



## REVIEW ARTICLE

# Whey as crucial component in rejuvenating athlete health- a review

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## ABSTRACT

In this review, we have made an attempt to relate the essential component whey with athletes which is very crucial part of their nutrition and its types and various outcomes of consuming this whey protein in the form of beverage which is ready to Drink juice as intact as an substitute or alternative for the normal water for athletes during their regular bouts and Practice session. This Whey beverage is having many benefits and it suits the condition of the athletes, mixture of a fruit juice in the combination of whey has created a remarkably combo. Here we have also highlighted the whey importance components along with different combinations of whey fruit beverages which have got the best acceptability from the consumers. This content mainly focused on the whey beverage importance for the athletes as sports drinks, with essential commercialization benefit of whey It also has both biological and common application of whey in various fields and how it can play an important part in the treatment of some serious illness. It plays a role in the treating disease like Gastrointestinal infection can prevent in excess production of free radical, helps in treating cardiovascular diseases, human immune virus (HIV), has good role in treating Hepatitis and Cancer. These are the common disease for the normal humans and also for the athletes this can be overcome easily with the help of whey based fruit beverage.

**Keywords:** Beverage, whey, sports drink, cardiovascular disease, dairy food

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## INTRODUCTION

Whey a greenish yellow colour salty liquid which is obtained from curd during cheese making and it is further divided into two parts sweet whey comes from coagulation of milk by chymosin at pH 6-7 (cheese whey), acid whey comes from acidification at pH less than 5. This whey applications were very high and beneficial for the mankind so its use was started from 1970s as whey baths which is helpful in nurturing the skin, but its effectiveness got reduced by mid 19th century as it created a burden on environment from the dairy industry, it was directly poured directly into rivers without any regulation and was also used as animal food (Papademas and Kotsaki, 2019)

Day by Day the increase in the cheese production has become a big never ending scenario for the managing the whey from 2017 to 2018 there was rapid increase of whey from 13 to 16 % this began an new era for way due to immense good effects of whey its demand in market increased during time which decreased the waste dumping of whey in the water streams, A food company developed whey product of low level of lactose with high protein even

powders are also in market which gain lot of attention and commercialisation with gym going people and athletes. Various companies are in pursuit of competition to gain lot of attention with their own whey-based products like Fonterra provide 80% of whey protein WPI 90% and native whey products these products are allowing great absorption with good advantage (Papademas and Kotsaki, 2019).

Fruits and vegetables are essential for human life and provide a variety of nutrients, including minerals, fibres, carbohydrates, and antioxidants. It creates a new and recharging mood for the person who is eating these fruits and vegetables and reduces the risk of diseases. Being perishable products these fruits and vegetables after harvest they have to be processed and they have to be converted into preserved form to make them available for the consumers in the market (Kumar et al., 2017).

Whey based non fermented beverages are manufactured with the edible portion of additives, water, sugar, and prescribed proportions of fruit juice which is fit for the consumption these whey-based beverages have high nutritional value and antioxidant property while coming to some fruits they have high nutritional value, but they are used very rarely because of their bitterness and astringency. The best way to overcome this to mix two or fruit juices with whey in appropriate proportion and to make a blend which give best taste and enhanced flavour which also fit for marketing increases the products shelf life. The role of the enriched components of the fruits present in the beverage helps the consumer to overcome the deficiency of that specific vitamin if he possess the same, this beverage serves as good appetizer it has good nourishing and sensory properties. Preparation of the beverage is one side of the coin, but storage is another side of the coin which is the most important step in the success of a beverage many advanced technologies apart from traditional pasteurization like high hydrostatic pressure, high intensity pulse electric field and ultrasound (Rathinasamy et al., 2021). Caseins are relatively heat stable at neutral pH but neutral pH, whey is not as heat stable. So, caseins present as typical ingredients whey is mainly used in meal replacements, smoothies, beverages, and sports drinks. These are mainly in small quantities, but they are protein efficiency is more with biological value of 104 Net protein utilisation 95 which are matching the egg protein nutritive value. It is the best source of glycomacropeptides, bovine serum albumin,  $\alpha$ -lactalbumin and  $\beta$ -lactoglobulin lactoferrin, lysozyme as they provide good health benefits. There are many varieties of whey-based beverages like Alcoholic, carbonated, fruit flavoured and plain these beverages are stable in the pH range of 3-3.2, highly soluble in 2 to 10 pH. Whey is a manufacturer friendly as they do not require to add any other components for its stability at that pH level (Shraddha and Nalawade, 2015).

Delayed onset muscle soreness (DOMS) is situation where athletes face this problem with continuous exercise even after containing fatigue in muscles which will further create sports injury like damage in muscle mass, fractures as they take intensive physical training. This may be examined by measuring creatinine kinase and myoglobin levels after exercise, as these are important indicators for detecting muscle injury. This situation can be controlled with physiotherapy and supplements but often due to some irregularities during manufacturing companies doesn't reveal any of the illegal substances which are banned by doping agencies this scenario will turn into a big problem and can drastically affect the athlete's career. This is basically because of unregulated quality control criteria where supplements might contain the banned substances in more quantity then recommended which further delays the recovery of an athlete. The World Anti-Doping Agency (WADA) regulates supplement usage very strictly. During examination of some supplements 15% of them are having anabolic steroids which are not at all mentioned in the components table of the products. The best and WADA recommended supplement is whey that to in whey protein substrate form it having large impacts on athletes health as it is having 50% essential amino acids, 26% branched chain amino acids here the whey is resembling protein structure with human skeletal muscle which makes the absorption of the whey protein very rapid when compared to other proteins, it reduces fatigue by augmenting muscle

protein synthesis reduces the protein breakdown, Whey has an impact on body composition and resistance exercise-induced increases in muscle mass and strength, but we need to look at the biochemical components of whey to see if it helps athletes perform better and recover faster (Lam et al., 2019).

Whey protein is an important food supplement for muscle growth and resistance training (Table 1). Whey protein also plays a function in physiological protection and performance enhancement during various types of aerobic exercise (Huang et al., 2017). 26% of Branched chain amino acids are present as the protein score in whey protein, During protein synthesis leucine plays an important role in protein metabolism as a key signal in the translation initiation pathway and it is also participate in reversible phosphorylation of proteins that maintain the control of 40s subunit of ribosome (Ha and Zemel, 2003).

**Table 1. Various components of whey (sweet and acid)**

Factors	S. Whey	A. Whey
chlorides	1.1	1.1
Calcium	0.4-0.6	1.2-1.6
Lactate	2	6.4
Lactose	46.0-52.0	44.0-46.0
Phosphate	1.0-3.0	2.0-4.5
Protein	6.0-10.0	6.0-8.0
Total Solids	63.0-70.0	63.0-70.0
	grams/litre	grams/litre

(Villarreal, 2017)

## WHEY PROTEIN MANUFACTURING

20% whey protein is present whole milk when casein is removed from the milk the whey is left and its concentration is about 65%. Rennet aids in coagulation of milk, chymosin is active component for coagulations, this rennet is found calf's stomach (newborn baby cows abomasums), here chymosin helps in absorption of the milk whereas adult cows don't have this enzyme, and then the whey is screened out through separator.

## WHEY BIOLOGICAL COMPONENTS

Whey proteins have all essential amounts of amino acids in higher quantity compared to various other sources (wheat, soya, vegetables, corn etc.). when compared to other amino acid spectrum the amino acids present in the whey can be utilized very efficiently then the free amino acids (Marshall, 2004). Branched chain amino acids in the whey are in high concentrations when compared with other protein sources (BCCAs- valine, isoleucine, and leucine) Leucine plays an important role in the protein translation as it helps during initiation. Sulfur-rich amino acids (cysteine methionine) are required for intracellular glutathione conversion, and these sulfur-rich amino acids are found in whey (Marshall, 2004).

## WHEY COMPOSITION

### $\beta$ -Lactoglobulin

The protein which binds to the lipophilic molecules mainly belong to lipocalins family which is termed as  $\beta$ -Lactoglobulin (BLG) they are the primary proteins consisting of 8 antiparallel strands which helps in binding of

lipophilic molecules and they are termed as  $\beta$ -barrel with no enzyme activity (Table 2). It has wide ligand and allergen binding ability as the first 17-18 amino acids are variable in nature (Marshall, 2004).

### $\alpha$ -Lactalbumin

This protein is essential for lactose synthesis with 12% of total milk protein, calcium binding domains with globular protein and has links with type – C lysozyme specially with primary structure, for forming lactose synthase complex it attaches with lumen surface of Golgi as protein assembly this structure degrades galactose -glucose linkage to form lactose.  $\alpha$ -Lactalbumin primary structure having a portion resemblance with lysozyme domain with 21-141- amino acids, whereas from 92-110 amino acids share glycoside hydrolase (Mehmood et al., 2019).

### Lactoferrin

It is a part of innate immune system having a structure of amino acids from 245-275 and 587-617 which resemble with other iron binding proteins. It is extracted from whey and expressed in different way it is also used in cancerous cell targeting by tagging lactoferrin to antibodies. Essential in formulations of specialised yogurts, infant food Formulas, cosmetics and etc. It has metal binding properties where it belonged to transferrin family (MEROPS FAMILY S60) glycoprotein which has wide enzymatic activity like the most essential and primary ones is transport and binding of the Fe ions, it also regulates and uptake Zn and Cu for the maintenance of body balance. Even with the presence of the cytokine activity lactoferrin has a wide range of allergen, potent antibacterial and anticancer properties (Marshall, 2004).

### Lactoperoxidase

By catalyzing the oxidation of estrogenic hormones, it causes breast cancer it also related with the cancerous cells as tagged for the lactoferrin. It is also located in the salivary glands and is part of the innate immune system. Its first function is to normalize hydrogen peroxide activity so that it can oxidize the needed substrate, and it generates a very effective antibacterial microenvironment. Lactoperoxidase causes oxidative stress and can lead to cancer (Mehmood et al., 2019).

**Table 2. Whey and its crucial components (Joshi et al., 2020)**

Components	Percentage	Benefits	Reference
Lactoperoxidase	0.50%	Resist bacterial growth	(Marshall et al., 2004)
Lactoferrin	1-2%	It is considered as antioxidant, antibacterial, antiviral initiates the good bacteria mainly found blood, saliva, bile, mucus, breast milk & etc.	(Marshall et al., 2004) (Parodi, 2007) (Krissansen, 2007)
beta-Lacto albumin	0-55%	Provides branched chain and essential amino acids which also acts as a source of energy source for muscles and inhibits allergy	Krissansen, 2007)
Glycomacropeptides	10-15	Stimulates the release of cholecystokinin in duodenum which further helps in digestion	(Beucher et al.; 1994)
Bovine serum Albumin	5-10%	Acts as essential amino acid and helps in regular metabolism	(Krissansen, 2007)

Immunoglobulin's	10-15%	It helps in immune modulation and found in colostrum It has protection from rotavirus and Helicobacter. pylori via prophylactic action.	(Marshall et al., 2004) (Korhonen et al.; 2000)
alpha- Lactalbumin	20-25%	Lacto albumin acts as immune stimulator which further reduces oxidative stress and it the best source for the essential and branched chain amino acids.	(Wong et al, 1997) (Marshall et al., 2004)

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### **Bovine Serum Albumin**

The three structures of its domain have developed due to the duplication and mutation of the initial gene, the biochemical assays used is due its inert and robust nature it modulates with the many popular assays like ELISA, Bradford protein analysis. One of the best studied proteins ever in the research area with many nicknames and most prominent is the fraction five (V) as it owes with albumin purification process, BSA has good buffering and pH solution maintenance capacity. Despite of the pH treatment it can fold back itself into its native structure as it is in heart shaped form (Marshall, 2004).

### **Lactoferrin (LF)**

Is a multifunctional transferrin protein with a molecular weight of around 76.5 kDa.

It can be found in a variety of liquids, including nasal, milk, and saliva. In humans, LF possesses antimicrobial properties and interacts with nucleic acids (Mehmood et al., 2019).

### **Glycomacropeptides**

Casein macro peptide is the C-terminal part of kappa casein (CMP). Molecular weight ranges between 6 and 10 kDa. The amino acid profile is quite distinctive. GMP contains a variety of chemical properties, including substantial emulsifying properties and pH stability throughout a large pH range (Marshall, 2004).

### **Immunoglobulin**

Immunological part of the milk is called immunoglobins. Antibodies known as immunoglobulins tackle a wide spectrum of pathogens. Human milk contains the most Ig, while cow's milk has a low level of Immunoglobulin. Its molecular weight ranges between 150 and 1000 kDa. These proteins contain immune-active peptides, which improve the quality of whey products (Mehmood et al., 2019).

### **Lactose**

The most essential component of whey is mostly the least important component and very hard to utilize. Lactose contributes for over 70% of the total solids in whey (Marshall, 2004).

### **Mineral**

Potassium and sodium are good source of electrolytes which are required during the sports activity as well as from a health condition such as diarrhoea; many minerals are partly bound to proteins like magnesium, phosphorus and calcium. While zinc is present in trace amounts, lactose helps in the absorption of magnesium with zinc, which is beneficial to human health (Mehmood et al., 2019).

**Table 3. Various components of whey (sweet and acid)**

factors	S. Whey	A. Whey
chlorides	1.1	1.1
Calcium	0.4-0.6	1.2-1.6
Lactate	2	6.4
Lactose	46.0-52.0	44.0-46.0
Phosphate	1.0-3.0	2.0-4.5
Protein	6.0-10.0	6.0-8.0
Total Solids	63.0-70.0	63.0-70.0
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(Villarreal, 2017)

**Vitamins**

Water-soluble vitamins are splashed into whey to varying concentration during the manufacturing process:70-80% riboflavin and biotin; 80-90% thiamine, nicotinic acid, folic acid, and ascorbic acid; 40-70% vitamin B12; 55-75 percent vitamin B6. When rennet coagulation was used instead of acid coagulation, more vitamin B12 was transferred into the whey (Marshall, 2004).

**MECHANISM OF ACTION**

Whey has good antioxidant activity by allowing cysteine proteins to work out in the synthesis of glutathione (intracellular antioxidant) (has glycine, glutamate, and cysteine) GSH is in reduced form whereas Riboflavin, niacinamide, and glutathione reductase are very crucial factors for reduction of GSH here cysteine contains thiol group that acts as a reducing agent and prevents oxidation and tissue damage, it is being investigated as anti-aging agent because of the GSH's antioxidant property. Lipid peroxides are converted into less harmful hydroxyl acids with help of glutathione peroxidases which is derived from the selenium and cysteine. Peroxidases interact with H<sub>2</sub>O<sub>2</sub> to reduce it in water maintain its oxidative potential. After one month of the peaking initiation the lactation continues the concentrations of the GSH and selenium decreases. Glutathione peroxidase activity in cow's milk and whey is the same as in the human milk here whey is taken as cysteine which further increase intracellular glutathione levels. Lactoferrin has ability to induce colony stimulating factor, macrophage cytotoxicity, activating natural killer cells and neutrophils. Whey helps in reduction of blood pressure as it is termed as good healthy dietary fiber supplement. In bovine beta lactoglobulin anti-hypertensive peptides have been isolated as a primary sequence, which give ACE inhibitor activity which stops conversion of angiotensin 1 to 2 acting as potent vasoconstrictor (Marshall, 2004).

**UTILIZATION OF WHEY**

About half of the whey which is produced is directly diverted into waste which is highly unacceptable. The small scale industries are facing a lot of difficulties in managing whey as of now regulations against whey disposal has been very strict which creates hard time for them, to avoid this situation these small industries owners are making deals with the livestock owners to feed the cows or buffalos or spread it in the agricultural land fertilizers, the whey processing is very less because of the unknown demand of less whey powders but in this modern era the use of whey is being more in the form of various substrates. Some part of whey concentrate, reduced lactose, mineral whey are used in the human

food products and blends are used in as feed for animals no fat dry milk is made by the whey based products other application where the whey is utilized are as follows like bakery, confectionary products, acid whey is used in the food

### **THERAPEUTIC VALUE OF WHEY**

Due its health benefits it targets all kinds of age groups from old to young people it also helps in treating some illness, like digestive tract diseases, etc. It has a great history bound to it for showing best benefits in diarrhea and other skin related diseases, scales in urinary tract, and helps in intoxication. As the beverage is having high amount of amino acids it is very much useful for the athletes. Mainly known for the branched chain amino acids like isoleucine, leucine, and valine. These are the first amino acids used during the resistance training which are directly metabolized into muscle tissues. They include GSH, GMP, lactoferrin with help of these component especially the beverage can be used to check the absorption capacity for the iron content and may be also used to improve the iron content absorption in the GIT (more useful in infants and neonates). It also has improve calcium.

Absorption in the older people who are suffering from osteoporosis it also poses antioxidant properties, antiaging agent (GSH), Glutathione peroxidase which is from cysteine and selenium they convert the lipid peroxides into hydroxyl acids. Reduction of the oxidative stress is possible with the chelation done by the alpha lactalbumin bovine beta lactoglobulin lowers the blood pressure as they are isolated peptides.

Minerals like potassium, involves in nerve transmission, muscular contractions, calcium used to maintain body alkaline pH and bone density with the effect of depolarization through magnesium. Iron beneficial bacteria inhibited by Lactoperoxidase, fungi growth is inhibited by lactoferrin. Whey contains many essential vitamins some are D,B2,A,B3,C,B5,B1 E and B6 (Marshall, 2004)

### **ESSENTIALITY FOR THE WHEY BASED BEVERAGES**

Cheese based whey was being used from ancient Greeks times for the therapeutic necessities. In 460Bc Hippocrates advised this for assortment of human ailments. There are 5 key points by which the market runs they are

Diverging functional beverage trends in worldwide

Flavour innovations

Product differentiation

Cross category innovation

Concentration of global beverage market

The major difficulties which are encountered in this beverage preparation is as follows

1. Depleted shelf life
2. High content of whey minerals causing sour flavour
3. High viscosity effects the thermal treatment
4. Crystallisation of lactose during storage

Coagulation of whey during thermal treatment

Even after limitations in using the whey they are largely utilised for the following reasons

1. Buffering capacity is seen for the survival of probiotic bacteria in GIT.
2. Increased viscosity of beverage increases the mouth feel.
3. Broad range of solubility (pH 3-8)
4. Act as carrier for the aroma compounds with blunt flavour.
5. Cloudiness of the tropical fruits is also solved (Shraddha RC and Nalawade T, 2015).

### **WORLD-WIDE MARKET**

The nutrient content of the product is playing a game changing role in the market which in turn create development of the new products, The worth of global level market is established and evaluated as 1544.61 billion dollar and counting it may increase beyond 1854.589 billion US dollars by the year 2024. Daily requirement of the nutrient is achieved by these beverages people believe in this idea very strongly because of this reason market for these products is increasing day by day. The market is changed regularly on the basis of the preferences of the consumers which may be sometimes alcoholic or non-alcoholic beverages depend upon the distribution channels. According to the recent reports beverage market has grown to 24 billion US dollars. The beverage nutritional criteria makes them healthy and efficient for drinking (Joshi et al., 2020).

### **ADDITION OF WHEY IN VARIOUS FRUIT JUICES**

There are many advancements in the dairy as well as beverage industry which produced many whey beverages with best acceptability from consumers, these beverages include various fruit pulp and juice extract which have been perfectly combined in a right proportion to make the best beverage for consumption as they contain many essential amino acids in addition with carbohydrates, protein, vitamins, mineral and dairy fibres. This incorporation of fruits will create or replace the breakfast or snacks with this beverage. The beverages are produced with different amount of ingredients with variable percentages of the whey, fruit pulps and etc. Whey based ginger mango beverage was made with 82 ml of whey, 10gms of mango pulp, 8gms of sugar, 0.5ml ginger extract and 0.05% guar gum was also added which has good shelf- life period. Another beverage with incorporation of mango with whey was also developed with guar gum, sugar. It was refrigerated for 30 days the study showed there was increase in TSS, reducing sugars, but ascorbic acid, pH was found to be decreased. strawberry is very beneficial fruit with various phenol, phytochemical and proanthocyanidins compounds they have a great role in the heart disease and cancer. Whey based strawberry beverage was made with various composition of whey i.e. 25%, 50% and 100% which was pasteurized for 30 minutes and stored for 90 days. The further analysis showed heavy microbial load but it was approved for safe consumption due its rich iron level and antioxidant property this strawberry beverage was also fortified with bisglycinate. This beverage consumption showed some reduction in the anaemia in young people.

Guava based whey beverage was also experimented Pasteurised and studied under various conditions with various concentration of the whey protein in it like 65% whey, 10% sugar, 25% guava pulp 0.05% guar gum, 1.5% preservative and 1% sodium alginate. All the tests came out very nicely with effect of good remarks research proved that this incorporation of the fruits can cure many diseases with addition of advantage for sports persons. These



drinks have shown a possible increase in the haemoglobin level in young people along with the good advantage of physical and mental wellbeing.

Watermelon being the cheap fruit in the market this fruit was also a part of beverage experiment which gained a lot of acceptance and passed the sensory tests with outmost score ,this fruit contains few phenol acid residues ,with low calorie and high fibres .This beverage contains 0.21% sucralose, guar fiber 3.84%, whey around 51.46 %, xanthene gum 0.5% falvour,10%KMS.pasteurisation was done at 80°C for 10 min and refrigerated .other different fruits were also utilised with whey protein, herbal materials, carbonated whey. Orange whey, pear whey, Apple whey, banana whey, pineapple whey ,pineapple bottle guard whey (Joshi et al., 2020).

## TYPES OF WHEY

There are many forms of whey which have their own essential application they are whey protein isolates (WPI), concentrates (WPC),fractions (rich fractions Beta-lactoglobulin and Alpha-lactalbumin, Lactoperoxidase, lactoferrin, Glycomacropeptides and casein) hydrolysates of whey protein .Categorisation of whey can be done with help of its taste like sweet whey (pH 6-7), Acid whey (<5). Basically Whey protein concentrates 34%,80%,90% and WPI are the beverage type ingredients which are very essential source of nutrition which is used as the major components in supplementation, beverage production and etc. There are few types of whey which are listed below

Thirst quenching carbonated beverage

Dairy type beverage

Mixture of whey

Alcoholic beverages

There are various fruit based flavours used some of them are orange, lemon ,grapes mango, apple, Pear, Raspberry strawberry, along with their blends of the fruits as they have been very much crucial in overcoming the undesirable smell of boiled milk, salty flour of whey based strawberry beverage was made with various composition of whey i.e. 25%,50% and 100% which was pasteurized for 30 minutes and stored for 90days .the further analysis showed heavy microbial load but it was approved for safe consumption due its rich iron level and antioxidant property this strawberry beverage was also fortified with bisglycinate .This beverage consumption showed some reduction in the anaemia in young people. Watermelon being the cheap fruit in the market this fruit was also a part of beverage experiment which gained a lot of acceptance and passed the sensory tests with outmost score, this fruit contains few phenol acid residues, with low calorie and high fibres. This beverage contains0.21% sucralose, guar fiber 3.84%, whey around 51.46%, xanthene gum 0.5%, 10%KMS.

Vegetables with incorporation of the whey was also a great success product with carrots and whey were used this includes blending of two main components and then heat treatment followed by packing in solubilisation of whey was reported during this type of experiments. There was also a development of tomato juice (65%) with addition of whey (34%), whey cream (0.4%) it has pH around 4.3-4.5 along with 2.5% butter fat. The carrot juice pasteurized with sugar syrup to deproteinate whey is called as Detskii it contain 20%of TSS and 15% sugar and acidity is higher than 12.5 degree Celsius (Shraddha and Nalawade, 2015).

## **PROCESSING OF WHEY INGREDIENTS**

The main recovery processes of whey ingredients occur prior to evaporation and/or spray drying. Separation of 13 ingredients with different molecular size membrane separation technique is used. Microfiltration is used to remove germs and fat globules, ultrafiltration is used to fractionate proteins can be achieved by ultrafiltration, nanofiltration helps in desalting and reverse osmosis aids in purification of water (Alane et al., 2018).

### **Demineralization of whey**

Salts in whey can show effect and it can also prevent whey from being used in food products. Lactose content is 50 percent in delactosed whey and protein concentration ranges from 13 to 28 percent, although mineral content is roughly 20% of total whey content. This results in a more unpredictable taste that can't be used in human meals but can be removed by desalting. The use of ionic exchange can demineralise whey. Electrodialysis is a more cost-effective and up-to-date whey demineralization method (DeWit, 2002).

### **Membrane filtration of whey**

Membrane filters are used in the fractionation of whey protein concentrates (WPCs), which includes (RO), (UF), (NF) and (MF), Semi-permeable membranes are used for separation, with a hydrostatic pressure gradient acting as the driving force. The separation is based on a sieving process using thin filters with predetermined pore sizes. Membranes have additional separation features that are crucial for ion separation. Microfiltration is used to remove microorganisms and lipid globules from whey. Separation of whey proteins by ultrafiltration. For dipropionate sample tiny molecules, such as demineralization products of whey, nanofiltration is used. NF is an electrodialysis desalting option. Reverse osmosis uses a greater pressure than conventional membrane processes to remove water against an osmotic pressure. RO is a technique that opposes osmosis rather than a filtering (DeWit, 2002).

### **Chromatographic separation of whey proteins**

Column chromatography was first described with protein sorting technology at industrial scale in the 70s.

Gel filtration chromatography (based on variations in molecular sizes), ionic exchange chromatography (based on charge variations), and affinity chromatography (as a technique using specificities in molecule-molecule interactions) are some of the techniques used to isolate Salts, proteins from whey according to specific protein components (DeWit, 2002).

### **Recovery of lactose from whey**

Lactose can be collected by crystallization with sweet/acid whey. It has some basic methods collecting lactose, it mainly depends on composition:

Deproteinated whey (conc.) in crystallization (e.g., ultrafiltration permeates from whey) (DeWit, 2002).

Crystallization in concentrated whey

### **Milk salts collection from whey**

It is taste developer with food we eat basically the salt ions such as Na<sup>+</sup> and are essential part of the person's life but basically salt is consumed rather than expected (20 times more). High intake of sodium can cause hypertension so producers are looking for the sodium less content to replace table salt the best solutions for this is to extract the milk salts from the whey and work it upon as table salts with high calcium concentrate as good extra benefit this substitute tastes the same as table salts, delactated whey is source of milk salts (Alane et al., 2018).

## **BLENDED FRUIT BEVERAGE**

Combined beverage with combinations of varieties of fruits will increase the Taste, texture, colour, and flavour of the product by removing astringency and bitterness which further enhances the shelf life of the beverage it is the best method for the preservation of fruits to prevent postharvest losses. In the recent study of combined blending of green tea, lemonade, and miracle fruit they found that miracle fruit was providing natural sweetness for the overcoming the bitterness. Litchi based fruit beverage was also made with addition of coconut water and lime which also used for overcoming some of the undesirable flavours. There was also study on pineapple and sour sop the ratio was found to be 80:20 and sensory tests were also conducted. The Apple cashew combined with other fruits like pineapple, mango, and sapota papaya, in various quantities these blends were affected with various sensory test and physicochemical evaluations. Apple cashews mix along with fruits Sapota, mango and pineapple was studied and got a good appreciation for its (Roy et al. 2016). Guava and pineapple juice was studied by Sarkar and Bulo (2017) it has also got the highest acceptability with the various ratios present in it like 60% guava, 40% pineapple. Agarwal and Kumar (2017) studied about mint and bottle guard blend with ratios of 150:20, 150:30, 150:40 and found the good acceptance from the study. Further jamun fruit along mango was studied and to overcome the acidity value and pale taste of the jamun mango was blended into it which got good sensory results Sharma et al. (2017). Aloe Vera gel along with carrot and orange combination is studied with 40% proportions which resulted in best acceptance (Hamid et al. 2014). Many other drinks combinations such as aloe Vera, pear (90:10; 80:20; 70:30 along with 5% spice extract); aloe Vera, ginger and anola were also studied and gave a good sensory analysis (Talib et al. 2016). Various ratios were checked in the above studies like 70:50:50 (aloe vera, ginger, anola) (Sasi Kumar et al. 2013). Bael and Aloe Vera also mixed and studied for various properties and they are very much useful for children but has to be taken within 90 days (Rathinasamy et al., 2021).

## **SPORTS DRINKS**

Sports beverages are the packaged drinks with high shelf-life period which contain carbohydrates, electrolytes, minerals, colouring, and flavouring agents. To minimise dehydration these beverages are given to sports athletes which contain electrolytes and carbohydrates as they are further absorbed and retentions of the fluid also takes place. Effectiveness of the beverage is achieved by gastric emptying, fluid retention, and Intestinal absorption. During exercise bouts sustaining water in body is essential for the daily needs which also enhance strength and helps in post exercise parameters. Muscle glycogen repletion can enhance with the inclusion of protein in the beverage which increases the performance and reduces the fatigue post exercise. Key components of the sports drink will come into mainstream commercialization of the beverage as a asset with the formulation of prescribed nutrients, normally these beverages are isotonic in nature with osmolality between 280-340 mosmol/kg. It also contains sucrose, fructose, maltodextrin and glucose as a carbohydrate, concentration of the sodium is very low ranging from 20-30 mmol/l and 5 mmol/l potassium. Best designed sports beverages can be consumed by the athlete in a perception of encouragement, rapid absorption, and easy rehydration. The basic performance response can be altered with slight change in the formulation of the sports drinks. In the course of manufacturing of sports drink milk and milks solids are the better alternatives in this present expensive scenario. Nowadays milk is consumed as a post training beverage

which enhances rehydration and increases muscle growth but when compared to whey-based beverage this essentiality is ruled out and whey-based beverage takes over normal milk, athletes daily recommendation of protein for a general training is about 1 gm and for intense training load its 2 gm. During endurance exercise the requirement of BCAA and essential amino acids is more as compared to a normal training which is provided by whey beverages which further particularly stimulate the muscle protein synthesis and increases the amino acid profile in athlete's body. During resistance training whey beverages improves body mass and performance in lean athletes Lands et al. In a study of whey based cysteine experiment there is an improvement in performance when compared with casein placebo at a rate of 20 g/day for 90 days, this defences by increasing intracellular glutathione by augmenting antioxidant to reduce muscle fatigue(Shraddha and Nalawade, 2015). A sport beverage basically contain caffeine and are consumed by the athletes after physical activity provides a good hydration it has carbohydrates, magnesium, potassium, sodium calcium for absorption. Many sports beverages also contain whey-based utility with vitamins and nutrients.

**Table .4 How can we form a sports drink(Shraddha RC and Nalawade T, 2015).**

Components	Application level%	Application level%
WPC-80	-	3.90
WPI	20.00	-
Fructose	76.64	6.00
Water	-	77.40
Citric acid anhydrous	0.65	1.00
Lime flavour	1.10	-
maltodextrin	-	11.00
Sodium benzoate	0.10	-
Sodium citrate	0.50	0.06
Mono potassium phosphate	0.40	-
Sodium chloride	0.50	-
Flavour colour	-	0.64
Antifoam agent	0.01	-
Yellow colour	0.04	-
Blue colour	0.06	-
Total	100.00	100.00
Procedure	Bottles were pasteurized under 88°C with a pH 2.85-3.0 by addition of phosphoric acid. all the normal dry components were also added 18%,82% water, perfectly stirred and hydrated.	At 15°C-25°C water was added with good agitation along whey protein concentrate -80for about 15-30minutes.now maltodextrin, fructose and sodium citrate was added and vortexed, then pH was changed with addition of acid solution along with the addition colour ,flavour, hydrates for 10 minutes .the containers were hot filled directly after heating up to 80°C-85°C for 15-30seconds then cooled down.

(Shraddha RC and Nalawade T, 2015)

A sport beverage basically contains caffeine and are consumed by the athletes after physical activity provides a good hydration it has carbohydrates, magnesium, potassium, sodium calcium for absorption. Many sports beverages also contain whey based utility with vitamins and nutrients (Papademas and Kotsaki, 2019).

**USAGES OF WHEY**

The dominant presence of lactose (72%) and minerals (8%) has to overcome. The possibilities of new techniques have created more application in bakery industries. Lactose, huge part of whey. They enhance the flavour, colour, smell, texture, and durability in the bakery industry. The use of demineralised whey is preferred, because as it is having blander taste. With help of column chromatography we can extract the components of whey(Marshall, 2004).

## Dairy products

### Yoghurt

Rapid growth in the consumption of fermented milk is increasing day by day as whey included products are modified with utmost quality yoghurt is made up of sweet whey powder, replacing skimmed milk, additives level 2– 5.2%. Addition of WPC34 at the level 0.7–2.0% or WPC80 at 0.5–0.8% is sufficient in the case of mixed yoghurt higher amount may affect the quality. Whey protein concentrates increase the viscosity of the yogurt and gel strength and demineralised whey powders. It also minimises the risk of syneresis in yogurt. Low mineral components will slightly affect the curd consistency so protein hydrolysates must be added. whey having many bioactive components which can increase the bacterial cultures and the sweetness in the yogurt comes with the addition of bifidum(Gustaw et al., 2016).

### Ice-cream

It includes whey powder, whey protein concentrates, WPI, water binding capacity, high nutritional value and ability to form foam. using low-cost ingredients will make the product cheaper the expected cost as we have expensive items in it like eggs, milk which can be substituted by whey protein concentrates and fat preparations (Królczyk et al., 2016; Jasińska et al., 2012).

Manufactured cheese and its substituent's sweet whey powder along with low lactose content of the cheese can be used for making whey cheeses. Adding whey protein with cheese will release casein with proteins, increases the rigidity of final output with the help of casein pH range 5.0-7.0 product proves to have low melting criteria with other products. They also prevent the lactose crystallization and browning of the product .There is a proper guidelines for whey addition in the cheese powder lactose: 5–8%, Whey protein concentrate 34 and Whey protein concentrate 80: 1–5% Whey protein Isolates 90: 0.5–1%, sweet whey powder: 4–8%.The highly famous cheeses are Myzithra, Ricottaand etc. (Wendorff, 2008).

## Bakery and confectionery Products

### Bakery products

Replacing whey proteins is also a good decision of minimizing manufacturing rate whey is widely used in pastry industries, productions breads cookies, biscuits, crackers, icing. due to cholesterol in the egg yolk, there is a serious need for the replacement of the egg yolk whey components whey protein concentrate 34 is suitable for chocolate chip cookies and whey protein concentrate80 is better substitute for egg in processes like cakes, breads and biscuits. Lactose is mainly used as an alternative for the sucrose in maillard reaction as it improves emulsification reaction which enhances flavor (Stoliar, 2009).

### Confectionary products

Demineralized, low concentration of lactose and isolates of whey are used in confectionary like candies, jellies, chewing gums etc. lactose is bulking agent gives sweet and less soluble than sucrose which further have low hygroscopic value it affects the color, taste and texture of the required output because of this reason lactose is used in low amount or reduced form whey protein concentrate are used in aerated confectionery and foaming properties better used in the protein bars for the athletes (Pernot-Barry, 2008)

### Meat and meat products

Mainly sausages ,mortadella, luncheon meat ,surimi, frankfurters are the products where whey is used in processing, here whey partially replaces meat an completely soy protein now with advanced technology we can make a best whey with good flavor and better taste it is very important to choose our requirement and our need to be matched in the kept criteria, various categories of the meat products prevent the reduction of weight in chemical process and durability which increase juiciness and palatable of product ,whey improves taste and gelation in the edible product as they exhibit antioxidant activity (Youssef and Barbut, 2011).

### Beverage products

whey is far better in technological way, w drinks can be manufactured from permeate or refined whey or ultra-filtered whey concentrate .they are as follows (Pernot-Barry, 2008).

### Whey beverages based on fruit juices

These products usually fulfill a part of the meal like breakfast type beverage, snack type beverage here the main components are healthy fruit juice composition along with the flavors which are mainly mango pulp, citrus, Apple, pear, strawberry, raspberry or fruit juice combination with various terms. As it proved to cover the undesirable taste or odor addition of these frits have proven to very essential for the commercialization of the product along with great health benefits for especially to athletes. Whey based mango beverage is basically a blend of 12% pulp and 8% sugar ,but in RTS we have 70% whey and 30% pulp which passed all the sensory tests, sample prepared with different combinations of whey and fruit juice concentrations as it gives good taste ,floor man best acceptability (Virkar, et al., 2017).

### Dairy-type whey beverages

Milk shakes, unfermented and fermented, flavoured and same outputs, full fat or even fat enrichment. Fermented beverages like sour milk, buttermilk, and various beverages. The main difference is the pH; neutral, most fermented beverage and acid whey are quite acidic, pH of 4.8– 4.5 (Zajšek and Goršek, 2010).

Deproteinizing of whey includes low alcohol production of beverage where the concentration of lactose is low addition of sucrose until alcohol content is reached or not (0.5-1%)then we go for flavor adding sweetening and the packaging some of the example as are sparkling wine from serwovit in Poland lactobacillus Rhamnus is gefius in finland and we have some other strains also they are *Lactobacillus rhamnosus* and *Bifidobacterium animalis* sp. Lactis, *Lactobacillus acidophilus*, *Lactobacillus delbrueckiis* sp. bulgaricus, *Streptococcus thermophilus* many scientist have paid lot of brain into development of the probiotic whey development which help in lowering the cholesterol level in blood also improves lactose metabolism, anticarcinogenic, immune stimulations, and decreases the high blood pressure (Mendoza et al., 2007; Shah, 2007).

**Table 5: Physicochemical evaluation of Mango pulp whey & Whey beverage (Alane et al., 2018)**

Parameters	Mango	Whey	Whey Beverage
Moisture (%)	79.48	90.51	84.605
TSS (0 Brix	26	6.6	15
pH	4.1	4.9	4.62

Acidity (%)	0.80	0.26	0.23
Ash (%)	0.99	0.86	1.001
Specific gravity	1.0329	1.0245	1.04
Density (Kg/m <sup>3</sup> )	1032.97	1024.50	1040
Black specs (per gram)	1	-	-
Brown specs (per gram)	2	-	-
Total sugar (%)	15.75%	3.29	11
Reducing sugar (%)	2.43%	2.17	2.20
Non-reducing sugar (%)	13.14%	1.12	8.80
Ascorbic acid (mg/100)	85.704	10.2	42.85

## WHEY BASED THIRST-QUENCHING CARBONATED BEVERAGES

CO<sub>2</sub> combined with fruit added to overcome the undesirable flavour and odour of cooked milk. The most famous type of whey beverage is the Swiss 'Revilla', other beverage Big MR, Frusighurt, and Taksi Bodrost, (an alcoholic beer-like beverage), Bodrost, (an alcoholic beer-like beverage Taksi (Shraddha and Nalawade, 2015).

### Alcoholic whey beverages

Here the important constituent is lactose with 70% used in the production of the beverage (Jeli et al., 2008)it can be separated

### Minimum alcohol beverage ( $\leq 1.5\%$ )

Fermentation of Lactose with help of microorganisms can be done here the addition of sucrose is there until the

### Whey based mango beverage physico chemical analysis (Alane et al., 2018)

Content of alcohol is reached to 1% followed by flavouring, sweetening in this mean time the lactic acid is produced with gives bit sour taste to the beverage (Jeli et al., 2008).

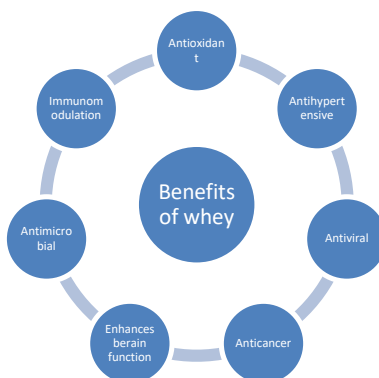
### Whey beer

This can be manufactured with Malt or without malt further fortified with mineral ,vitamins and hydrolysates of starch .this creates a foamy texture with bad odour with terrible taste with low solubility of proteins alone inhibition of the beer yeasts (Jeli et al., 2008).

### Whey wine

This product of the whey contains low alcohol amount around 11% giving fruit smell which starts with Deproteinization by beta galactosidase ,transferring it into smaller proportions, cooling yeast addition, fermentation, transferring it into smaller fractions, storing, purifying, and bottling (Jeli et al., 2008).

## BIOLOGICAL APPLICATIONS OF WHEY



Health benefits of Whey (Papademas and Kotsaki, 2019).

## MUSCLE BUILDING

Branched chain amino acids are high in whey which stimulates the protein synthesis, muscle building, and retention. It also protects the degradation of the muscle, it is the building block of the amino acids that can further help in building muscle in low tone athletes or people. It is absorbed very quickly in the blood as it is termed as fast acting protein. After practice session when athletes take this whey beverage it readily helps in the speedy recovery of the muscles by providing the BCCA to the athletes (Smith, 1976). During competitive events low level of BCCA should be replaced within 1 hour or less depending upon the game which the athlete is playing. Bodybuilders highly prefer whey because of its wonderful nutritional characters which helps in building muscle in lean athletes. It is very good in the powder or beverage form which gives rapid energy for overcoming the fatigue, over dosage of anything is quite harmful to the body or the athletes out is suggested not take more than 30gms of protein in one sitting as more than that will create high load on liver this beverage if taken in consistent form and will result in wonderful efficiency (Smith, 1976).

## Cardiovascular Disease

Increased consumption of the high fat rich diet creates many health problems mainly cardiovascular disease as it is not only related one factors many other cofactors are also related to this scenario as they are old age, obesity, sedentary lifestyle high alcohol intake, fat diet. Milk is one of the best composition of 12 types of fats includes oleic acids, free sterols, cholesterol, sphingolipids these milk products lowers the blood pressure and minimises hypertension (Marshall, 2004). In a study of 20 people where fermented milk with whey was given for the subjects to check whether there is a change in the lipid and blood pressure levels it was conducted for 8 weeks and control group was also present this showed a variable results as the test regime showed high density lipoproteins and low TAG and systolic blood pressure but in the control the result was vice versa (Marshall, 2004).

## Human Immunodeficiency Virus

Use of whey for these patients is done for the increase in the levels of glutathione and cysteine proteins in HIV-positive individuals. In a study, 30 subjects with HIV gets a daily dose of 45 g whey protein from few sources Immunocal, Protectamin. The two products have different amino acid profiles and Protectamin showed increased glutathione levels but Immunocal group had no significant elevation (Marshall, 2004).



## **Hepatitis**

For the patients of hepatitis B or C whey beverage show good effects and it is found that lactoferrin prevents the adverse effects of hepatitis c virus in human (prevents). There was study conducted for the chronic HCV patients by giving the few quantity of BL showed a difference in pre-treatment of HCV there is decrease in HCV RNA and serum alanine transaminase but patients with high pre-treatment of HCV RNA did not change anything (Marshall, 2004).

Another study of 45 subjects have been done with 1.8,3.6,7.2 grams of lactoferrin for eight weeks response was observed for only four subjects with HCV RNA was visible and other eight subjects had a viral response but 50% decrease in HCV RNA after treatment ended. There was no significant result for the change in the dosages. Adding this technique with the interferon therapy may be useful (Marshall, 2004).

## **Cancer**

Prevention of the cancer is one of the major problems in the present situation but whey has given his contribution make help in the diagnosis of the cancer here stimulation glutathione is the mechanism for immune modelling which might increase the concentration of the glutathione, enhance the immunity and detoxify carcinogens .it has also been discussed about the iron binding capacity may also provide potential in treatment by being mutagenic agent which created oxidative stress (Marshall, 2004). In animal studies this whey has shown very good incidence in lowering down the tumours in colon cancer, as metastasis is inhibited by the lactoferrin which affects the initial tumours in the mice. Albumin (serum) has shown breast cancer inhibition in vitro. In hamster study it reduces the basal epithelial cell proliferation by induction of tumour growth chemotherapy induced oral mucositis with the fractionated whey (Marshall, 2004).

## **Obesity**

Obesity in people can be reduced by high carbohydrate and less fat diet. Whey proteins have 95% protein, and it has a remarkable commercial significance in weight reduction program. BMI is increased with amino acids (Mehmood et al., 2019). For reducing obesity calcium breaks the lipids with no ill effects on muscle in the animals (Mehmood et al., 2019)

## **Osteoporosis**

Osteoblastic cells proliferation is caused with the help of whey and suppresses bone resorption. 98% of lactoferrin and Lactoperoxidase can be easily formed from cation exchange forming milk basic protein. Recent experiments on high increase in the femoral bone strength in the rats, the study was carried with 30 subjects (male) given 300mg of whey for 16days which showed a variable result in osteocalcin and procollagen showed a great result in good bone formation (Mehmood et al., 2019).

## **Gastrointestinal health**

Runners are more concerned with GIT disorders many of them have diarrhoea in marathon races. Due to decreased blood flow in the intestinal tract created damage in the intestine wall but here the it is directed towards working muscle with nutrient deprivation with high intestinal permeability further damage walls(Ha and Zemel, 2003). This also creates some problems like indigestion of food before the event. Whey and its components have essential function Gut; toxin binding is inhibited as glycomacropetides show probiotic effect which stimulates cholecystokinin, for better

functioning of digestive tract lactose plays an important role by hydrolysing galactooligosaccharides. Whey is a probiotic vehicle which plays a crucial role in the Gastrointestinal tract here there is plausible mechanism where athlete with GIT dysfunction can get benefitted with the consumption of Whey beverage (Ha and Zemel, 2003).

### **Free radical production**

ROS increases metabolism along with the chronic diseases risk; this ROS will delay and help in recovery, performance, and repair. In whey we have two small components they are lactoferrin and lactoferricin which possess antioxidant activity via iron binding capacity .in oxidative reactions the lactoferrin in its native state makes the chelating of iron which inhibits bacterial growth. With help of cysteine containing proteins it further synthesises glutathione (intracellular antioxidant) (Ha and Zemel, 2003). Athletes who consumed whey-based protein for 30 days have improved their muscular performance when compared to casein group here and there is increase in the intracellular GSH as the synthesis of Glutathione and its antioxidant property is the only reason for the better performance Studies suggest that they also plays a huge role in various pathways along impairment in physiology (Ha and Zemel, 2003).

### **Pharmacology of Whey Protein**

A protein has required amount of AA, but it is useless if it is not digested as well as absorbed easily, protein is digested rapidly, which makes it best as a post-workout beverage. The biggest of an issue this is for you, the more important the purity of the protein purity makes as the big challenge for any of the scientist to look for its better results. Various proteins have a various taste, but many people enjoy the milk, milky taste of whey protein component (Smith, 1976).

### **Side Effects**

Lactose intolerant develops many types of allergies, and they cannot sustain the infections caused by consuming lactate. Such lactose intolerant people get allergy after eating milk is the main constituents of the whey it is very useful for the normal people and to the athletes it is having two phases in it like 1. Isolates 2. Hydrolysates they remove fat and lactose so that it doesn't provide any harm to the people who are intolerant. Kidneys get affected with high consumption of whey. Liver can be damaged with heavy whey dosage. Minerals in the bones can be possible to lost with the excessive intake of whey further leads to osteoporosis of blood increases with heavy consumption of the whey, metabolism of the kidneys become little effected because of the whey (Smith, 1976).

### **Other application of whey**

#### **Infants' formula**

In baby foods the peptides and proteins are used very often. It has increased number of amino acids in infant formulas like lysine, methionine and threonine (Desnilasari and Kumalasari, 2017).

#### **Media**

It helps in protection of active components and removes loss of properties in due course of interval. To get in the final form of the product that is powder we need to perform microencapsulation which further used as food substituent's (Desnilasari and Kumalasari, 2017).

## Edible coating

An edible coating for food can be done by whey protein coated and characterized by best automated needs, a power full wall against 23 lipids, especially, oxygen. Fruits are sprayed or covered with whey (Shraddha and Nalawade, 2015) (Ismail et al., 2021).

## CONCLUSION

The present review states many things about whey-based beverage application its essentialities types of blends fruit-based mixtures and etc. It has a very good and essential application in the field of sports with a remarkable need for the more development of such beverages which are handy for the athletes to carry, and they are also portable with high rich nutrients with many amino acids particularly essential branch chain amino acids which maintains bodies essential protein metabolism and improves the performance of athletes.

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