eds) Wathes C M and Charles D R. CAB INTERNATIONAL, Wallingford, UK. For Symposium Devegowda G, Raju M V L N, Afzali N and Swamy H V L N. 1998. Mycotoxin picture world-wide: Novel solutions for their counteraction. Proceedings of 14th Alltech's Annual Symposium on Biotechnology in the Feed Industry. pp. 241-55. 5 May 1997. Bangalore.

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Articles	Yes	Yes	Yes
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