International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

Review Article

Multifaceted Whey Protein: Its Applications in Food Industry

Kriti Sharma[1], E.S. Chauhan[2]

[1]Research Scholar, [2]Associate Professor,
Department of Food Science and Nutrition, Banasthali Vidyapith Rajasthan (India)

Corresponding Author: E.S. Chauhan

ABSTRACT

Whey, a protein complex derived from milk is prepared in the dairy industry as a by-product of cheese and casein manufacture. The major components of whey in decreasing amounts are β-lactoglobulin, α lactalbumin, bovine serum albumin, immunoglobulins and others. In recent years, there has been an increasing interest in the use of whey protein due to functional properties such as water binding, solubility, gelation, emulsification, foaming, flavour binding, etc. Whey and whey components are value-added ingredients in many foods including dairy, infant formulas, sports nutrition foods, meats, bakery, confections, snack foods, beverages and other food products to develop functionality of foods in the food industry. They have also potential health benefits beyond their nutrient content. In this review, we have summarized functionality properties of whey proteins. They can be widely used in food as an ingredient because of their functionality including gelation, emulsification, chelating agent, antioxidant activity, foaming, thermal stability, solubility, flavour binding and water-binding capacity.

Key words: Solubility, foaming, gelation, emulsification, functional foods

INTRODUCTION

Whey is a co-product of cheese making and casein manufacture in the dairy industry. Whey protein is a rich source of bioactive peptides which plays an important role in the dietary management of chronic diseases. The biological efficacy of whey protein is a function of its processing technique. Whey proteins are generally marketed in three forms such as whey protein concentrate (WPCs), whey protein isolate (WPIs) and whey protein hydrolysate (WPH). [1] The concentrate has fat and lactose along with the quintessential proteins (29–89%); [2] the isolate is made of 90% protein [3] and the hydrolysate is the semidigested form of protein. [4] Whey protein concentrate is a substance obtained by the removal of sufficient non-protein constituents from whey so that the finished dried product contains not less than 25% protein. Whey and its preparations may serve as substitutes. According to many sources, their use can have a positive impact not only on the consumers' health, but also on the finances of many companies by reducing the costs of raw materials and thus lowering production costs. [5,6] The whey proteins which include β-lactoglobulin, α-lactalbumin, lactoperoxidase and lactoferrin are the main source of whey health-promoting properties. [7] Lactoferrin is a bioactive milk protein with a comprehensive activity. It shows many physiological functions like antifungal, antiviral, antibacterial, anti-tumour, and anti-inflammatory. Also, lactoferrin has a positive effect on the nervous system and is able to bind iron. [8]

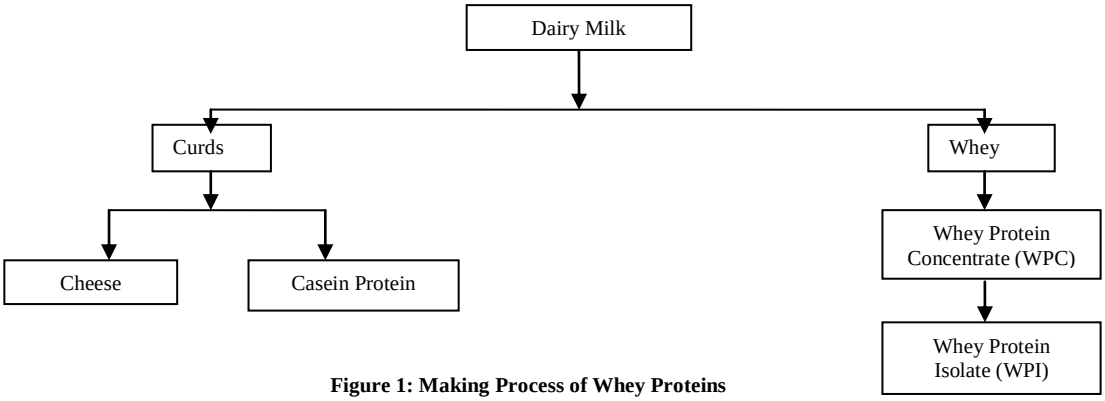

Figure 1: Making Process of Whey Proteins

Since, the major fraction of whey solids is lactose along with soluble proteins, vitamins and minerals. Various biotechnological processes and physicochemical processes have been applied to utilize whey as a substrate to produce industrially important and valuable products. [9] Whey products such as WPIs and WPCs are well known functional groups of dairy ingredients from industrial point of view that are widely used in various food applications. Due to their unique functional properties they are used as ingredients in foods such as gelation, emulsification, foaming, thickening, flavour and fat binding capacity. [10] WPCs may alter properties in food systems such as hydration, flavour/texture and surfactant, visual, textural, structural and rheological. Whey-based ingredients are utilised in a wide range of food categories such as bakery products, meat/fish products, dairy products, fruit beverages, medical and nutritional applications, food for catering to special needs (such as infant formula, dietetic foods) and nutraceutical foods. [11]

Whey due to its rich protein content can be utilized in preparation of various protein rich beverages as well as by removing its astringency. It can be concluded that whey based beverages have nutritional importance and emulsifying nature thus, are employed as the functional beverages and sports drink also. [12] Major whey proteins, β-lactoglobulin, α-lactalbumin and blood serum albumin have excellent surface active properties. Hence, whey ingredients can be used as good wall material and emulsifier for encapsulation. In the last few decades, the use of WPI has received a remarkable interest for the production of films for food packaging. Indeed, whey protein components (α-lactalbumin and β-lactoglobulin) have been widely studied for their potential use as agents able to form edible and biodegradable films based on a waste stream from the cheese industry. [13]

This review paper presents applications of whey and whey preparations in the food industry. The uses of whey discussed includes: meat and meat products, reduced-fat products, dairy products, yoghurts and ice creams, cheeses, bakery products and whey drinks.

Table 1: Functional Property of Whey Proteins

Functional properties	Mode of action	Food system
Solubility	Protein solvent	Beverages
Water binding	Hydrogen bonding of water entrapment of water.	Meat, sausages cakes, breads.
Viscosity	Thickening, water binding	Soups, gravies, salad dressing.
Gelation	Protein matrix formation and salting	Meat baked good, chesses.
Emulsification	Formation and stabilization of fat emulsions.	Sausages, salad dressing, soup, cake, coffee whitener and infant formula.
Whipping/foaming	Forms stable film	Chiffon cakes, desserts, whipped toppings.
Browning	Undergoes Millard reaction.	Bread, confections, sauces, micro wave meat.
Flavour/Aroma	Lactose react with milk protein	Baked goods, sauces, confections, soups dairy products.

(www.diet with dairy.com)

Foaming

Whey proteins play an essential role to include favourable characteristics in the confectionary products. These products could replace traditional proteins such as egg albumin and milk proteins. [14] Whey proteins-enriched products carry very good foaming characteristics hence, widely used in foaming application in foods. Foaming properties of whey proteins products are also important with respect to whipped toppings, cakes and other desserts. [15] Reported that WPC possessing higher protein (more than 80%) could be used to prepare low fat ice cream without sacrificing the mouth feel.

Emulsification

Whey protein concentrates may be used as an ingredient in whole and comminuted meats. The main functional requirements of whey proteins in added to comminuted meat products are good emulsifying or fat binding properties and ability to support matrin formation. [16] Whey protein concentrates have good emulsifying capacity. WPCs can be used to replace eggs in bakery products and new cereals-based products have been formulated from hydrolysed rice and modified rice starches. Replacement of eggs by whey proteins in cake manufacture has both economic and nutritional advantages.

Water Binding and Viscosity

Water binding capacity that prevents the depletion of mass during thermal processing and storage of the product, increases juiciness of the final product and facilitates cutting cold meat products into slices; viscosity which improves the consumers' palatable impressions during consumption of the product (biting and chewing); which is directly related to the ability to bind water. Whey proteins can be incorporated into certain food products not only to increase water holding capacity but also improve other features such as nutritive value, solubility, emulsification capacity, viscosity, organoleptic properties. [17]

Gelation/Gelatinization:

Whey proteins products have been promoted as a replacement for egg white in gelling applications, including cakes and meat products. [18] WPCs can also be used as fat replacer in most of the meat products, it also tenderize the meat, binding agent in processed fish products, yoghurts and various cheeses to improve the yield, nutritive value and consistency. Various fruits or other ingredients can be added to the gel in order to make them more attractive or to enhance their nutritional value. [19]

Applications of Whey Protein Concentrates in Food Industry

1. Meat and Meat- Products

Whey protein may partially replace meat protein or can be completely as a substitute for soy protein and other binding agents, fillers, modified starch and hydrocolloids. [20] The use of whey proteins in processed meats is increasing due to the changing attitude of consumers.

2. Products with Reduced Fat Content

Replacing part of the lipids with so-called fat substitutes can help in preventing negative phenomena. Whey proteins are widely used during the production of salad dressings, soups and sauces, mayonnaise, meat, yoghurts, and ice cream preparations. [21] WPCs with high protein content have very little perceptible flavour. Low-protein WPCs such as WPC34 can, in turn, impart a slightly milky, sweet aftertaste to products to which they have been added. Therefore, when fat content is reduced and a WPC is added, the composition of the product should be corrected. [22]

3. Bakery and Confectionary Products

Whey may be widely used in the baking, confectionery and pastry industries for the production of breads, cakes, cookies, biscuits, crackers, muffins, and icing. WPC34 is suitable for products such as spice cookies or chocolate chip cookies as a partial replacement for both egg and fat. On the other hand, WPC80 is a good substitute for eggs in products such as bread, cakes and biscuits (both dry and soft) and muffins. Using WPCs, which are classified as fat

mimetics, we can lower fat content by up to 50%, and thereby increase the moisture content of the finished product, such as cakes, cookies, muffins. [23] WPCs and isolates, and lactose have been used in the following confectionery: chocolates and chocolate chips, candies, jellies and chewing gums. [24]

[25] Found that in the case of foams obtained from WPI and WPC80 prior to thermal fixation (in the production of meringues), increased protein content and reduced sucrose addition led to an improvement of their rheological properties. The obtained high-protein meringue with a reduced sucrose level may be a new food product, attractive for physically-active people and athletes with increased demand for complete protein.

[26] supplemented wheat bread with whey proteins except in crust and crumb colour; had higher sensory scores than control and fermented whey proteins concentrate (FWPC) breads. Supplementation with 50% whey proteins produced bread with better quality than control and supplemented samples. Bread supplemented with 100% FWPC had higher moisture, protein, fat and ash content and other supplemented samples.

4. Dairy Products

WPCs are most often used by manufacturers of yoghurt. 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 (a greater amount of the additive may adversely affect some quality characteristics). Replacing skimmed milk powder with WPCs causes, among other effects, increased gel strength in solid yoghurt, increasing the viscosity of mixed yoghurt and reduces the risk of syneresis in both types of yoghurt [27] demonstrated the ability of non-heated whey protein-high methoxyl pectin complex to act as fat-replacer and texturing agent in reduced-fat yoghurt. [28] suggested replacing milk with WPCs and with protein-fat preparations. They compared the control sample without the addition of whey products or fat-protein preparations with ice mixtures with a 50% addition of WPC65 and WPC80, as well as with 50% addition of whey-fat preparations containing vegetable fats (coconut oil, palm oil). The organoleptic properties, fat content and dry matter content was evaluated. The acidity and hardness of the blend and the ice cream as well as fluffiness and meltability were measured. The best result was obtained with the addition of WPC80 (a high score in the organoleptic evaluation, low melting behaviour and the degree of aeration).

[29] studied the quality of low fat ice cream with incorporation of WPCs, up to 40% fat replacement. It is acceptable without sacrificing the mouth feel. Similarly, an Indian popular frozen dairy product Kulfi was also prepared by replacing MSNF (milk solid non-fat) to an extent of 40%. The resultant product had higher overrun, mouth feel and better acceptability than standard kulfi. WPC80 as a replacer for egg yolk seems to be a rational solution in the case of Gelato ice creams for producers who want to reduce manufacturing costs without change desired characteristics of the finished product. [30]

The big advantage of whey preparations is their high nutritional value. [31] showed that the addition of whey protein preparations to processed cheese analogues, as well as replacing casein with these proteins, increases the hardness of the final product which may be important for the preparation of products for slicing. In turn, the analogues supplemented with whey products exhibited lower meltability as compared to cheese analogues prepared solely on the basis of acid casein in a pH range of 5.0–7.0. It is believed that production of ricotta cheese is one of the most convenient, least problematic ways to utilise whey. [32]

5. Other Applications of Whey Proteins in Food Industry

Another protective use of whey proteins is as an edible coating for food. [33,34] Because of these properties whey proteins are very important in food industry. In

addition to alcoholic beverages, there are also soft whey drinks. [35] Fruit concentrates based on citrus fruits, mangoes, bananas, strawberries and others are used in their production. It is possible to add cocoa, vanilla, honey (which can be a substitute for other sweeteners) or bran (which enriches the finished product with dietary fibre). Powdered whey drinks (instant) which may be enriched with vitamins and minerals are a large group. [36] Other products popular among consumers include RTD (Ready to Drink) beverages, manufactured on the basis of whey protein isolates and concentrates. [37]

[38] prepared food by using soy whey because whey contains minerals, water soluble vitamins and about 20% of milk proteins. Ready to use mixes were prepared by cereals, pulses, vegetables/fruits and nuts with soy-whey. Different products like idli, dhokla, halwa, sattu and upma were prepared and analyzed for mineral and other nutritional parameters. [39] found that the production of soup sticks concentrated whey was utilized as diluents in place of water. Paneer whey concentrated to 30% total solid (TS) can effectively be used as a diluents without adversely affecting the sensory attributes. This replacement contributes for the nutritional attributes and also for the economy of operation of dairy plants by reducing the cost of effluent treatment.

Formulation of ready to use technology in various foods has diversified the food habits of people worldwide. Process development for instant mixes of various indigenous dairy products is finding grip in the recent past. Gulabjamun is one of the most popular delicacies in India. [40] developed gulabjamun mix from skim milk powder (SMP) and WPCs. WPCs can successfully replace skim milk solids to an extent of 40% in the formulation of instant gulabjamun mix without sacrificing any functional and sensory characteristics of gulabjamun. [41] prepared kadhi. Whey can be successfully substituted in place of butter milk in kadhi and in place of water in pakoras preparation. Addition of whey improved the sensory qualities in respect of appearance, texture, flavour and overall acceptability of kadhi and pakoras. Whey substation in pakoras improved its fat, crude protein and total solid contents.

CONCLUSIONS

The functional properties of whey proteins are solubility, gelling, emulsifying, foaming and water binding properties. In the manufacturing of food products, whey and whey preparations can be used as functional additives or for partial substitution of fat and non-fat constituents. Also, partial replacement of fat by high-protein preparations is uniquely associated with a reduction in the caloric value of the final product. In addition, the improvement of the functional properties of food products such as textural properties seems to be a key issue from a practical stand point. Whey and its concentrates undeniably have great potential both as a source of valuable nutrients and as the basis for functional foods that will contribute important health benefits to the consumers.

REFERENCES

1. GT Sousa, FS Lira, JC Rosa, EP de Oliveira and LM Oyama. Dietary whey protein lessens several risk factors for metabolic diseases: a review. Lipids Health Dis. 2012; 11(1):67.
2. G Bounous. Whey protein concentrates (WPC) and glutathione modulation in cancer treatment. Anticancer Res. 2000; 20(6): 4785-4792.
3. A Hayes and PJ Cribb. Effect of whey protein isolate on strength, body composition and muscle hypertrophy during resistance training. Current Opin Clin Nutr Metab Care. 2008;11(1):40-44.
4. A Kanda, K Nakayama, T Fukasawa, J Koga and M Higuchi. Post-exercise whey protein hydrolysate supplementation induces a greater increase in muscle protein synthesis than its constituent amino acid content. British Journal of Nutrition. 2013;110(6):981-987.
5. R Bozanic, I Barukcic, KL Jakopovic and L Tratnik. Possibilities of whey utilisation. Austin J. Nutri. Food Sci. 2014;2(7):1036.

6. AK Singh and K Singh. Utilization of whey for the production of instant energy beverage by using response surface methodology. Advance J. Food Sci. Technol. 2012;4(2):103–111.
7. R Kumar, RB Sangwan and B Mann. Separation and application of bioactive whey proteins. Technological Advances in the utilization of dairy by-products, 22nd short course; 2008.
8. M Darewicz, A Iwaniak and P Minkiewicz. Biologically active peptides derived from milk proteins. Med. Wet. 2014;70(6):348–352.
9. Prazeres, R Ana, Carvalho, R Fatima and Javier. Cheese whey management: a review. J. Environ. Manage. 2012;110:48–68.
10. Larsen LB, A Wedholm-Pallas, H Lindmark-Mansson and A Andren. Different proteomic profiles of sweet whey and rennet casein obtained after preparation from raw versus heat-treated skimmed milk. Dairy Sci. Technol. 2010;90(6):641-656.
11. C Onwulata, P Huth. Whey processing, functionality and health benefits. John Wiley and Sons; 2009.
12. S Nagar and S Nagal, S. Whey: composition, role in human health and its utilization in preparation of value added products. Int J. Food Ferment Technol. 2013;3(2):93.
13. S Kokoszka, F Debeaufort, A Lenart, Voilley, Andree. Water vapour permeability, thermal and wetting properties of whey protein isolate based edible films. International Dairy Journal. 2010;20(1):53-60.
14. Wit DJ. Functional properties of whey proteins in food systems. Neth Milk Dairy J. 1984;36:71-80.
15. HM Jayaprakasha, H Satyanarayana and A Triumalesha. Effect of substitution of skim milk solids with spray fried whey protein concentrate on the quality of kulfi. In proceeding of IV International Food Convention of Food Scientists and Technologists IFCON-98. Central Food Technological Research Institute, Mysore; 1998a. p. 191.
16. HM Jayaprakasha, H Satyanarayana, A Triumalesha and Shobha. Effect of substitution of skim milk solids with spray fried whey protein concentrate on the quality of ice cream. In proceeding of IV International Food Convention of Food Scientists and Technologists IFCON-98. Central Food Technological Research Institute, Mysore; 1998b. p. 192.
17. W Kneifel, P Paquin, T Abert, JP Richard. Water holding capacity of proteins with special regard to methodological aspects-a review. J. Dairy Sci. 1991;74(7):2027-2041.
18. N Melochouris. Critical aspects in development of whey protein concentrate. J. Dairy Sci. 1984; 67(11):2693-2702.
19. AK Rathore, AK Chauhan and KL Bhatia. Gelling properties of whey protein concentrates and its industrial application. Indian Dairyman 2004;56(2):61-66.
20. MK Youssef and S Barbut. Effects of two types of soy protein isolates, native and preheated whey protein isolates on emulsified meat batters prepared at different protein levels. Meat Sci., 2011; 87(1):54-60.
21. T Zhang, J McCarthy, GR Wang, Liu Y.Y and MR Guo. Physiochemical properties, microstructure, and probiotic survivability of nonfat goats' milk yogurt using heat-treated whey protein concentrate as fat replacer. J. Food Sci. 2015;80(4):788-794.
22. BR Johnson. Whey protein concentrates in low-fat applications. U.S. Dairy Export Council, Applications Monograph. Low-fat applications; 2000. p. 1-8.
23. M Stoliar. Whey ingredients in bakery products. U.S. Dairy Export Council, Applications Monographs. Bakery; 2009. p. 1-8.
24. A Pernot-Barry. Importance of whey ingredients in confectionery products. 5th International Whey Conference, Paris; 2008.
25. M Nastaj, B Sołowiej and W Gustaw. Physicochemical properties of high protein meringues made from different whey protein preparations. Zywnosc. Nauka. Technologia. Jakosc. 2014; 21(2):33-47.
26. H Jooyandeh, KS Minhas and A Kaur. Sensory quality and chemical composition of wheat breads supplemented with fermented whey protein concentrate and whey permeate. J. Food Sci. Technol. 2009; 46(2):146-148.
27. A Krzeminski, F Angelika, K Busch-Stockfisch, W Mechthild and J Hinrichs. Whey protein–pectin complexes as new texturizing elements in fat-reduced yoghurt systems. Int. Dairy J. 2014; 36(2):118-127.
28. M Jasinska, J Trzcinski, I Dmytrow and A Mituniewicz-Małek. Whey protein concentrates and whey-fat preparations as

powdered milk substitutes in soft service ice cream. Acta Agrophys. 2012; 19:37-50.
29. SA Khillari, PN Zanjad, KS Rathod and M Raziuddin. Quality of low fat ice cream made with incorporation of whey protein concentrate. J. Food Sci. Technol. 2007; 44(4):391-393.
30. MS Alfaifi and CE Stathopoulos. Effect of egg yolk substitution by sweet whey protein concentrate (WPC), on physical properties of Gelato ice cream. Int. Food Res. J. 2010; 17(3):787-793.
31. B Sołowiej, S Mleko and W Gustaw. Physicochemical properties of acid casein processed cheese analogs obtained with different whey products. Milchwissenschaft. 2008; 63(3):299-302.
32. E Salvatore, M Pes, G Falchi, D Pagnozzi and Pirisi A. Effect of whey concentration on protein recovery in fresh ovine ricotta cheese. J. Dairy Sci. 2014;97(8):4686-4694.
33. S Galus and J Kadzinska. Whey protein edible films modified with almond and walnut oils. Food Hydrocolloid. 2016;52: 78-86.
34. M Frenzel and A Steffen-Heins. Whey protein coating increases bilayer rigidity and stability of liposomes in food-like matrices. Food Chem. 2015;173:1090-1099.
35. AC Baldissera, F Della Betta, ALB Penna and JD Lindner. Functional Foods: a new frontier for developing whey based protein beverages. Semin. Cienc. Agrar. 2011;32(4):1497-1511.
36. I Jelicic, R Bozanic and L Tratnik L. Whey-based beverages-a new generation of dairy products. Mljekarstvo. 2008;58(3):257-274.
37. S Rittmanic. Whey proteins in ready-to-drink beverages. U.S. Dairy Export Council, Applications Monograph. Beverages 2006. p. 1-8.
38. S Sood, S Minhas, M Kalia and R Modgil. Studies on formulation of ready to use weaning foods mixes with soy-whey. J. Dairying Food. 2010;29(1):42-46.
39. Malik J, Kulkarni S. Incorporation of concentrated whey in the production of soup sticks. Indian J. Dairy Sci. 2009;62(1):14-19.
40. KV Rai and HM Jayaprakasha. Formulation instant gulabjamun mixes from admixture of spray dried skim milk powder and whey protein concentrate. J Food Sci. Technol. 2004;4(3):244-247.
41. AR Jindal, M Singh and FC Shukla. Utilization of chhana and paneer whey in the preparation of kadhi and pakoras. J Food Sci Technol 2005;42(15):31-35.

How to cite this article: Sharma K, Chauhan ES. Multifaceted whey protein: its applications in food industry. Int J Health Sci Res. 2018; 8(10):262-268.

******