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NUTRITIONAL AND THERAPEUTIC PROPERTIES OF WHEY

Muhammad Rizwan Tariq[1*], Aysha Sameen[1], Muhammad Issa Khan[1], Nuzhat Huma[1], Adeela Yasmin[1]
[1]National Institute of Food Science & Technology, University of Agriculture Faisalabad-Pakistan
[*]E-mail: rizwan_choudary143@yahoo.com

Abstract
High nutritional quality, effective biological activity and distinctive functional properties are the leading attributes of whey proteins that help sustain curiosity in their deployment, not only in the food industries but also in associated areas such as the pharmaceutical and biomedical fields. Whey protein is a combination of globular proteins secluded from whey, the liquid material obtained as a by-product during cheese production process. Some preclinical studies have recommended that whey protein may acquire anti-inflammatory or anti-cancer properties. The whey protein effects on human health are of great importance and are presently being investigated as a way of reducing disease risk, as well as a possible complementary treatment for several diseases. Whey protein is frequently marketed and ingested as a dietary supplement, and various health claims have been recognized to it in the alternative medicine community. Whey is essential in the bodybuilding today because of its ability to be digested very rapidly. Whey helps open up blood flow by inhibiting an enzyme which mainly constricts blood vessels; this allows better flow of nutrients to necessary areas to help repair and rebuild muscle tissues. Whey is also an admirable basis of bioavailable calcium which prevents bone loss in both post-menopausal women as well as hypoestrogenic female athletes.

Keywords: whey, whey protein, whey protein concentrate, whey protein isolate, flavor.

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1. INTRODUCTION

Whey is the major by-product in the cheese manufacturing from milk which representing 80 and 90% of the volume of transformed milk. Whey contains approximately 4.5% (wt/vol) lactose, 0.8% (wt/vol) protein, 1% (wt/vol) salts, and 0.1 to 0.8% (wt/vol) lactic acid (Moreno-Indias et al., 2009). Whey is the greenish-yellow coloured liquid which is drained off of the coagulated cheese curd during the process of cheese making (Smithers et al., 1996). Whey forming sours off-flavors, tentatively has a docile flavor but rapidly oxidizes (Whetstine et al., 2003). The major characteristics of is that it contains nearly about half of all the solids that found in the whole milk. The solids that present in whey are proteins, fat, lactose and minerals (Blaschek et al., 2007). In the past years it was a difficult practice to dispose the liquid whey and often pumped into rivers, local waterways, fields or ocean/seas and used as an animal feed (Smithers et al.,, 1996). Cheese whey was considered as a pollutant because it has high biological oxygen demand and chemical oxygen demand, due to disposal which is costly. Discharging whey into lakes and rivers removed the economic burden of disposing of whey in waste treatment amenities (Kaur et al., 2009). The Environmental Protection Act (EPA) has placed some limitations on land-spreading as a manner for whey disposal, which is an encouragement to come across supplementary uses for whey and whey products (Outinen, 2010). Whey is spray dried into different whey powder because it can not be used best in liquid state. The composition of whey powder can be further tainted to concentrate specific whey components. Whey contains a high meditation of protein so it reasonably suitable to use whey in human food. The manufacturing industries are getting small economic return by the use of whey in animal feed (Smithers et al., 1996).

Whey Types

There are many different sources of whey as there are various types of cheeses. Sweet whey (pH $\geq$ 5.8) that is obtained either from the manufacture of usual enzyme-produced cheeses (Cheddar, Edam) i.e., cheese whey or from the production of (rennet) caseinates, i.e., rennet casein whey. Acid whey (pH < 5.0) obtained from the manufacture of fresh acid

cheeses (Quarg, cottage) and acid casein whey, obtained from the manufacture of acid casein by acidification of skimmed milk. Medium acid whey (pH 5.0 to 5.8), that is obtained from the production of some fresh acid cheeses (Danbo, queso, blanco). (Akbache et al., 1993; Zadow, 2003). Sweet whey and acid whey are two principal types of liquid whey. Both originate from the manufacturing process of rennet casein or natural cheese. Fresh whey is dried to prepare both types of sweet whey powder and acid whey powder. pH of acid whey by definition has 5.1 or lower. Acid whey is a by-product of the manufacturing process of acidified cheeses such as cream cheese and cottage (Welderufael and Jauregui, 2010). It contains all the original constituents of acid whey except the water. Milk is acidified to a pH of 4.6, at which point the casein coagulates and precipitates so Acid whey is produced. It is higher in mineral content than sweet whey especially calcium phosphate. It may be used in snack foods, frozen entrees and salad dressings. The protein content of acid whey and sweet whey powder are similar to the range of 11-14.5% (USDEC, 2003). Sweet whey is manufactured by removing a substantial portion of water from fresh sweet whey which is the whey separated from the production of renneted cheeses have an off-white to cream-coloured product (American Dairy Products Institue, 1998). Acid whey powder has a fat content of 0.5-1% which is lesser than Sweet whey powder (1-1.5%). Both sweet whey and acid whey have an equal amount of protein, 11-13.5%, however the lactose contents are more in sweet whey (63-75%) (USDEC, 2003). In the food industry Sweet whey is most commonly used and its pH is 5.8-6.3 and titratable acidity of 0.1 (pouliot, 2008).

There are some other types of liquid whey as demineralized whey and reduced lactose whey. Demineralized whey mean reduced mineral whey which is obtained by the removal of a some portion of minerals from the pasteurized whey. There are various methods to make demineralized whey, mostly it is prepared by separation techniques such as ion exchange and must not exceed 7% ash content (USDEC, 2003). The primary use of demineralized whey is its use in food systems where mineral concentration and contents are crucial. Some products in which it is being used are diet food formulations, infant foods and prepared dried mixes. Mineral concentrated whey also branded as reduced-lactose whey, is a cream to dark cream-coloured product and is manufactured by drying the whey that has already been treated to remove a small portion of the lactose content (Szajewska and Horvath, 2010). The lactose content of the dry product is removed by physical separation techniques such as precipitation, dialysis or filtration and must be less than 60% (dry weight) (Szajewska and Horvath 2010; USDEC, 2003). Such types of whey are increasingly becoming popular as a nutritional ingredient in various products such as powdered beverages, sauces, meats, baked goods and others (USDEC, 2003).

Whey Components

Whey protein products composition differs depending on various factors, including the source of the milk, production method, type of cheese and manufacturer's specifications (Whey Protein Institute, 2003). Whey proteins consist of a range of personage protein components. Current advancements in the technology have enabled a number of producers to divide and purify these proteins. It is well known that whey proteins have a greater biological value (100) than any other natural or prepared food source (Pasin and Miller, 2000). WPC is the major source of globular proteins in food and food products that are primarily used as foaming, emulsifying and gelling ingredients. These whey proteins are commonly used in powder form that is produced by a spray-drying treatment. It is well notorious that ß – lactoglobulin is the main protein component in the whey (Bernard et al., 2011). The two major whey proteins are α-lactalbumin and ß-lactoglobulin (Fitzgerald and Murray 2006). Liquid whey has natural protein composition of 0.7% whey protein, 0% casein protein, 0.7% ash, 0.05 % fat, 4.9% lactose and 6.35% total solids (Smithers et al., 1996). The whey has many important constituents of the

protein like α-lactalbumin (21%), ß-lactoglobulin (54%) and lesser amounts of glycomacropeptides, immunoglobulins, bovine serum albumin, lactoperoxidase, lactoferrin, and lysozymes (Adil Rocafi, 2011; Smithers et al., 1996).

α-lactalbumin makes up around 20-25% of whey protein (Francis and Wiley 2000). It is a dense compact globular protein having four disulfide bridges and 123 amino acid residues (Ben Ounis et al., 2010). The amino acid tryptophan is prominent in α-lactalbumin. α-lactalbumin is the prime protein present in human breast milk and is a brilliant source of essential amino acids. One of the key properties of α-lactalbumin is that it is the only whey protein component that can bind calcium and make it vital for liberation of calcium to the infants and fetus. (Fitzgerald and Murray, 2006).

ß-Lactoglobulin makes up more or less 50-55% of the whey protein. It binds fat-soluble vitamins and making them more available to the body and provides an outstanding source of essential branched chain amino acids (BCAAs). These amino acids are considered to avert muscle breakdown and store glycogen during the exercise. Branched chain amino acids may be obligatory in many individuals having liver conditions such as cirrhosis. In infant formulas various hydrolyzed versions of ß-lactoglobulin are frequently used to lower probable allergic reactions (Francis and Wiley, 2000).

Glycomacropeptide (GMP) is a trifling protein component making 15-20% of whey protein (Burrington, 2000). The reaction of chymosin rennet to that of κ-casein form glycomacropeptide during the manufacture of renneted cheeses (Pasin, 2000). Glycomacropeptide may be present in sweet whey but not in acid whey due to isoelectric precipitation of casein rather than rennet hydrolysis because acid whey is formed when the pH is reduced to 4.6 (Lowe et al., 2011). Hence glycomacropeptide is painstaking to be a digestion regulator because it is a biologically active protein that absolutely affects the digestive system by suppressing the thirst. A pancreatic hormone called cholecystokinin, that causes the feeling of fulfillment glycomacropeptide enhances its excretion (Walzem 1999 and Pasin 2000). Another affirmative effect of glycomacropeptide is that it aids to handle and restricts the formation of dental cavities and dental plaque (DMI, 2003).

Immunoglobulins (Ig) are 10-15% of the total whey protein. It is a protein found in colostrum (Whey Protein Institute, 2003) which is a thin yellowish fluid that is secreted by the mammary glands during parturition, and precedes the assemblage of the true milk. Three classes of bovine Immunoglobulins are Immunoglobulins A, Immunoglobulins G, and Immunoglobulins M. Igs show greater denaturation temperatures as compared to ß-lactoglobulin. (Ben Ounis et al., 2010) originate that Immunoglobulins are very heat sensitive in the existence of bovine serum albumin, probably due to their interaction with the free thiol group.

Bovine serum albumin (BSA) Approximately 5-10% of the whey protein is BSA, the least whey protein component. Nonetheless, BSA has precious fat binding properties (Francis and Wiley, 2000). Bovine serum albumin contains almost one free sulfhydryl group, 582 amino acid residues and 17 intramolecular disulfide bonds (Ben Ounis et al., 2010). Bovine serum albumin can be reversibly denatured by adding acid or heat at 40-50°C or by base (Ben Ounis et al., 2010). In the manufacture of the antioxidant glutathione bovine serum albumin also functions in the binding of fatty acids (Frank 2001; Whey Protein Institue, 2001).

Lactoferrin an inconsequential protein component, makes up about 1-2% of whey protein. All other protein components of whey except lactoferrin have pI's (isoelectric point) in the acidic region hence it can be easily extracted from liquid whey by cation-exchange methods. It is a cationic protein having an isoelectric point (pI) of 9 (Smithers et al., 1996). Benefits and Functions of lactoferrin comprise protection against free radicals, promotion of cell growth, antioxidant action and stimulation of the growth of *Bifidobacteria* (Von Elbe, 2001).

Properties and Applications

Kaur et al., (2009) defined whey as a pollutant although it can be used as a sweetener in various food products due to the presence of the significant amount of lactose in whey and whey permeates after treating with the enzyme lactase and strenuous into syrup for proper use. The dairy whey is painstaking one of the most polluting food byproducts or co-products because it consists of high proportion of lactose which is (75%) of the total whey solids. There are various ways of whey discarding included piping into lakes, rivers or the oceans, spreading over fields, funnelling into caves and feeding into ruminants. There is also another option that would be the discharging of the whey into lagoons for oxidation or into the municipal sewage system, but the high BOD and COD of whey usually creates severe effect on ecosystem (Smithers, 2008). Whey products such as WPIs and WPCs are well known functional groups of dairy ingredients from industrial point of view widely used in various food applications (Foegeding et al., 2002). Due to their unique functional properties they are widely used as ingredients in foods such as gelation, emulsification, foaming, thickening, and flavor and fat binding capacity (Bhak et al., 2005). The whey products hold many diverse functional characteristics that lead themselves logically to multiple applications as food ingredients in various eras. Recently deployment of whey proteins as functional food ingredients has been increased.

There are various factors that influence the functional characteristics of whey proteins such as the source of whey protein content, management worn during mechanized, lipid, and mineral content. Whey proteins own a wide variety of functional characteristics such as fat and flavor binding, solubility, gelation, emulsification, and foaming (Larsen et al., 2010). Adil Rocafi (2011) described functional properties of whey as physicochemical properties which preside over the feat and deeds of proteins in food systems during processing, preparation, consumption, and storage. The functional properties of whey proteins affect the whey protein interactaction with other gears, particularly when positioned in a food function. Various whey protein powders exist in the system; WPI has greater level of protein than WPC. Both WPI and WPC have astonishing functional characteristics such as whipping, emulsification, solubility, fat binding, heat setting and gelling properties and water binding/thickening characteristics (Fukuhara, 2006).

WPC has various precious functional attributes as a food ingredient. WPC may alter properties in food system such as hydration, flavor/texture, surfactant, visual, textural, structural, and rheological (DMI, 2003). The functional properties of whey protein concentrate are unfavorably affected by the lingering lipid content of WPC (Illanes, 2011). Whey proteins proffer a wide range of potential functionality. WPC have lesser protein content and are more restricted in function than those of higher protein content as WPI. Due to their water binding abilities WPC are naturally very soluble (Smith *et al.,* 1999). It remains soluble over a broad pH range and in scrupulous near to pH 4.5, so they can be worn in acidic drinks as quick energy supplements. They can also carry emulsifying characteristics and turbidity to food products (DMI, 2003).

The functional characteristics of whey proteins are often viewed by a various conformational position. As a result, any alteration or modification distressing that shape will affect the properties (Pouliot 2008). A number of factors that leads protein denaturation are pressure, heat, extreme pH changes, interfacial forces, and organic solvents (Giampietro et al., 1997). In this heat treatment is the most frequently used agent in the food processing and the scope to which proteins denature, affects the overall nutritional and functional quality (Giampietro et al., 1997). Sensible heat treatment of WPC has revealed to progress its foaming characteristics (Harper, 2000; Koller et al., 2008).

Whey as a functional beverage

Numerous Lactic beverages have been

prepared by using different levels of total solids contents of yogurt/whey mixture and carrageenan. The physiological and chemical uniqueness of these beverages are much similar to those of viable products that are being used. Most of the beverages displayed non-Newtonian fluid behavior with thixotropy and yield stress. The total solids content of the yogurt/whey mixture lactic beverages has a greater impact on the rheological performance of these products than that of carrageenan level. There is a wide range of consistency determination are observed by changing the total solids content and stabilizer level ((Tamime and Robinson, 1999 and Penna et al., 2003).

Arle Dairy Cooperative of Sweden and United States Dairy Company developed a dairy snack drink with brand name of Nature's Wonder which is a 100 per cent natural whey-based beverage. The beverage is nominated as a nutritious snack drink having no distinctive flavor but have a curious blend of various fruit juices like pineapple, orange and passion. Whey beverage competed with other snack drinks without affecting milk sales and fruit juices. Its shelf life is projected up to 6 months (FDA, 2011).

Manufacturing techniques and Formulations worked out for different flavour variations that made from whey and whey products (Fox, 2009). Orange flavor with a light taste of milk having 15.5 % carbohydrates, 17% total solids, 0.2% fat, 0.65% protein, 0.6% ash and 43°C temperature, titratable acidity or pH 4. During sterilization of whey beverage by Ultra High Temperature, coagulation can be prevented by addition of 0.08% pectin and 0.15% carboxymethyl cellulose (Guimarães et al., 2010; Dragone et al., 2009).

Various experiments were carried out to determine the sensory attributes of pasteurized blends of cottage cheese whey (0%, 25%, 50%, 75% and 100% whey) and grapefruit juice and the personal property of processing alternatives and storage at 38°C. A trained sensory panel rated six parameters (grapefruit, saltiness, sourness, sweetness, astringency, cheesiness). Cheesiness and saltiness was increased, while astringency, sourness, sweetness, and grapefruit flavor were decrease as the amount of whey was increased. Vacuum stripping had reduced cheesiness and increased grapefruit flavour and sweetness but Protein removal did not affect the sensory attributes while lactose hydrolysis was increased sweetness and decreased cheesiness in blends with more than 50% whey. The flavor of various blends remaind stable for 14 weeks at 38°C (Alexander and Cabana, 2010).

In an experiment the athletes were provided whey protein drink and it was found that the players seemed statistically significant temporary positive effects after utilizing the active drink compare with after using placebo. The hemoglobin content of blood was also higher after the period with active drink. There werre no other variations regarding the other laboratory tests, field tests and self registered values between the periods with the different sports drinks (Fahlstrom et al., 2006)Many whey protein drinks in the category of sports have focused on increasing the amount of whey protein in the drink. There is a lot of curiosity from the games nutrition companies for the rich protein, clear and acidic beverages (Etzel, 2004).

Health Benefits

Whey protein is becoming a major component of the diet and is especially important to the human nutrition. Whey based products are excellent sources of various vitamins like thiamin, riboflavin, pantothenic acid, vitamin B6 and B12 (Tunick, 2008). On the basis of optimal performance and functionality whey protein products ranges in the content of minerals, protein, and fat levels to ensure nutritional enrichment. Inclusion of whey proteins into food products provides brilliant nutritional repayment.

Whey and whey components contain alot of precious minerals. These minerals assist to improve the functional properties of whey proteins. These include monovalent potassium, sodium, magnesium and chloride ions, phosphate and citrate (Anonymous, 2003).

WPCs have high protein levels and overall are very wholesome. These are good sources of

sulfur-containing amino acids which are demonstrated to preserve antioxidant levels in the body (Pasin and Miller, 2000). ß-lactoglobulin which is present in whey is an excellent source of essential and branched chain amino acids that are required in some those with liver abnormalities. The people who suffer from cirrhosis may have a positive effect and overall health benefits after consumption of whey products in the diet. Whey proteins have contributed in reducing infant allergic problems associated with infant formula (USDEC, 2003). Essential amino acids make-up over 60% of the total protein content of whey (Pasin and Miller, 2000). One method that is used to estimate the protein quality which based on the amino acid requirements of humans is the Protein Digestibility Corrected Amino Acid Score (PDCAAS) which is sanctioned by the USDA. PDCAAS must follow the criterion that includes essential amino acid profile, approximate nitrogen composition and true digestibility (Pasin and Miller, 2000). According to the PDCAAS, the ideal protein has a value of 1.0 and it covers all of the essential amino acid requirements of the human body (Pasin and Miller, 2000). Whey protein has a maximum score of 1.14 (Pasin and Miller, 2000). Whole egg and milk casein have scores of 1.0, soy protein has a value of 0.99, and wheat gluten 0.25 (Whey Protein Institute, 2001; Frank, 2001).

2. CONCLUSIONS

Whey is becoming a major element of the diet and is chiefly imperative to the human nutrition. On the basis of optimal concert and functional attributes whey protein products ranges in the concentration of minerals, protein, and fat levels to ensure nutritional enrichment. Keeping in view the nutritional importance of whey, there is a dire need to change the dairy industrial waste and by-product into useful form. This will solve the dumping problem as well as reduce the environmental pollution and also assist in production of value-added products.

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