Exploring versatility of whey protein in pharmaceutical and allied sciences

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Abstract :-

The pharmaceutical industry has shown a great deal of interest in whey protein, a byproduct of cheese production, because of its many possible uses. This abstract gives an overall review of whey protein's use in pharmaceuticals, emphasizing its benefits, drawbacks, and recent research developments. Biocompatibility, high nutritional value, functional qualities, and health-promoting bioactive peptides are just a few of the many benefits that come with whey protein.
Nutraceuticals, scaffolds for tissue engineering, drug delivery systems, and functional meals are just a few of the pharmaceutical formulations that use it. But there are drawbacks to whey protein as well, such as allergenicity, flavor/taste problems, price, solubility/stability issues, and regulatory complications. Nevertheless, research is still being conducted to investigate potential pharmacological uses of whey protein, such as drug delivery, tissue regeneration, immunomodulation, and anti-infective therapy. Overall whey protein is promising alternative to existing pharmaceutical excipients due to its versatility, biocompatibility, stability and safety properties.

Key words:-

Whey protein, biocompatibility; solubility; stability; immunomulation; anti-infective; innovative pharmaceuticals.

Introduction :-

Whey is a byproduct of producing casein (6%), which is produced in excess of 96% of cheese. Acidic (acid action) or sweet (enzyme action) whey is made using the casein coagulation technique. Typically, 80–90 L of whey are produced for every 100 L of milk used in the cheese-making process. The typical yield from 10 L of milk is 1 kilogram of cheese (the remaining 9 L being whey), depending on the type of cheese (e.g., semi-hard or hard). Therefore, it is clear that huge cheese operations can produce up to several million liters of whey every day. Global whey production is expected to be around 160 million tons annually, nine times the amount of cheese produced, and it is growing at a pace of one to two percent per year [1].
Thirty percent of whey is still used as pig feed, applied as fertilizer to agricultural land, or even poured into rivers or the ocean [2]. The remaining seventy percent of whey is processed into various products. Due to its high chemical oxygen demand (COD) of over 60,000 parts per million and high biochemical oxygen demand (BOD) of 35,0000 parts per million, whey is regarded as one of the most polluting foods by co-product streams [3][4].

These are organic byproducts of the cheese-making process. Approximately 3.5% of the protein in cow's milk is made up of collagen, with whey proteins making up the other 20%. When casein is extracted from whole milk during the cheese-making process, whey—which comprises lactose, proteins, and lipids—remains. Thanks to developments in processing technology, liquid whey may now be used to produce a variety of products with differing protein concentrations on an industrial scale.

Whey, commonly known as cheese serum, is the yellow-green liquid part of milk that is formed after the coagulation of milk using proteolytic enzymes or acids, following the separation of the curd [6]. For decades, the disposal of this material was deemed problematic due to its high biological oxygen requirement and high organic matter content.7

Today, nevertheless, whey proteins are used for their bioactive components and acknowledged as a possible nutritional source. Its high nutritional content makes it useful for a variety of commercial food products and has a strong connection to the dairy sector. Fresh liquid whey used to make cheese is typically made up of 94.2%

water and 50% total solids, of which 0.8% are whey proteins, 0.5% are minerals, 0.1% are fat, and 4.3% are lactose, the primary ingredient.8

Compositions:

Milk is a complex osphate groups to serine residues. Phosphate groups are crucial to the casein micelle's structure.meal that is rich in various bioactive molecular species. The mammary glands generate it to protect and feed the young mammals. In addition to providing vital nutrients, milk also contains growth factors, hormones, and modulators that can affect how the gastrointestinal tract develops and grows (Table 1). [9, 10].

Components	Composition	Practical attributes	Reference
Powdered Sweet whey	14.5% - 11.0% protein Lactose: 63.0 - 75.0 percent Fat: 1.0% to 1.5% Ash: 8.2% to 8.8% Moisture range: 3.5% to 5%	Minimal source of protein Dairy solids and flavour Solubility Dispersible	[47]
Powder Acid whey	11.0% to 13.5% protein 61.0% to 70.0% lactose Fat: 0.5% to 1.5% Ash: 9.8% to 12.3% Moisture range: 3.5% to 5%	Low protein source Dairy flavour and solids Solubility dispersible	
Whey protein concentrate (34%)	From 34.0% to 36.0% protein Sugar: 48.0% to 52.0% 3.0% to 4.5% fat 6.5% to 8% of the total is ash. Moisture range: 3.0% to 4.5%	source of protein Emulsification The ability to dissolve gentle dairy taste Development of color and taste	
Whey protein concentrate (80%)	80.0 - 82.0 % protein 4.0% - 8.0 percent lactose Fat: 4.0% to 8.0% Ash: 3.0% to 4% Wetness: 3.5% to 4.5%	abundant source of protein Emulsification whipped fat-binding The ability to dissolve Warming up or gelling Water-binding	
Whey protein isolate	90.0 - 92.0 % protein Lactose: 0.5–1.0 percent Fat: 0.5% to 1.0% Ash: 2.0% to 3.0% 4.5% of moisture	High solubility source of protein	

Table: 1 Typical Whey Product Composition and Their Functional Characteristics.

CASEINS :-

Approximately 80% of milk proteins are caseins. Casein and casein, as well as s1 and 2-caseins, are the main casein fractions. Every protein is conjugated, and the majority of them have esterified phosphate groups to serine residues. Phosphate groups are crucial to the casein micelle's structure. Caseins are unique in that they are poorly soluble at pH 4.6.
The protein bends specifically because of the huge quantity of proline residues. chain and prevents the development of secondary structures that are densely packed and organized. The casein micelle is a colloidal particle that contains the majority of the casein proteins. To facilitate more effective nutrition, casein micelles form a clot in the stomach and contain substantial amounts of very insoluble CaP[11].

2. Concentrates, Isolates, and Hydrolysates of Whey Protein:

There is one content are needed globally because of the expanding popularity of healthy eating [12]. A sedentary individual should consume 0.8 g of protein per kilogram of body weight each day (g/kg/day) on average [13].

This much protein is needed to keep the body's nitrogen balance positive and its metabolism operating normally. Supplemental proteins come in a variety of forms, including whey, egg, soy, hemp, and casein. Milk whey is one of the best sources of easily assimilated amino acids since it has the highest concentration of these amino acids, which are also easily available [14].

Additionally, milk whey proteins are acknowledged as beneficial components due to their numerous benefits linked to their consistent consumption, such as regulating appetite, facilitating satiety, and aiding in the recovery from exercise [15].

3. Whey Proteins' Biological Characteristics Linked to Bioactive Peptides:

Whey proteins' biological properties are well recognized and utilized. more and more by a variety of businesses in food applications and scientific research projects. 50% of whey protein is consist of eight of lactoglobulins , which facilitate the attachment of minerals including Zinc and calcium. It also has some sequence similarity with proteins that bind to vitamin R. In contrast, however, it is highly recommended that foods or infant formula contain lactalbumin in order to promote diets high in protein [16].

Biological properties of whey protein derivatives :

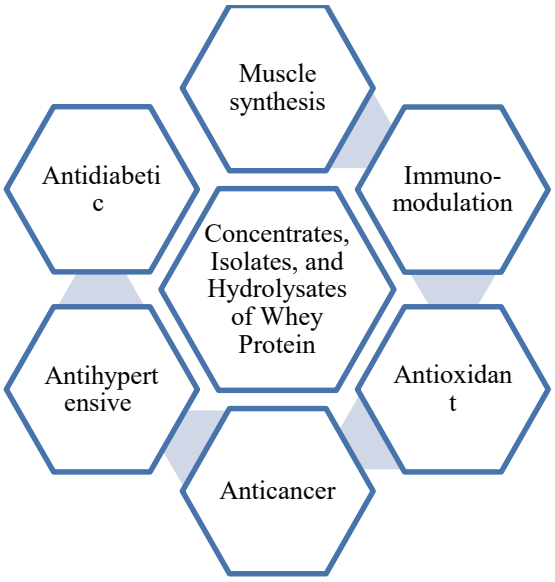

Fig. 1 Biological properties of the whey protein derivatives

Whey protein applications include:

1) hydrolysis of whey proteins by enzymes : Enzymatic hydrolysis is a typical technique iof peptides using a variety of enzymes. Most proteases are the most commonly utilized and they can either be non-specific or selective to the target protein. Food makers prefer to use enzymes for the hydrolysis of whey proteins because of the enzymes' precise site of action, quick reaction times, and abundance of sources (plant, animal, Bromelain chymotrypsin, pepsin, and trypsin are the most often. are the most commonly utilized enzymes, and each has unique reaction conditions (temperature, pH, and time) Biological properties of the whey protein derivatives mention in Fig,1 . [17,18].

2) The Bioactive Peptides' Antioxidant Properties:

Numerous conditions, including diabetes, cancer, cystic fibrosis, atherosclerosis, aging, and a host of other degenerative diseases, can be brought on by oxidative stress in the body. The precursor of the antioxidant glutathione, whey protein, demonstrates antioxidant activity by mitigating the negative consequences of stressors.

Bioactive peptides derived from whey proteins have been demonstrated to increase intracellular glutathione levels and decrease the production of the in vitro interleukin IL-8, a cytokine that plays a role in respiratory tract pathophysiology [19].
Patients with cystic fibrosis showed a decrease in the blood level of C-reactive protein when compressed whey (20 g/day) was supplemented for a month [20].

3) The Bioactive Peptides' Antihypertensive Effect:

The reninangiotensin system is closely linked to the bioactive peptides from whey protein concentrates, isolates, and hydrolysates that have angiotensin-converting enzyme (ACE) inhibitory or antihypertensive activity. For this reason, eating foods high in antihypertensive peptides on a regular basis can help lower blood pressure and avoid cardiovascular diseases. [21].

4) The bioactive peptides' antidiabetic properties

One of the most important medical conditions that causes a number of problems, including angiopathy, eyesight loss, and blood flow restriction, which results in tissue hypoxia and ulcers that heal less quickly, is diabetes [22].

The Bioactive Peptides' Anticancer Properties:

Numerous studies have demonstrated the positive the effects of protein whey intake on cancer patients. whey protein According to a study, compared to rats in the control group fed unhydrolyzed whey protein, rats with colon cancer showed a decrease in the appearance of both macroscopic and microscopic tumors when administered whey protein hydrolysate [23].

The Purpose and Features of Whey Protein:

Whey Protein Denaturation by Heat Composition and processing parameters have a big impact on food's thermal processing. While the lactose and protein content are compositional elements, the processing parameters include The temperature, pH, ionic strength, and pace of processing are among the heating. Foods containing whey proteins that are heated to a low temperature (40 °C) cause blactoglobulin to become denaturated; higher temperatures (50 °C to 60 °C) cause the thiol group to unfold and become exposed [24].

i) Hydration and Whey Protein Solubility:

The hydration qualities of whey proteins are influenced by a number of physical and chemical factors. Complete protein Particle aggregation state, size, shape, and porosity surface net charge is one of the chemical parameters, and protein type are examples of physical parameters. Both hydrophlicity and hydrophobicity [25] .
can be optimized through the use of hydration properties [26]. For instance, the best results in terms of enhancing the hydration qualities are achieved from whey protein powders that are produced by carefully regulating spray drying conditions to generate 200–150 u.m. particle sizes. [27].

ii) Whey Proteins' Capacity to Gel:

Proteins found in whey can produce gels with a variety of characteristics, from smooth, soft curds to viscous, rubbery, and rigid gels. Hardness, cohesiveness, color, stickiness, and mouthfeel are among the characteristics that differentiate them [28].
The form of decreasing syneresis as a result. During food applications, the gel's shape, color, mechanical strength, and elastic qualities are all crucial. Aggregates are formed when heat-treated whey proteins change their structure beyond a certain temperature. When these aggregates cool, they solidify into transparent to opaque, viscous gels that range from soft to stiff. The kind of protein, concentration, temperature, pH, and calcium all affect how gels form [29]].
Heat-induced gels are created in two stages: first, a structural network is established when the heat-exposed protein changes shape through interactions between proteins and the unfolding of polypeptide segments [30].

iii) Whey proteins' emulsification property:

Emulsions, which are diverse systems formed by dividing a phase or phases into continuous phase, which can be stabilized by including molecules that are attracted to surfaces. attraction for both the dispersed and dispersed/continuous phases, a property known as amphiphilicity. Emulsifier addition is primarily done to lower

interfacial tension and promote dispersed phase diffusion. An interfacial membrane surrounds the oil droplet in emulsion systems supported with proteins in order to prevent coalescence, flocculation, creaming, or oiling off [31].

Whey protein isolates and their derivatives:

The impact of adding a mixture of high-methoxyl pectin and non-heat-treated whey protein to low-fat yogurt was documented in a study [32].
The yogurt benefited from the whey protein's ability to substitute fat and give it texture. Another study demonstrated how adding whey proteins to whole-fat yogurt made from skim milk powder stabilizes emulsions and enhances overall smoothness. High molecular weight whey protein aggregates and decreased ability to emulsify were produced when the droplet merger was employed; yet, a more stable emulsion was produced when the mixture was run via a homogenizer operating at high pressure (20–100 MPa).[33].

Benefits of Combining Whey Proteins and Derivatives with Other Supplements:

Additionally, the usage of whey proteins could be limited since certain of its ingredients, including, such a-lactalbumin and lactoglobulin have been have been linked to pecially in young children. There are reports of some kids developing stomach issues. connected to triggering allergies, especially in young people. It has been seen that some kids experience respiratory allergies [34].

Whey proteins and derivatives:

their function as coating materials and encapsulating agents - Consumers are searching for natural, nutrient-rich ingredients in their foods and beverages as they grow more health-conscious [35].
As a result of the recent emergence of bioactive compounds as functional ingredients, novel formulations and value-added meals have been produced. Examples of these include minerals, lipids, taste and aroma components, minerals and ions, antioxidants, lycopene, and [36].
. In order to overcome these obstacles and take into account the growing market demand for unique ingredients with added value in food, food manufacturers began putting the procedure into practice [37].

WHEY PROTEINS AND PEPTIDES: A THERAPEUTIC APPLICATION:

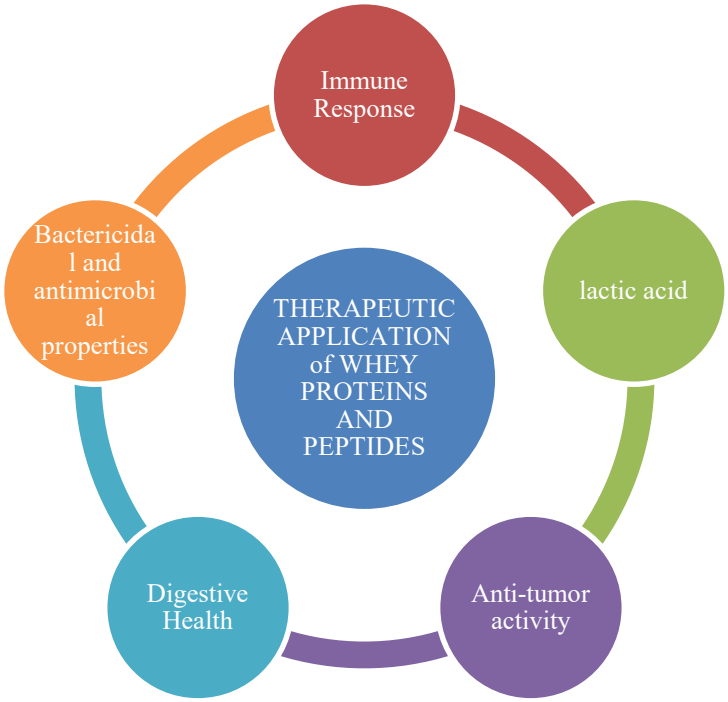

Fig.2 Whey proteins and peptides: a therapeutic application

the polypeptide chain of the intact whey protein, the bioactive peptide sequences are dormant. By stimulating hormone production, peptides generated during the intestinal digestion of whey proteins may have a role in regulating both postprandial metabolism and nutrient entry. The synthesis of bioactive proteins during fermentation can further contribute to the therapeutic advantages of whey proteins Whey proteins and peptides: a therapeutic application mention in fig.2. [38].

i) Immune Response:

A key component of the body's defenses against bacterial, viral, fungal, and parasitic illnesses is the immune system. as well as several cancer types [39].

ii) lactic acid:

Whey protein has strong lactoferrin and metal-binding properties. Because lactoferrin binds iron that would otherwise accelerate oxidative processes, it serves as a mechanism of both Free iron scavenging and iron supply[40]. Against both, lactoferrin exothermic bacteriostatic and bacteriocidal activity. Bacteria that are gram-positive and gram-negative [41]. One of lactoferrin's antibacterial mechanisms of action is its binding to the lipopolysaccharides of gram-negative bacteria. It has also been reported that fungicidal action, specifically against species of Candida, exists [42].

iii) Anti-tumor activity:

Numerous reports, investigations, and trials have been conducted on nutrition to determine the anticancer characteristics of foods [43].It is generally accepted that diets low in total and saturated fats and high in grains, fresh fruit, fiber, and green vegetables are good for you. There has been comparatively little focus on bovine milk. According to epidemiological research, those who drink milk have a lower risk of colon and rectal cancer than people who don't [44]..

iv) Digestive Health:
Bioactive compounds included in whey have the power to improve intestinal health. Whey components have four advantageous impacts on intestinal health modification: prebiotic effects, antibacterial and antiviral properties, anticancer characteristics, and immune-stimulating actions [45].

V) Bactericidal and antimicrobial properties:

The most well-known whey component with antibacterial activity in the digestive tract is immunoglobulin. They make about one percent of the total weight of whey proteins and are mostly found in sources produced from milk. It has been demonstrated that IgG binds the toxin that Clostridium difficile produces, lessening the harmful effects of infection [46].

Conclusion:

The perception of whey and its application has evolved throughout time from that of a byproduct to that of a valuable raw resource. Governments have been forced by environmental concerns to enact laws governing the disposal of whey. Consequently, scientific advances have led to the development of various technologies that enable the conversion of what was once considered "waste" from the production of cheese into a valuable and affordable raw material used to make a variety of goods and components for the food sector.
Antioxidant action, immune modulation, passive immunity, and anti-carcinogenic effects.Disease prevention, toxin binding, cell growth stimulation, antibacterial, antimicrobial, and antiviral properties, platelet binding, anti-inflammatory, and hypotensive effects are just a few of the biological functions that whey and its constituents are involved .

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