Harmful Effects of Adulterated Whey Protein Supplement

Siddhant Lashkar

CHAPTER 1

Introduction: -

Whey protein (WP), a critical component of milk proteins, has received great attention for its so-called contribution to muscle building and body weight regulation. Despite the increased popularity, consumption of WP has raised concerns about potential health effects, which this review is intended to explore. The properties of WP may vary based on various reasons like casein precipitation method, storage temperature, heat treatment, and other factors. WP is usually subjected to several processing methods, such as ultra and/or microfiltration or ion exchange, to produce WP isolate (90–95% protein, negligible fat, lactose, and minerals), hydrolyzed WP for improved absorption and lower antigenic reactions, and WP concentrate (protein content 20%–85%, along with variable levels of fat, lactose, and minerals). There is a complete analysis of the composition and concentrations of WP. WP is a good source of critical amino acids (AAs), which is rich in both sulfur-containing and branched-chain Aas the comprehensive breakdown of major components in WP, including Beta-Lactoglobulin, Alpha-Lactalbumin, and different Immunoglobulins, highlighting their possible concentrations. **Ghafoori Z., Tehrani T., Pont L., Benavente F.**

Protein powders, along with those that include herbal and nutritional additives such as vitamins, minerals, and other natural or synthetic substances, may be associated with hepatotoxicity. Protein supplements are often inaccurately labeled and misleading regarding their contents. In this self-funded apparent study, we extensively analyzed common protein supplements in India to identify potential hepatotoxic substances according to commercial standards. All the products went through a thorough examination, i.e., for total protein content, fungal aflatoxin screening, pesticide residue analysis, heavy metal detection, steroid detection, and full biological and inorganic profiling, as per industry practices.

Zhang Y., Min L., Zhang S.,

The majority of the protein supplements failed to match the marketed and labeled protein content, whereas some over-reported the claimed levels, sparking concerns regarding potential "protein/amino spiking. " In addition, the top brands had detectable fungal toxins and pesticide residues. Furthermore, several of the highly rated formulations contained toxic heavy metals such as arsenic and lead, some featuring hepatotoxic botanical extracts like turmeric, Ashwagandha, green tea extract, and Garcinia cambogia. Indian products were subpar to those from multinational firms. The occurrence of several potentially toxic substances, including benzene derivatives, cycloheptatriene, isopropyl alcohol, and toluene, in an unregulated and non-standardized ingredient combination raised overall concern. We believe that the protein-based dietary and herbal supplement industry must undergo strict examination, regulation, and basic safety research before they are made available in the marketplace. Companies must make their protein powder "ingredient complexities" easier to understand to avoid natural and artificial ingredients interacting negatively within the consumers. Companies must avoid using known toxic agents to avoid putting unnecessary health weight on the community. Keywords: drug-induced liver injury, hepatotoxicity, nutritional and herbal supplements

Zheng N., Li D., Sun Z., Wang J

Dietary foods and supplements, in the form of animal, dairy, or plant-based protein preparations, are widely used by normally active individuals, athletes, bodybuilders, and some patient groups. Furthermore, protein supplements are used in weight reduction programs and are incorporated in diets with low protein levels. Dietary and health supplements (HDS), which can be proteins themselves that contain or do not contain supplemental botanical substances, vitamins, minerals, amino acids, and other natural or synthetic ingredients, have increasingly raised issues about hepatotoxicity with links to liver injury, failure, and death. One recent study found that the ingredients of HDS associated with liver damage in the United States are frequently mislabeled. Complementary and alternative medicine product investigations identified adulterants and contaminants associated with poor manufacturing

practices. Complementary and alternative medicine product studies purchased from both online and traditional retailers in the United States found the presence of toxic metals. As with the Food and Drug Administration's function, food safety and standards The Food Safety and Standards Authority of India (FSSAI) does not approve health dietary supplements (HDS) but regulates the application of good manufacturing practices. Producers are required to ensure the safety of protein-based HDS ingredients, while the FSSAI checks labeling and content on the basis of test results submitted by producers, which are not public or transparent. Yet, protein supplements usually have incorrect labels, deceptive contents, misleading advertisements, and unclear quality. Existing literature shows a lack of transparent information on protein supplement quality analysis from a proactive healthcare perspective. **Master P.B.Z**

Moreover, much published literature related to liver toxicity attributed to protein-based HDS does not have qualitative product assessments. Our aim was to critically analyze widely available protein products by employing a validated and standardized method, to provide transparency on content, labeling authenticity, adulteration, and contamination. The novelty of our research is in its unique, public-interest orientation, independently funded, to reveal potential toxic constituents. We have undertaken detailed quantitative protein, qualitative product, and chemical and toxicology tests in compliance with the norms of the industry, on the popular protein supplement brands being retailed in India.

The safety and quality of food products have always been a top priority in the food sector. Making sure that the ingredients of the food match their labels and determining if any toxic substances have been added is very important to consumers, distributors, and manufacturers. Food fraud can cause serious economic impacts and pose severe health threats to consumers. In the contamination of wheat gluten and rice protein concentrate with high concentrations of melamine and cyanuric acid for use in pet food led to the death of many pets. The melamine scandal in China led to the sickening of hundreds of thousands of babies.

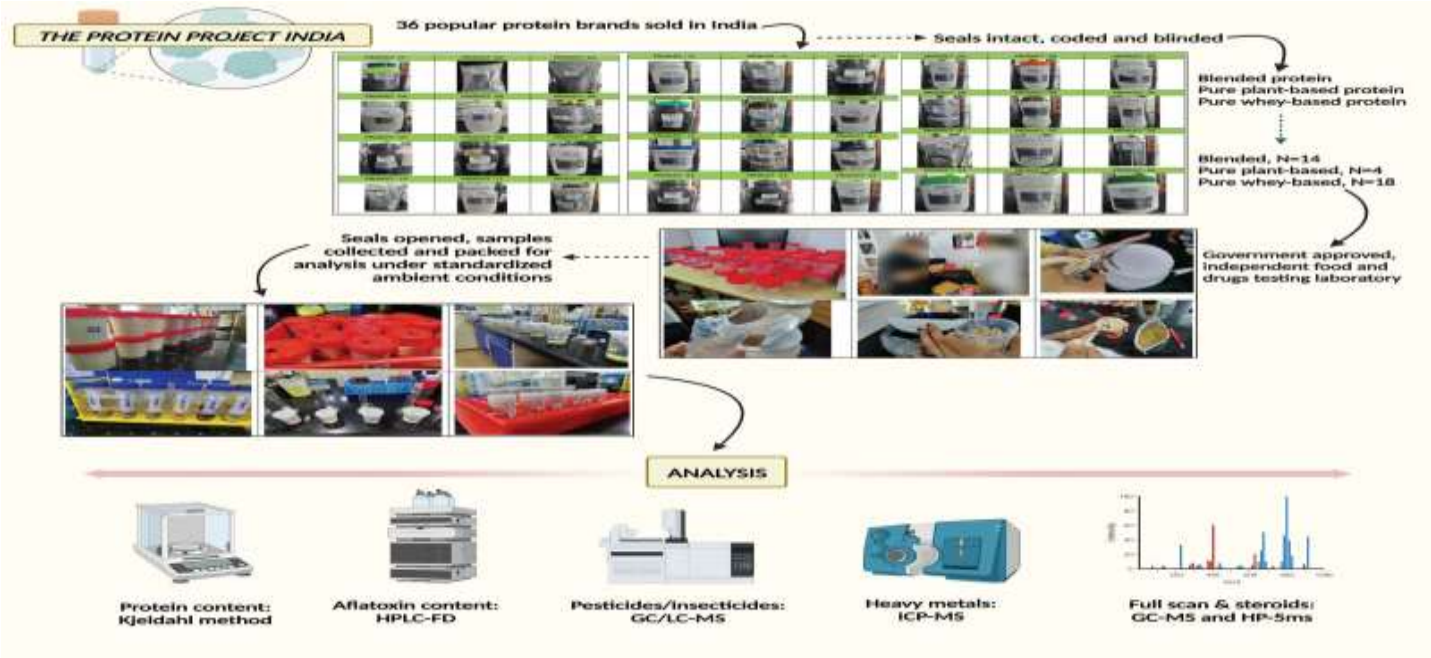
Fig 1

Types and Concentrations of Whey Protein Supplements.

WHEY PROTEIN (WP) Type	**Concentration**
WP Isolate	90–96%
WP Concentrated	24–99%
Hydrolysed WP	Variable and changes are seen
Undenatured WP	Variable, common range 25–99%

Some finished food items have been recalled in the last couple of years as a result of intentional adulteration. To protect their populations' health and economy, certain nations have imposed trade restrictions in order to hinder such occurrences. Therefore, maintaining food quality so that adulteration cannot occur is crucial for consumers as well as government agencies. In recent times, increased consumer health and fitness awareness has fueled significant growth in the consumption of sports supplements. Whey protein sports supplements are specially favored by sportspersons and fitness enthusiasts for their ability to replace needed proteins during workouts and improve performance in sports. Whey protein concentrate (WPC) powder with 50–85% protein on a dry matter and the key quality indicator of protein-based products is their protein content, which is an essential part This is normally estimated by applying standard Kjeldahl and Dumas techniques, which quantify total nitrogen in a sample to determine its protein quantity. But such techniques do not have the facility to discriminate between protein and non-protein nitrogen. Thus, the disadvantage of these measuring processes leaves scope for potential adulteration. Certain profit-oriented manufacturers have falsely added cheap soy protein powder or nitrogenous material like urea and melamine

to whey protein powder to conceal adulteration while bringing about spuriously high protein test values. The addition of cheap amino acids and their derivatives to modify protein content has become a common adulteration practice these days. Amino acids and derivatives that are frequently found in whey protein-based exercise supplements include amino acids commonly consumed and derivatives such as creatine, taurine, and L-glutamine because of their lower prices than whey protein, nitrogen content, and assertions that they improve performance in sports and post-exercise recovery.



WP supplementation has received a lot of attention in health and sports lately. Athletes frequently use WP trying to enhance muscle mass, strength or body composition. WP supplementation nutritional and physiological characteristics and influence on the body. Composition and performance are extensively researched, but results are not always identical. Because of the absence of standardization of the study in the aspects of sample, tests applied, time, amount or types of protein supplements and others. Several studies have deeply examined the influence of WP supplementation on Sports. These studies have resulted in the establishment of widely accepted guidelines Regarding the use of whey protein (WP) in athletic environments, the meta-analysis

by Davies et al. concluded that WP supplementation provides a small to moderate improvement in performance of muscle function recovery after endurance training. Yet less than half of the included studies reported a universally positive result. Notably, WP administration time and dosage are crucial for the athletes to tap its benefits completely. Pre-exercise and post-exercise supplementation are critical, for instance.

Studies by Kim et al. indicated that consuming whey protein at the very onset or termination of a training session greatly accelerates muscle protein synthesis (MPS). Additionally, the quantity of WP consumed matters; studies highlight a specific dosage range that optimizes muscle recovery and growth while minimizing negative effects. Insights from Naclerio and Seijo discuss the appropriate amount of WP intake that athletes should consider for effective muscle repair and growth following exercise. Other research shows improvements in muscle mass due to enhanced satellite cell recruitment, improved strength, performance enhancement, and accelerated recovery, as well as positive body composition shifts, specifically when oral ingestion coincides with resistance training, although results are mixed. The amino acid leucine is particularly important in initiating MPS, and its inclusion in WP most likely plays a significant role in its effectiveness. Additionally, WP's rapid absorption and digestion cause an instant and extensive increase in insulin and blood amino acids levels, which may be responsible for desensitizing insulin receptors and potentially for insulin resistance. Finally, the COVID-19 pandemic caused significant changes in physical activity habits and in dietary intakes,

especially as concerns protein intake. Such putative health effects, considering opposite research, further justify the need for a detailed assessment of the health impacts of WP.

This review aims to provide a balanced evaluation of the health hazards and advantages of WP, on the basis of an extensive review of existing scientific literature.

This section outlines the various types of Whey Protein (WP) supplements, highlighting their respective protein content. It also gives details of the major protein constituents present in whey, along with their relative concentration levels. The major proteins present in whey, along with their relative concentration levels to total whey protein, are β-lactoglobulin (~55%), α-lactalbumin (~20%), blood serum albumin (~7%), immunoglobulins (~13%), and minor proteins (~5%). This is a thorough analysis of major constituents of Whey Protein (WP) and their percentage concentration. The overview includes several constituents ranging from major proteins such as Beta-Lactoglobulin and Alpha-Lactoalbumin to less common but relevant constituents such as various Immunoglobulins, Lactoferrin, and enzymes.

Constituents and the components along with the concentration of commonly and daily used whey protein supplements shown with this table: -

Fig 2

Composition and Concentration of Whey Protein Constituents.

WHEY PROTEIN Constituents	**% Concentration**
Beta Lactoglobulin (β-LG)	50–55
Alfa-Lactoalbumin (α-LA)	15–20
Immunoglobulin A (IgA)	<15
Immunoglobulin G1 (IgG1)	
Immunoglobulin G2 (IgG2)	
Immunoglobulin M (IgM)	
Bovin Serum Albumin (BSA)	5–10
LActoferrin (Lf)	<1–2%
Lysozyme (Ly)	<1%
Lactoperoxidase (Lp)	<1%
Casein Macropeptides	<10%
Sulphydryl oxidase	<1%
Superoxide Dysmutase	<1%

Pre and post training supplementation has been shown to speed up and make up the recovery process fast and also the muscle building and advanced hypertrophy fast and effective, for example **Kim et al**

Shown us that whey protein consumed immediately after workout session can boost or speed up the muscle building and recovery process

CHAPTER 2 : -

LITERATURE REVIEW :-

This critical narrative review presents an assessment of the existing literature on the health implications of whey protein (WP) supplementation, focusing on potential risks and adverse effects. WP is widely used for muscle growth and weight loss but has been associated with a host of health concerns. Our exhaustive analysis included an extensive search across

numerous databases, resulting in the selection of 21 preclinical and human studies that together provide a comprehensive insight into the health effects of WP. The review highlights notable findings, such as WP's potential association with liver and kidney damage, changes in gut microbiota, a rise in acne occurrences, effects on bone density, as well as emotional and behavioral alterations. These observations emphasize the complexity of WP's impact on human health, displaying both positive and negative outcomes depending on various dosages and environments. Our study recommends prudence in protein intake in instances of liver and kidney damage, as well as acne susceptibility, and proposes potential positive effects on gut microbiota, humoral and behavioral factors, and general bone and muscle mass in elderly subjects.

Li M., Liu F.

We emphasize the need for WP intake moderation and suggest continued investigation to elucidate its long-term health effects. Health professionals and those considering WP supplementation ought to be aware of these possible hazards and consider its use with knowledgeable caution. Keywords: whey protein, health hazards, collateral effects, liver injury, kidney injury, physical exercise, acne, bone density, sedentary populations, chronic consumption, review study by **Vasconcelos Q.D.** shows the ill and harmful effects of the whey supplementation which are unethically adulterated

Little is known concerning adverse effects as well as future potential negative repercussions linked with WP supplementation. Alarm has been sounded, in partic-ularly high doses among sedentary people, particularly over liver and renal function long term. Such worries are, however, shared by all re-searchers concerned, with several disagreeing with earlier results. Other concerns have also been made during the study that WP may activate allergy or precipitate lactose intolerance symptoms. High WP supplementation can contribute to an excessive amount of animal protein in the diet, which can increase the risk of disease such as type 2 diabetes (T2DM). Ingestion of WP, especially at high doses, can impact the pathogenesis of T2DM via diverse physiological mechanisms. Above all, the high contents of branched-chain amino acids (BCAAs) in WP can contribute to insulin resistance, a primary determinant of T2DM development. This is be-cause BCAAs, especially leucine, can stimulate the mammalian target of rapamycin (mTOR) pathway, which plays a crucial role in insulin signaling and glucose control. **Chen X., Yang W. et al**

Chronic stimulation of this pathway has been associated with impaired insulin signaling and reduced glucose uptake in muscle cells, allowing for hyper-glycemia. Additionally, a rise in protein consumption can increase the pancreas's demand for insulin, which can lead to beta-cell dysfunction gradu-ally. Moreover, the rapid digestion and absorption of Whey Protein (WP) result in a rapid and significant increase in blood amino acid and insulin levels, which can lead to insulin receptor desensitization and enhance insulin resistance.

S.I Benito P.J., Reuter C.P.,

Moreover, the COVID-19 pandemic introduced significant changes in both physical activity levels and food preferences, especially the types of protein sources consumed. These possible health problems, together with contradictory study outcomes, demonstrate the need for a critical evaluation of the health impacts attributed to WP. This review aims to provide a balanced perspective on the health risks and benefits of WP based on an exhaustive review of the existing scientific literature. The below table depicts the various types of Whey Protein (WP) supplements, highlighting their respective protein contents. It also enumerates the major protein components found in whey and their percentage concentrations. The major proteins in whey and their relative percentages (in terms of total whey proteins) are β-lactoglobulin (~55%), α-lactalbumin (~20%), blood serum albumin (~7%), immunoglobulins (~13%), and trace proteins (~5%). This table provides a detailed analysis of the major constituents present in Whey Protein (WP) along with their corresponding concentration percentages. It covers a broad spectrum of elements ranging from major proteins such as Beta-Lactoglobulin and Alpha-Lactoalbumin to less common but significant ones like different Immunoglobulins, Lactoferrin, and enzymes. **Lombardo M., Guseva E., Perrone M.A., Müller A., Rizzo G., Storz M.A.**

Additionally, WP's ability to improve body composition is a key factor for sportsmen competing in weight-sensitive events, and thus it has become popular among most athletes. Nevertheless, emphasis on the importance of correct dosage and timing in terms of WP consumption is critical, as its misuse can lead to adverse consequences. Hence, customized nutritional strategies are recommended for sportsmen using WP supplements based on their individual sporting needs and health status.

The liver plays a critical role in protein metabolism as the main organ responsible for breaking down amino acids from both external and internal sources within the body.

Amino acids can either be used by the liver to generate energy (gluconeogenesis) or to synthesize new proteins.

The byproduct of amino acid breakdown for energy in the liver is urea, which is then excreted by the kidneys and out of the body. Though some studies indicate that high protein consumption would lead to liver dysfunction in the long term, there is limited human evidence, as in studies conducted **by Nhean et al.**

Whey proteins tend to interact with metal ions, influencing different areas in the quality of human life. These interactions have two main implications: they create opportunities for application in food and nutraceutical purposes, but at the same time, they become analytical challenges regarding their study and influence on food processing, preservation, and interactions. **Renner J.D.P., Rech Franke.**

Furthermore, whey proteins interact with metal ions in a complex way, making understanding essential, which can lead to the assembly of metalloproteins, metallocomplexes, nanoparticles, or aggregates, thereby creating a biologically active complex. The dynamics of metal–protein interactions are understandable to recognize, and in that regard, it is important to develop analytical methods alongside studies on changes in biological activity and determining how these interactions influence different fields. This review aims to investigate the chemistry of β-lactoglobulin, α-lactalbumin, and lactotransferrin, their interactions with a myriad of metal ions, the analytical techniques used for their study, and their implications for food and nutraceuticals. The amino acid tryptophan, which is predominantly located in animal protein sources, is the main ingredient in serotonin, a neurotransmitter responsible for mood regulation. Our diets heavily influence serotonin levels, and consequently, our moods. Meals high in carbohydrates, particularly those with a greater glycemic index, greatly enhance serotonin production.

Serotonin modulates mood by alleviating feelings of anxiety, aggression, and depression. Some researchers suggest that a high protein intake particularly from animal sources or whey protein leads to increased availability of branched-chain amino acids (BCAAs). These BCAAs may inhibit tryptophan's ability to cross the blood-brain barrier, diminishing its availability and ultimately leading to lower serotonin synthesis. Bodybuilders, who usually follow high-protein diets with protein product supplementation, are found to experience higher anger levels than the rest of the population. **Sepandi M., Samadi M., Shirvani H. et al**

Gyms and fitness centers promote healthy living. At the same time, some nutritional errors and incorrect supplementation habits are noticed among the sample population. All these can lead to discomfort, injuries, or plateauing. Among the most important blunders is inadequate protein content within the diet. This research should assess both protein quality and protein quantity consumed among men involved in amateur strength training in men between the age of 18 and 35, involved in amateur strength training in Szczecin (Poland), were examined. Information on supplementation, physical exercise, and self-estimated nutritional knowledge was collected via the author's questionnaire. Statistical processing of results was performed with the Statistica12 program. Participants' average protein intake was 1. 8 grams per kilogram on average, with the maximum score being 3. 7 grams per kilogram and the minimum being 0. 9 grams per kilogram. Protein intake ranged from 70. 2 to 295. 7 grams with a mean of 147. 8 grams (22%), which is in contrast to the study group mean of 129–133 grams, which corresponds to 14% of energy from proteins. It was found that protein supplementation accounted, on average, for 31% of the study group's total protein intake.

Br. J. Nutr. 2021

The results reflect an insufficient proper dietary regimen concerning supplementation in the studied group. It is advisable that the people engaged in strength sports receive additional training in nutritional values and the rules of eating a healthy, balanced diet. Milk and other dairy products have a key position in human nutrition since they are eaten throughout life because they contain a rich nutrient content. However, due to their significant nutritional value, milk can also act as a favorable environment for various microorganisms, which can pose health risks from foodborne illnesses. To ensure food safety, thermal processing methods are typically employed. Pasteurization and indirect ultra-high temperature (UHT)

treatment (≥135 °C) are the main thermal processes utilized in the dairy sector. The impact of these thermal treatments on nutrient changes particularly concerning proteins, lactose, and vitamins has been extensively explored. Notably, research on how thermal treatments affect milk proteins predominantly focuses on whey protein denaturation. Whey proteins have garnered significant interest due to their extensive biological effects, such as antibacterial properties, combating inflammatory diseases, enhancing immunity, reducing blood pressure and cholesterol levels, and aiding in bone repair. **da Silva T.G., Rieger A.**

Thermal treatment of milk leads to changes in milk whey proteins' properties, and this ultimately impacts their functionalities. Previous research has indicated that heat treatment of whey proteins prior to enzymatic hydrolysis alters the nature of peptides produced and the effect on subsequent bio-functional activities such as angiotensin-converting enzyme (ACE) inhibitory function and iron chelation capabilities. Most immune-active proteins that are found in milk also lose activity after thermal treatment.

Generally, whey proteins tend to undergo conformational transitions as temperatures increase, especially upon ultra-high temperature (UHT) treatment. In this study, we evaluated UHT treatment at 135 °C in order to measure the nutritional preservation attained by a correspondingly lesser heating intensity on milk. We contrasted differences between UHT-treated milk at 135 °C and higher temperatures by comparing against earlier studies carried out at 142 °C. While the changes in milk protein profiles caused by different thermal processes have been studied extensively, much remains unknown about the nutrient variations of low-abundance proteins of milk whey under different temperatures, as well as the nutrition retained due to an appropriately diminished intensity of UHT, especially from a proteomic analysis point of view.

Yang and coauthors discovered 211 whey proteins, comprising some low-abundance forms, among five milk species by conventional shotgun proteomics. Based on their differential accumulation protein analysis, certain functional proteins were chosen as candidate biomarkers for each species. In addition, a proteome study measured 129 bovine milk proteins, and nutritional differences after processing processes such as pasteurization, spray drying, and freezing were observed. This work seeks to analyze the nutrient differences in the whey proteins from milk of dairy cows after pasteurization at 85 °C for 15 seconds and UHT treatment at 135 °C for 15 seconds, with specific focus on low-abundance proteins by employing advanced proteomic tools, to characterize and compare the nutritional impacts of various thermal processes.

Dietary supplements, especially protein, are used by athletes in order to satisfy daily exercise and training requirements, and research on their impact with regard to recovery and sports performance has increased. Protein supplements are preferred over traditional proteins because of their ease of availability and accessibility. In addition to whole protein supplements such as whey protein, interest has also grown in supplements that consist of only amino acids for maximizing skeletal muscle development and optimal weight control. The current data on protein and amino acid supplementation effects were the focus of this study to evaluate. The greater part of evidence suggests protein supplementation, most importantly from milk proteins, leads to increased muscle protein synthesis, improved lean mass, and promotes recovery after physical exercise. **Appl. Physiol. Nutr. Metab. 2021**

Conversely, findings on amino acid supplementation, such as branched-chain amino acids, glutamine, or leucine, are variable and do not strongly support their application. Heart failure (HF) is one of the leading causes of morbidity and mortality across the world. The contractile efficiency dysfunction of the heart leads to several neurohormonal and metabolic derangements, developing an imbalance of anabolic and catabolic processes, most often resulting in a reduction of skeletal muscle mass. HF has a significant impact on muscle function and body composition in patients and has been found directly related to important morbidity and increased need for institutional services. In HF patients, nutritional support must be given priority, mainly to prevent continued weight loss, as muscle mass regain may not be possible. Muscle mass loss is a strong predictor of frailty and reduced survival in HF patients, and early initiation of nutritional support can correct this problem. A significant number of individuals with HF experience muscle mass depletion, which contributes to diminished exercise capabilities, challenges with daily activities, lower quality of life, and a rise in mortality**. dos Santos E.M., Moreira A.S.B., Huguenin G.V.B.,**

Meals rich in protein promote muscle protein synthesis, and dietary protein supplementation offers a potential intervention for this condition, particularly where pharmacological options are limited. Dietary recommendations for older

adults (above 65 years) suggest an increase in the daily intake of protein (1–1. 2 g/kg/day; 1. 2–1. 5 g/kg/day in the presence of inflammatory conditions), if possible, from high-quality protein food items like whey protein, which has marked amounts of essential amino acids, including leucine. With aging, there is also a resistance to muscle anabolism; hence, a proposed daily intake of approximately 25–30 g of high-quality protein is advisable to maximize muscle protein synthesis. Whey protein isolate (WPI) is an elite protein that has been shown to be more effective at triggering muscle protein synthesis than other sources of protein. It is extremely digestible and rich in leucine, a key driver of post-meal stimulation of muscle protein synthesis. WPI has also been shown by some studies to be more potent in stimulating this synthesis than other protein sources. Ingestion of whey protein isolate (WPI), especially with exercise like resistance training, has been shown to increase muscle protein synthesis and gain skeletal muscle mass and to augment recovery from exercise. **Boscaini S., Skuse P., Nilaweera K.N., Cryan J.F., Cotter P.D.**

A recent pilot study **by Haß et al**. found that when older people participated in vibration and resistance training with a high-protein diet supplemented with WPI whether or not omega-3 fatty acids were added there was a significant increase in muscle power, leading to stronger legs and faster chair rise times.

However, many heart failure (HF) patients experience difficulties in their physical activity capacity that are hindering, and these can include physical impairment and limited access to cardiac rehabilitation services.

The isolated effect of WPI supplementation in HF patients without exercise training remains unclear despite being a promising area. Accordingly, the aim of this research was to identify whether WPI supplementation compared to a placebo helps induce body composition changes, specifically muscle mass and skeletal muscle strength, in patients with chronic heart failure.

CHAPTER 3

Problem identification: -

As we know, there are many cheap whey protein products available in the market that are fake and adulterated, which can harm human health when consumed. Manufacturers add cheap additives like flour, cheap nitrogenous materials like urea, melamine, taurine, glutamine, and other cheap ingredients to reduce production costs. This process can overstate the protein content of the powder without changing its texture or appearance much.

Common adulterants: Soy protein, urea, melamine, creatine, taurine, glutamine, and other inexpensive amino acids.

Reason for use: These substances are high in nitrogen and are frequently used as a crude marker of protein content in laboratory tests, allowing manufacturers to falsely claim higher protein levels.

Consumption of whey protein contaminated with adulterants can lead to a number of unwanted effects, such as gastrointestinal discomfort in the form of bloating and gas, possible kidney strain due to overconsumption of protein, liver damage caused by toxic chemicals added as adulterants, allergic reactions, and nutritional deficiencies caused by substitution of authentic protein content with lower-cost substitutes; in severe cases, it can lead to hormonal imbalances and other systemic health issues. The aim of this study is to examine the adverse consequences of contaminated whey protein supplements on human health in terms of risk posed by contaminants, toxic additives, and lowered nutritional value. The research intends to evaluate possible short-term and long-term implications for health, including effects on metabolism, organ function, and immune system reaction. This study will analyze a number of impurities in whey protein powders, ranging from fillers, heavy metal, to unofficial ingredients. The study will look at the resultant health effects following the consumption of unclean substances, review what current regulatory thresholds are, and suggest ways product safety and product quality control are improved in the dietary supplement arena.

Source:

"Adulteration of dietary supplements and their safety implications"

by A.S. Gupta et al., Journal of Food Science and Technology, 2020. The study will be constrained by access to contaminated samples, local differences in supplement quality, and practicality of generalizing laboratory findings to

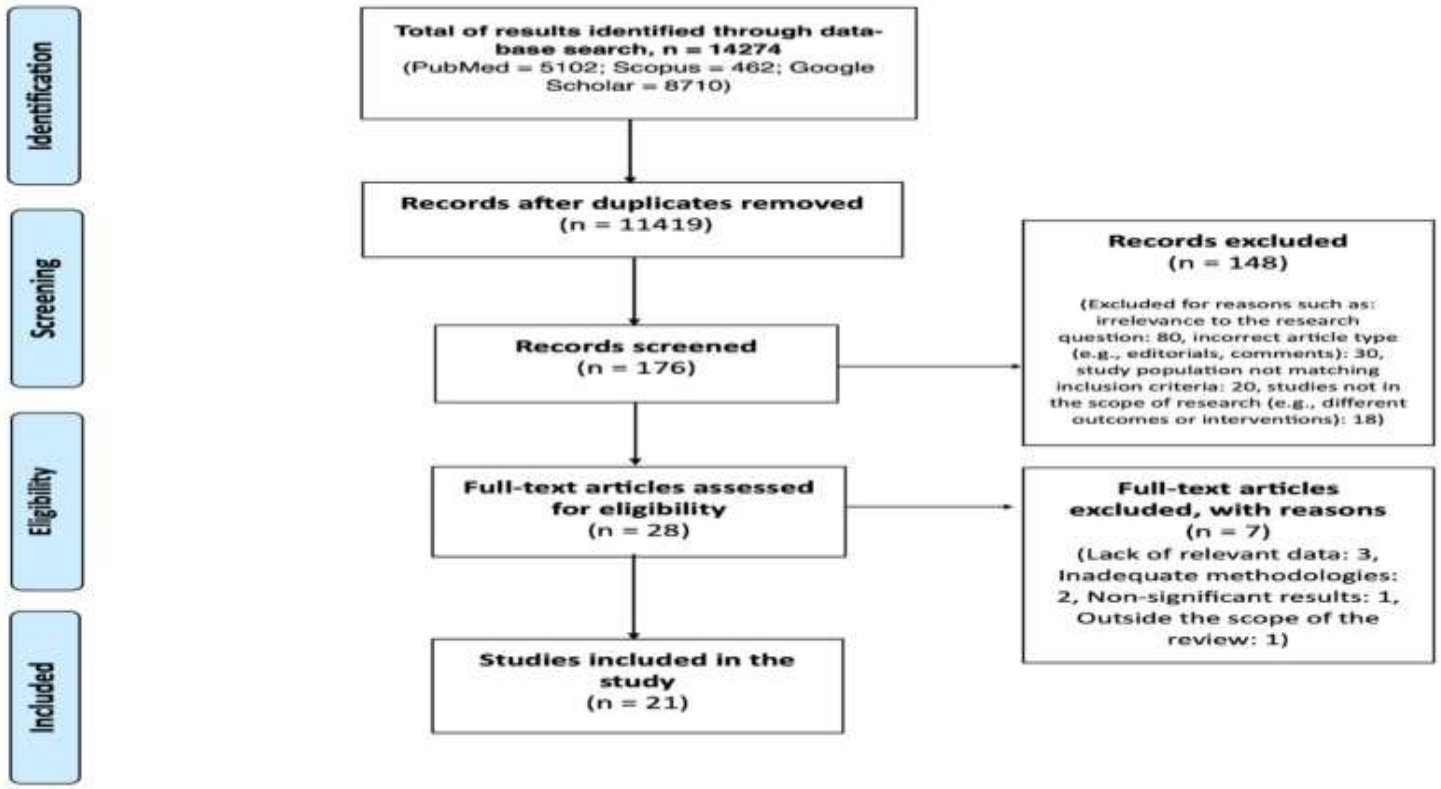
actual consumption patterns. Furthermore, the study might face challenges in detecting all possible contaminants given the intricate process of adulteration. The focus of the research can be on short-term or immediate health impacts, whereas longer-term impacts can be assessed with more comprehensive longitudinal studies. Inconsistencies in regulatory requirements between regions might impede the consistency of the scope and results of the research. The aim of the study and review is to identify and detect all the harmful effects caused due to poor manufacturing or adulteration that affects the health of the consumers and cause ill effects on the body and organs when they are consumed without proper monitoring and lab tests

CHAPTER 4: -

METHODOLOGY: -

The review was done with the aid of several databases such as PubMed, Scopus, and Google Scholar, and conforms to the Scale for the Assessment of Narrative Review Articles (SANRA) standards. The following keywords were employed: "whey protein" OR "whey protein supplementation" AND "adverse effects" OR "side effects" OR "liver toxicity" OR "kidney function" OR "acne" OR "gut microbiota" OR "mood swings" OR "anger" OR "allergic reactions" OR "digestive issues" OR "contraindications". This strategic search was designed to provide a thorough list of studies pertinent to the adverse effects of WP supplementation. Inclusion Criteria That were included in the review were clinical trials, preclinical data, observational or case-control research, case-series and prospective cohort research. The studies were published between 1 January 1990, and 31 October 2023, and were in the English language. The exclusion criteria were review articles, conference abstracts, commentaries, and (single) case reports, and duplicate publications that originated from the same trials. Also, any review with WP supplementation side effects in the abstract or title was carefully examined to obtain additional relevant references. Importantly, reports of positive effects of WP were excluded since they fell outside the scope of this review as intended. The exclusion of studies with non-significant findings or positive effects of WP was done to concentrate this review on possible adverse effects. Nonetheless, it is recognized that this exclusion may reduce the generalizability of our analysis and introduce a selection bias. Although these studies may provide a more balanced picture of WP's total health effect,

Fig 3



This table shows the process followed in the literature review process, from the initial database search to the final selection of studies to be included in the review. It outlines the number of papers found, screened, and assessed, and the reasons for the exclusion of some studies, leading to the final selection of studies relevant to inclusion in the review.

This study shows the follow up period and outcomes formed by the use of the whey protein supplement based on their quantity and doses

Fig 4

First Author	Model	WP Dose	Follow-Up Period	Outcome
Amanzadeh	Male Sprague Dawley rats, (8 weeks old, Weight 232 g)	3.34 g/kg/day:	59 days	↓ urinary pH, ↑ ammonia and calcium concentration in urine in the ↑ protein group ↓ bone density at the femur level in the ↑ protein group
Orosco	Male Wistar rats (Weight 200–250 g)	190 g/Kg alpha-lactalbumin	6 days	↑ Serotonin production ↓ Anxiety after alpha-lactalbumin consumption
Aparicio	Albino male Wistar rats (Young, Weight 150 g) undergoing endurance training	Not specified	3 months	↑ Renal volume; ↑ Calcium excretion with high protein intake ↓ Effects of high protein with endurance exercise
Delamaire	Male Sprague Dawley Rats	8.7–13 g/dL	15 days	↔ Presence of mesenteric fat ↓ Low neonatal weight ↑ Weight gain in puberty/adulthood Food intake increases ↑ Serum insulin, leptin, triglycerides increases Pancreatic β-cell number; ↑ Adipocyte size
Nunes	Sedentary Wistar rats (250 to 300 g; 90 days old) undergoing endurance training	1.8 g/kg post-training	8 weeks	↑ Plasma ALT/AST; ↑ Liver/kidney toxicity with protein supplements, no training ↓ Liver/kidney toxicity with protein + resistance training
Deminice	Wistar rats (weight 120 g)	Not specified	4 weeks	↑ Hepatic oxidative stress markers in protein-supplemented vs. control
Gürgen	Young male Wistar albino rats (Weight 170 g) Untrained mice	Not specified	5 days and 4 weeks	↑ Inflammatory interleukins/TNF-alpha with 4 weeks protein supplementation ↑ Liver toxicity; ↑ Apoptotic signals

First Author	Model	WP Dose	Follow-Up Period	Outcome
Sanchez-Moya	In vitro (donor faeces)	Variable	24 h	↑ Bifidobacterium and Lactobacillus with whey supplementation. ↑ Production of short-chain fatty acids.
Zhou	Female Kunming mice (age 6 weeks, weight 25–30 g)	Variable	7 weeks	↑ SOD concentrations; ↓ Oxidative stress with protein supplementation. ↑ Lactobacillus; ↓ Helicobacter; positive intestinal effects

14,274 papers were initially identified by database searches. After screening, there were 11,419 remaining records after removing duplicates. They were excluded in studies that do not clearly concern the unwanted side effects of WP supplementation or wherein the focus lies outside of what is intended with our review. In fact, infant formulas fall in the discussion but not under results, since WP here would not be a supplement to normal diet nutrients but a central component of the nutritional intake. Wrong types of articles were those that were purely theoretical and had no empirical evidence, or were editorial views and not research studies. The full text of 176 studies was assessed. Of these, 148 were removed upon reading the title and abstract for reasons including lack of relevance to the research question, inappropriate type of article, and non conforming study populations. Upon further scrutiny, 7 papers were removed due to absence of data relevant to the purpose (n = 3), poor methodologies (n = 2), non significant findings (n = 1), and being out of scope for the review (n = 1). Finally, 21 studies were included in the review based on the inclusion criteria. Two authors (E.C., and D.C.) independently extracted information from the included studies. This involved the first author's name, year of publication, trial participant details (e.g., number of participants in intervention and control groups, mean age and age range), length of the intervention, trial design, and definition of the intervention and associated control. In cases of conflicts between the two main authors, a third author (M.L.) was consulted to make a decision. The analysis of 21 studies presented varied results regarding the effect of WP on different aspects of health. The study found twelve human studies, eight pre-clinical studies, and one that utilized an intestinal simulator. Summary of these health and side effects studies of WP supplementation appears in Table for human studies for preclinical studies. The table provides an overview of preclinical investigations examining the health effects and side effects of whey protein supplementation. It provides data on the first author, year of publication, model employed in the experiment, whey protein treatment dose, duration of follow-up, outcomes observed, and references. Abbreviations: ↑: Increased, ↓: Decreased, ↔: No change/Stable, ALT: Alanine Aminotransferase, AST: Aspartate Aminotransferase, SOD: Superoxide Dismutase, TNF-alpha: tumor Necrosis Factor-alpha.

CONCLUSION FROM THE METHOD: - Overall, the negative health effect of whey protein (WP) has yet to be entirely realized. The review identifies the intricate nature of WP supplementation and encourages the perspective of weighing its potential benefits and risks. Increased protein consumption certainly affects liver and kidney functions, although it is unclear whether this effect might lead to concrete damage and what an upper dosage limit would be. In the case of acne, more research is needed, as the existing body of literature is rather sparse and mostly consists of single case reports. WP appears to have a positive impact on the structure and function of the gut microbiota, as well as emotional and behavioral functions, without a significant association with increased anger levels.

Finally, evidence does not strongly suggest a faster rate of bone density loss in the elderly but instead seems to favor the maintenance of muscle mass. The review findings together with the most important findings. Further in-depth investigations into the possible negative effects of WP supplementation are needed. Overview of Key Findings and Conclusions on the Impact of Whey Protein on Different Health Factors. This table is a summary of the main findings and messages on how whey protein impacts liver and kidney function, acne, gut health and microbiota, emotional and behavioral impact, and bone metabolism. Topic Key Findings Conclusion/Takeaway information are: - Liver Function Moderate WP intake does not adversely affect liver function in healthy subjects. Exercise care in instances with existing liver disease. **Schlickmann D.S., Molz P. et al 2020**

Generally safe for the liver, with precautions for liver-related diseases. Kidney Function For healthy individuals without renal disease, WP consumption within recommended limits is safe. Excessive protein intakes overload stressed kidneys. Safe only for normal kidneys within bounds, but caution needed in cases of kidney problems. Acne Inconclusive evidence, possible link in vulnerable individuals. More research is needed to establish this relationship. Gut Function and Microbiota Positive effects on gut function and microbiota, enhancing gut barrier integrity and countering inflammation. A promising

Topic	Key Findings	Conclusion/Takeaway Message
Liver Function	Moderate WP intake does not harm liver function in healthy individuals. Caution advised for pre-existing liver conditions.	Generally safe for liver, but caution needed for liver diseases.
Kidney Function	In individuals without kidney disease, WP intake within recommended limits is safe. Excessive protein can stress diseased kidneys.	Safe within limits for healthy kidneys, but caution needed for renal disease.
Acne	Mixed results, possible link in susceptible individuals.	More research needed to clarify the relationship.
Gut Function and Microbiota	Beneficial impact on gut health and microbiota, enhancing gut barrier and reducing inflammation.	Promising role in gut health, further research warranted.
Emotional and Behavioral Influences	No conclusive link to significant emotional or behavioral changes.	No primary association, individual responses may vary.
Bone Metabolism	Positive impact on bone health, potentially aiding in bone density and strength.	Promising role in bone metabolism, further research warranted.

action in gut well-being, where more needs to be learned. Emotional and Behavioral Effects No certain association with significant emotional or behavioral change. No proven correlation; may vary with an individual's reaction. Bone Metabolism Positive impact on bone metabolism, potentially increasing bone density and strength. A promising effect on bone metabolism, further research needed.

CHAPTER 5

RESULTS AND DISCUSSION: -

Results and Discussion of Further Work: Harmful Effects of Adulterated Whey Protein Supplements - A detailed examination of current studies reveals an alarming incidence of tampering with whey protein supplements that poses severe threats to consumer health. Observations from multiple research initiatives and reports present a range of adverse outcomes pertaining to intentional or unintentional inclusion of unstated ingredients.

Outcomes of the Review: The articles under review regularly indicate that the adulteration of whey protein supplements tends to fall within a number of broad categories, each of which is associated with adverse outcomes:

Amino Acid Spiking (Nitrogen Spiking): The most common form of adulteration involves the addition of more affordable, non-protein amino acids (such as glycine, taurine, creatine, and arginine) to increase the overall level of nitrogen as tested by standard protein assays. While these amino acids are not poisonous in regular amounts, this activity deceives the consumer about the actual protein content and can lead to inadequate protein consumption, especially for those needing more, such as athletes or patients recovering from illness. Besides, excessive intake of individual amino acids can result in gastrointestinal discomfort (diarrhea, nausea), alterations in electrolyte equilibrium, and possible long-term renal and hepatic stress. Addition of Forbidden or Toxic Ingredients: More seriously, certain supplements have been found to contain illegal substances like anabolic steroids, stimulants (such as DMAA and ephedrine), and prescription drugs (such as sibutramine). The well-documented adverse effects of these adulterants include cardiovascular problems (hypertension, arrhythmias, heart attack), liver damage, kidney damage, neurological issues (anxiety, psychosis, seizures), hormonal imbalance, and even death. The presence of these compounds is a major threat to consumer safety, particularly because they are often not declared on product labels.Contamination with Heavy Metals and Other Toxins: Occasionally inadvertently as a result of manufacturing processes, contamination with heavy metals (such as lead, arsenic, mercury, and cadmium), pesticides, and microbial toxins has been detected in some protein supplements. Chronic exposure to heavy metals can cause neurological impairment, kidney dysfunction, developmental problems, and an increased risk of cancer. Microbial toxins can cause acute gastrointestinal distress. Undeclared Ingredients and Allergens: The development of undeclared ingredients, including fillers, artificial sweeteners, and allergens (e.g., soy, gluten, and unexpected dairy products in some whey isolates), may induce allergic reactions, gastrointestinal issues, and other adverse effects for susceptible individuals. Discussion: The findings of this review highlight the public health concern represented by adulterated whey protein supplements. These deceptive practices not only rob consumers financially but also put them at risk of a range of potential health dangers, some of which are serious or even fatal. Poor regulatory oversight and the intricacy of the supplement market are responsible for the prevalence of adulteration. Consumers tend to rely on product labels and advertising claims, which can be misleading or outright false. The variations in manufacturing practices and the international supply chain also make it more difficult to ensure quality control.

The financial incentives for spiking products with fake ingredients are high. Employing lower-cost ingredients can substantially reduce production costs, allowing unscrupulous manufacturers to reap higher profits at the expense of consumer health. The difficulty of identifying particular adulterants without sophisticated laboratory testing makes this problem even more serious.

Scope for Further Work: On the basis of the findings of this review, several avenues for future research and action emerge: Better Testing Methods: Further work is needed to develop faster, cheaper, and more accessible testing methods to detect a broader range of adulterants in protein supplements, both nitrogen-spiking agents and banned substances. Portable testing equipment could empower consumers and regulatory agencies. Tougher Regulatory Policies: It is extremely important to make a case for stricter regulations and enforcement by regulation bodies. That would involve

requisite independent third-party testing, evident labelling requirements, and robust follow-up monitoring post-launch. Cooperating globally is necessary to confront the international element of the industry of supplements.

Consumer Education and Awareness: Public health campaigns are necessary to educate consumers on the risks of supplement adulteration, how to recognize suspicious products, and the importance of purchasing from reputable sources. Long-Term Health Impact Studies: Continued research is necessary to assess the long-term health consequences of consuming adulterated protein supplements, particularly concerning chronic exposure to low levels of contaminants or the cumulative effect of amino acid spiking. Development of Authentication Technologies: Research into technologies like blockchain or sophisticated spectroscopic techniques for authenticating products and enhancing supply chain transparency may help consumers ensure the authenticity and quality of supplements and the degree of adulteration in this market and create strategies for monitoring and regulating online vendors.

CHAPTER 6

CONCLUSION AND SCOPE OF FURTHER WORK :-

The study "Harmful Effects of Adulterated Whey Protein Supplements" focuses on identifying and assessing the health risks associated with the consumption of contaminated whey protein. The findings can include: Determining the harmful substances commonly present in contaminated whey protein, such as heavy metals, toxins, or prohibited additives. Determining the long-term health effects of ingesting these contaminated protein supplements, which can include kidney damage, gastrointestinal ailments, and hormonal imbalance. Reporting on the prevalence and impact of adulterated whey protein in the market. Significance: The importance of this study is in raising awareness about the risks of taking tainted supplements, particularly as whey protein increases in popularity among the fitness and wellness communities. It aims to enhance public health consciousness and could prompt stricter regulations on supplement quality control.

Contribution to the Field:

This research will be valuable in that:

It will help bridge knowledge gaps regarding the specific risks associated with tampered whey protein supplements.

It will present evidence helpful for regulatory bodies to improve quality control processes.

It will assist consumers in making more informed choices and assist manufacturers with producing safe, high-quality supplements.

Practical application:-

Consumer Awareness and Education: The research can offer the consumers with knowledge of the dangers involved in the acquisition and consumption of adulterated protein supplement and thereby create healthier options for such consumers in the selection of products and prevent toxic supplements. Regulatory Policy and Enforcement: Thus shall ensure for the authorities and the government policy makers to implement more stringent quality control measures in manufacturing and supply of supplements such as whey protein supplements so that improved monitoring and testing being undertaken, can be enhanced.

Quality Assurance Supplement Manufacturing: To the manufacturers, the research can serve as an important tool in enhancing their quality control process, through which their products will be safe from unsafe adulterers. This can take a long way in creating safety for the products and then establishing consumer trust towards the company.

Scientific Breakthroughs: The study could also result in two breakthroughs of newer analytical techniques for detecting adulteration in supplements and hence allow laboratories and regulatory authorities to rapidly determine substandard product.

FORENSIC SIGNIFICANCE :-

Impure whey protein supplements carry serious threats extending into forensic science mainly due to their capability of inflicting injuries and demanding their precise identification and examination as of the dangerous fillers. Follows below is a list summarizing the forensic relevance associated with threats offered by adulterated whey protein supplements:

1. Making Connotations between Contamination and Sicknesses

Identifying the Adulterant: Forensic analysis is required for identifying the specific compounds that have been utilized for whey protein adulteration. This involves the application of sophisticated analytical techniques like chromatography (e.g., HPLC, GC-MS), spectroscopy (e.g., NMR, IR, Raman), and mass spectrometry to identify undeclared additives.

Connecting Adulterant to Health Problems: Once the adulterant is identified, forensic toxicologists and health professionals can create a correlation between the recognized adulterant and the unhealthy health problems experienced by the consumers. This can include examining medical records, conducting toxicology tests of biological samples (blood, urine, tissue), and reading scientific studies on the well-documented effects of the adulterant substances.

Dose-Response Relationship: Forensic analysis may further be required to assess the potency of the adulterant in the supplement and the amount ingested by the affected individual to determine whether the level of exposure was sufficient enough to cause the seen harm.

2. Criminal Responsibility and Legal Consequences:

Evidence of Intent: Forensic examination can help establish whether the adulteration was intentional (fraudulent) or accidental during manufacturing. The type and quantity of adulterants, as well as the means of distribution, can provide indications of the intent of the perpetrators.

Food Safety Law Violation: The presence of poisonous or undeclared chemicals in food supplements violates food safety regulations across most regions. Forensic results showing adulteration can be used by government agencies (such as the Food Safety and Standards Authority of India - FSSAI) in order to procure criminal charges for manufacturers and marketers.

Consumer Rights: Evidence from forensic examination can support consumers' civil claims against companies supplying adulterated products, supporting them to be compensated for health expenses, harm, and misery.

3. Community Health and Safety:

Sources of Contamination: Forensic analysis can ascertain the sources of contamination or adulteration and thereby prevent public harm by severing the batch of affected goods and recalling same.

Improving Quality Control: Research on contaminated supplements can provide valuable information for manufacturers who seek to improve their quality control measures and prevent future incidents.

Designing Detection Methods: Forensic research helps design more sensitive and faster methods of detecting adulterants in food supplements, which is beneficial to regulatory agencies in their enforcement and monitoring activities.

4. Types of Hazardous Adulterants and Their Forensic Significance:

Nitrogen-containing compounds (e.g., urea, melamine, glycine, taurine): These are often supplemented to falsely increase protein content in nitrogen analysis (e.g., Kjeldahl or Dumas procedures). Although some, such as glycine and taurine, are amino acids, their excess consumption can have adverse effects. Melamine and urea are toxic industrial substances that may cause kidney damages and other health issues. Forensic analysis focuses on the identification of these chemicals and quantification of their concentrations to ascertain the extent of adulteration and possible health hazards. Anabolic steroids and stimulants: These unlisted ingredients get into products to enhance performance or aid in weight loss in illegal manners. Their presence can cause serious health problems, including heart issues, hormonal imbalances, and nervous system effects. Forensic testing can detect these illegal ingredients, which can lead to legal repercussions and protect consumers from these unsafe ingredients.

Heavy metals (e. g., lead, arsenic, cadmium, mercury): Contamination during the manufacturing process can lead to the presence of harmful heavy metals. Prolonged exposure to these poisons can lead to organ damage, impair the nervous system, and even cause cancer. Forensic analysis quantifies these metals to determine whether their levels exceed safe limits, creating a public health issue.

Pesticides and mycotoxins (e. g., aflatoxins): Such contaminants may result from raw material or improper production processes. These have the ability to cause immediate and long-term health effects, including liver dysfunction and increased potential for cancer. Forensic analysis is required for quantitation and detection of such toxins to support evaluation of level of contamination and resultant health hazard.

Lower-cost fillers (e. g., rice flour, soy protein): While not always detrimental in small quantities, these ingredients deceive consumers about the real protein content and quality they are buying. These substitutions can be revealed through forensic analysis, which is important to combat economic fraud and consumer protection.

Pharmaceutical medication (e. g., diuretics): These can be added to facilitate weight reduction or disguise other drugs in dope tests. The secret inclusion of these can lead to extreme side effects and adverse interactions with other medications. Forensic toxicology plays a critical role in detecting them.

In conclusion, the adverse consequences that accompany tainted whey protein supplements have substantial forensic significance. Forensic science provides the necessary means and information to identify adulterants, establish connections to detrimental health effects, aid legal proceedings, and safeguard public safety and health in the area of dietary supplements.

References:-

1.Ghafoori Z., Tehrani T., Pont L., Benavente F. Separation and characterization of bovine milk proteins by capillary electrophoresis-mass spectrometry. J. Sep. Sci. 2022;45:3614–3623. Doi: 10.1002/jssc.202200423. [DOI] [PMC free article] [PubMed] [Google Scholar] https://analyticalsciencejournals.onlinelibrary.wiley.com/doi/abs/10.1002/jssc.202200423

2.Zhang Y., Min L., Zhang S., Zheng N., Li D., Sun Z., Wang J. Proteomics Analysis Reveals Altered Nutrients in the Whey Proteins of Dairy Cow Milk with Different Thermal Treatments. Molecules. 2021;26:4628. Doi: 10.3390/molecules26154628. [DOI] [PMC free article] [PubMed] [Google Scholar]https://www.mdpi.com/1420-3049/26/15/4628https://www.mdpi.com/1420-3049/26/15/4628

3.Master P.B.Z., Macedo R.C.O. Effects of dietary supplementation in sport and exercise: A review of evidence on milk proteins and amino acids. Crit. Rev. Food Sci. Nutr. 2021;61:1225–1239. doi: 10.1080/10408398.2020.1756216. [DOI] [PubMed] [Google Scholar]

https://www.tandfonline.com/doi/full/10.1080/10408398.2020.1756216

4.**Kim C.-B., Park J.-H., Park H.-S., Kim H.-J., Park J.-J. Effects of Whey Protein Supplement on 4-Week Resistance Exercise-Induced Improvements in Muscle Mass and Isokinetic Muscular Function under Dietary Control. Nutrients. 2023;15:1003. doi: 10.3390/nu15041003. [DOI] [PMC free article] [PubMed] [Google Scholar]**

https://www.mdpi.com/2072-6643/10/2/221

5.Li M., Liu F. Effect of whey protein supplementation during resistance training sessions on body mass and muscular strength: A meta-analysis. Food Funct. 2020;10:2766–2773. doi: 10.1039/C9FO00182D. [DOI] [PubMed] [Google Scholar]

https://pubs.rsc.org/en/content/articlehtml/2019/fo/c9fo00182d

6.Sepandi M., Samadi M., Shirvani H., Alimohamadi Y., Taghdir M., Goudarzi F., Akbarzadeh I. Effect of whey protein supplementation on weight and body composition indicators: A meta-analysis of randomized clinical trials. Clin. Nutr. ESPEN. 2022;50:74–83. doi: 10.1016/j.clnesp.2022.05.020. [DOI] [PubMed] [Google Scholar]

7.Cohen, P. A., et al. (Year). Analysis of Ingredients of Weight Loss Dietary Supplements. JAMA Internal Medicine.

8.Zhu K., Meng X., Kerr D.A., Devine A., Solah V., Binns C.W., Prince R.L. The effects of a two-year randomized, controlled trial of whey protein supplementation on bone structure, IGF-1, and urinary calcium excretion in older postmenopausal women. J. Bone Miner Doi: 10.1002/jbmr.429. [DOI] [PubMed] [Google Scholar]

https://cdnsciencepub.com/doi/abs/10.1139/apnm-2020-0674

9.Reis C.E.G. Discussion of "Whey protein supplementation and its potentially adverse effects on health: A systematic review"—Unsubstantiated claims of adverse effects of whey protein supplementation on human kidney and liver function. Appl. Physiol. Nutr. Metab. 2021;46:90–91. doi: 10.1139/apnm-2020-0674. [DOI] [PubMed] [Google Scholar]

.Vasconcelos Q.D. Whey protein supplementation and its potentially adverse effects on health: A systematic review. Appl. Physiol. Nutr. Metab. 2021;46:27–33. doi: 10.1139/apnm-2020-0370. [DOI] [PubMed] [Google Scholar]

11.Vasconcelos Q.D. Whey protein supplementation and its potentially adverse effects on health: A systematic review. Appl. Physiol. Nutr. Metab. 2021;46:27–33.. [DOI] [PubMed] [Google Scholar]12.Reis C.E.G. Discussion of "Whey protein supplementation and its potentially adverse effects on health: A systematic review"—Unsubstantiated claims of adverse effects of whey protein supplementation on human kidney [DOI] [PubMed] [Google Scholar]