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Protein based fat replacers: Types and health benefits

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Abstract
The food industry places a high priority on the creation of no- and low-fat products as customers continue to look for ways to improve their dietary practices. Using fat substitutes is crucial to maintaining the sensory and physiological effects that fat has on the body as a meal component. To achieve low-calorie, low-fat claims and prevent quality degradation after fat removal or decrease, fat replacers are utilized. It has been found that protein-based fat substitutes are the most efficient at replacing the highest percentage of fat while also providing a variety of health benefits. Protein-based fat substitutes come from both plant and animal sources, including milk, wheat, eggs, and corn. This review studies different protein-based fat substitutes on the market, as well as their health benefits.

Keywords: milk, wheat, eggs, and corn, food industry, fat replacers

Introduction

Consumers have recently reduced their consumption of foods high in sugar, fat, salt, and chemical additives due to its health effects (Paglarini *et al*., 2020). They are concerned about high saturated fat consumption because it has been linked to the emergence of various chronic ailments, including obesity, hypertension, and hence an increased risk of cardiovascular diseases (Tarino *et al*., 2010) [3]. This has led to an increase in market for functional foods. High-fat meals that are often made of saturated fatty acids, cholesterol, and trans-fatty acids have been modified to be healthier (Paglarini *et al*., 2020). However, the presence of fat in food is preferred since it enhances emulsion qualities, acceptability, palatability, textural features, etc. As a result, utilizing fat replacers in diet is necessary to replace fat. These fat replacers have fewer calories per unit than fat molecules (Kew *et al*., 2020) [4]. Fat replacers are generally classified as fat mimetics or fat substitutes. Fat mimetics are macromolecules that resemble triglycerides chemically and physically whereas the molecular composition of ingredients referred to as fat substitutes, differ from true fat and they are either protein or carbohydrates-based (Ognean *et al*., 2006) [34]. Proteins are usually referred to as polypeptides and are organic substances made up of amino acids (Yashini *et al*., 2019). When compared to other macronutrients, proteins provide more satiety and contribute to only 4 kcal per gram, making them an excellent replacement for fat (Benelam, 2009; Veldhorst *et al*., 2009) [1, 2]. They have demonstrated the greatest ability to replace fat relative to all other known fat substitutes and is therefore a viable fat replacer due to its functional characteristics. Protein also decreases the risk of developing chronic diseases to varying degrees and offer health advantages. The primary source of protein and an increased consumption of it affect the nutritional makeup of food, replacing carbs and fats in the diet (Richter *et al*., 2015) [5]. Protein-based fat replacer can be classified as plant-based or animal-based protein fat replacer depending upon its origin and may come from meat, eggs, soy, or other sources. Animal and plant proteins are used to create protein-based fat substitutes that replicate the texture and sensory qualities of fat in meals. They typically have a spherical form and are 0.1-3.0 microns in size (Yashini *et al*., 2019).

Protein based fat replacers

A high-protein diet has been demonstrated to improve body composition and metabolism. Protein is a crucial macronutrient. According to a recent study, protein deficiency is one of the biggest public health issues, particularly in poor countries (Gomes *et al*., 2009) [6]. According to new studies the regulation of body composition and bone health, gastrointestinal function and bacterial ecology, glucose homeostasis, cell communication, and satiety are all areas where protein and amino acids play more intricate roles (Millward *et al*., 2008). Foods high in protein typically contain both plant and animal proteins.

Functional characteristics of protein in the food system include solubility, viscosity, water binding, emulsification, gelation, binding of fat and taste, foaming, and textural features (Kinsella & Melachouris, 1976) [7]. Protein functionality is influenced by the composition, processing techniques, additives, and pH. It has been claimed that the protein-based fat replacement strategy benefits foods with lower fat content. The addition of protein-based fat substitutes not only replicates the properties of fat but also lessens the detrimental effects of protein interactions in low-fat diets. The fat in dairy products, ice cream, mayonnaise, sour cream, butter, cheese, and other baked goods can be replaced with protein-based fat alternatives (Marcus, 2013) [8].

Animal Protein Based Fat Replacers

Animal based protein fat replacers are derived from poultry, eggs, meat, fish and contain all essential amino acids. These are considered superior proteins due to their easy digestion and higher biological value than plant proteins (Millward *et al*., 2008). Animal proteins make for an excellent fat substitute because of their various functional qualities, including emulsion stability, ability to keep fat and flavour, foaming activity, etc. (Yashini *et al*., 2019).

Egg white protein

Major proteins found in egg white like Ovalbumin (54%), ovotransferrin (12%), ovomucoid (11%), ovomucin (3.5%), and lysozyme (3.5%) have a lot of potential for industrial applications (Campbell *et al*., 2003). Various techniques are used to extract the protein from eggs, including salting out, aqueous biphasic systems, and more. The isolated proteins can be employed in the food and pharmaceutical industries either unmodified or after being altered by enzymes. The primary application of lysozyme is as a food preservative. Ovomucin is used as a tumour suppressant, and ovalbumin is frequently used as a nutritional supplement (Abeyrathne *et al*., 2013). Rovers *et al*., (2016) [13] compared the rheological and tribological characteristics of model food systems to examine the potential of microbubble dispersions in egg white protein as fat substitute and texture modifier. When introduced into a model food system, it was demonstrated to be an effective fat replacer (liquid with and without thickeners). The authors also noted a reduction in friction, albeit with less mouthfeel and indicated that the egg white protein's microbubbles may be employed as fat substitutes.

Plasma protein

Protein from bovine blood plasma is inexpensive. Bovine blood is mixed with anticoagulant in the slaughterhouse, then centrifuged at 1000 g for 15 minutes to separate the bovine plasma (Yashini *et al*., 2019). It is used as a fat replacer due to its excellent functional properties. Viana *et al*., (2015) [14] examined how the quality of ham paté would be affected by the addition of globin (10%), plasma (10%), or both (5%) as fat substitutes. Following the fat replacement and 25–35% fat reduction, the results indicated an increase in moisture and protein concentrations. The consistency, flavour, and aroma remained unchanged.

Whey protein

Twenty percent of the protein in milk comes from whey protein, a residue of the dairy industry. It is made from the proteins that are soluble at a pH of 4.6 and 20°C after caseins have been extracted from milk (Patel, 2015) [15]. Whey protein solutions are made by combining powdered whey protein with deionized distilled water and stirring with a magnetic stirrer for 90 minutes at room temperature. Whey can undergo additional processing to create spray-dried products such as WPCs, WPIs, or whey protein hydrolysates as shown in Figure 1 (Gangurde *et al*., 2011) [28]. Depending on the intended use and outcomes, whey can be used as a fresh pasteurised liquid or in the form of condensed products Whey Protein Concentrate (WPC) or Whey Protein Isolate (WPI). Lobato-Calleros *et al*., (2004) [16] the rheological characteristics of microparticulated whey protein (MWP), whey protein concentrate (WPC), and a combination of both in low-fat and high-fat yoghurt. The findings demonstrated that (a) MWP and mixtures of MWP and WPC did not modify their rheological properties and (b) WPC had similar flow and viscoelastic properties to that of full-fat yoghurt.

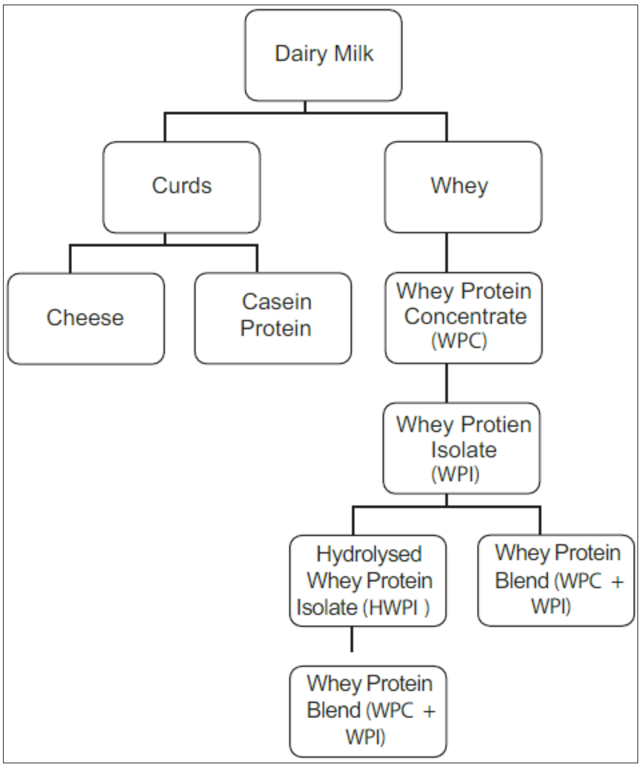

Fig 1: Manufacturing of whey protein
Gangurde, H., Chordiya, M., Patil, P., & Baste, N. (2011) [28]. Whey protein. Scholars' Research Journal, 1(2)

Gelatin

Collagen, which is used to make gelatin, is obtained from animal sources as skin, bones, and connective tissue of pigs, cows, fish, birds, and insects. It contains a lot of essential amino acids (Yashini *et al*., 2019). Gelatin was utilised at five different levels: 0, 0.25, 0.5, 0.75, and 1 percent by Farahnaky *et al*., (2011). They tested five samples of low-fat ice-cream with 20 percent fat each for viscosity, Bostwick consistency, textural hardness, and sensory qualities before being compared to a control sample with 30 percent fat. The outcomes showed that gelatin was able to enhance the low-fat cream samples qualities in comparison to the 30% control. Sensory evaluation tests revealed that the low-fat creams with 0.75 and 1 percent gelatin had the same perception scores as the 30 percent fat control.

Plant Based Protein Fat Replacers
Plant proteins make up the majority of the world's available protein per capita and are often regarded as incomplete proteins. As a result, as compared to animal proteins, plant proteins frequently include less amino groups, such as sulphur, methionine, lysine, and threonine (Young and Pellett, 1994) [9]. Due to larger consumption of non-essential amino acids, plant protein may be able to reduce the risk of developing chronic degenerative illnesses (Nishinari *et al*., 2014) [10]. Plant based protein can be derived from various sources like pulses, cereals, fruits and vegetable. Some plant based proteins are pea protein, soy protein and wheat gluten (Massey, 2013) [11]. Plant proteins are being used by food makers because of their ability to replicate the qualities of fat in low-fat diets.

Pea protein
The four main types of pea protein are albumin, prolamin, glutelin, and globulin, the latter two of which constitute the main storage proteins in pea seeds. Pea protein has a high quantity of lysine and an amino acid composition that is well-balanced (Lu *et al*., 2020) [17]. In order to replace protein ingredients made from animal sources, the food industry is constantly looking for less expensive alternatives that are also healthy. Due to its non-genetically modified organism (GMO), gluten-free, nutritive, and low allergenicity, pea protein offers potential in addressing this gap (Lam *et al*., 2018) [18]. In a study conducted by Visi *et al*., (2018) [19] turkey sausages made in the Bologna style had some of their fat replaced with pea fibre or potato starch. When fat was partially replaced with some quantities of pea fibre (0.6, 1.2 percent) or potato starch, the majority of the textural qualities of full fat turkey sausage were recovered in the sausages (1.9%). It was found that sensory evaluations of low fat sausages and instrumentally assessed values of hardness and chewiness correlated significantly.

Soy protein
Soya bean contains a protein called globulin, which is insoluble in water along with roughly 40% protein, 20% oil, 15% mono- and oligosaccharides, and 15% dietary fibre (Nishinari *et al*., 2014) [10]. Because glycinin, a substance with known gelling, emulsifying, and foaming capabilities, is present, soy protein exhibits excellent emulsifying and whipping properties (Renkema & Vliet, 2002) [21]. In a study conducted by Nery *et al*., (2015) [22] the fatty acid profile of panela-type cheese (a Mexican fresh cheese), emulsified soybean oil with soy protein isolate and different carrageenan was employed as fat replacer. Due to soy protein isolate in emulsified soybean oil, the replacement of milk fat in panela-type cheese led to greater cheese yield values and moisture content, as well as a concurrent reduced fat phase and higher protein content. The substitution of fat led to a texture that was stiffer but less cohesive, springy, and resilient. These texture variations were caused by unique interactions between the casein and carrageenan in the matrix of rennet-coagulated cheese.

Wheat gluten
Gluten is a wheat protein that, on a dry basis, is made up of 75% protein and 25% carbohydrate and lipids. The hardest of all wheat varieties, durum wheat has a protein content that ranges from 9 to 18 percent (Delcour *et al*., 2012) [23]. In addition to the inherent attributes of wheat, which are anchored in genetic as well as environmental factors, gluten functionality and its contribution to the quality of the finished product depend on the processing of wheat flour. In the industrial setting, gluten is created using wet processing. Gluten may be utilised in baked goods due to its capacity to absorb water, elasticity, viscosity, and cohesivity (Wieser, 2007) [24]. In a study conducted by Zhang *et al*., (2021) [25] wheat protein modified with barley beta-glucan was used as a fat replacer in microwave cakes. Wheat protein was modified by glycosylation using barley beta-glucan at 70 °C, and the resulting glycosylated wheat protein was examined. They found that Glycosylation decreased the surface hydrophobicity of WP from 3787.8 to 2179.4 at pH 7.4, which resulted in an increase of 24.05 percent in emulsifying activity and a rise in emulsifying stability by 51.66 percent. Moreover, because of improvement in emulsification and hydrophobicity, it may be used as a substitute in microwave cakes. The results of the current study suggest that GWP could replace 50% of the additional oil in microwave cakes.

Corn zein protein
Zein, which makes up around 45 to 50 percent of the protein in corn, is the main storage protein. Commercial interest has been sparked by zein and related resins' ability to produce long-lasting, glossy, hydrophobic grease-proof coatings as well as their resistance to microbial attack (Shukla & Cheryan, 2001) [26]. Its dissolution in aqueous alcohol solutions led to its initial identification in 1897. Zein and other hydrophobic proteins can substitute fat because they share many of the same properties. Gu *et al*., (2016) [27] concluded that the reduced-pressure distillation approach can address the issues that arise with microparticulation techniques. They used a zein-based fat analogue to make mayonnaise in order to study the effects of fat substitution and the permitted level. Based on tests of the prepared zein-based fat analogue's appearance, stability, total calorific value, rheological, microstructure, and sensory properties, they found that the acceptance level for substituting fat ranged from 1 to 40%.

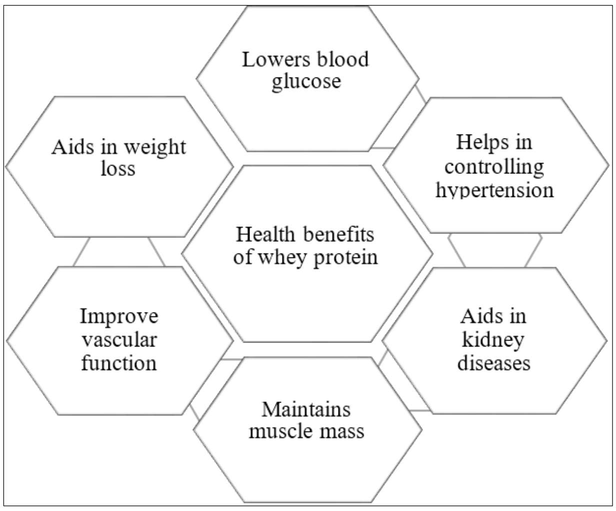

Fig 2: Health benefits of protein and protein based food products

Health benefits of protein and protein based food products
Proteins can be categorized on the basis of their functions, enzymes and structure. Amino acids combine to make

proteins, which are molecules that contain nitrogen. They act as the primary structural element of the body's muscles and other tissues. They are also utilised to make haemoglobin, enzymes, and hormones (Hoffman & Falvo, 2004) [30]. Whey protein which is a by-product of cheese making helps to prevent diseases including hypertension, diabetes mellitus, obesity, and cardiovascular disorders since it contains necessary amino acids, antioxidants, functional peptides, and immunoglobulins (Patel, 2015) [15]. Whey protein can be quite helpful for controlling weight. Leucine is one of several components of whey protein that are being researched for its potential to increase satiety, affect glucose homeostasis, retain lean body mass, and stimulate fat reduction (Jacqmain *et al*., 2003) [29]. Because of their nutritional, health-improving, and practical benefits, whey proteins from cows are frequently used in food products. GI-digested whey proteins increase the levels of antioxidant indicators in intestinal cells. Following digestion in the gastrointestinal tract, -lactoglobulin and -lactalbumin shield human intestinal cells against the production of free radicals (Corrochano *et al*., 2018) [31]. One of the top causes of death worldwide is high blood pressure (140/90 mmHg) (Mancia, G. *et al*., 2007) [32]. Epidemiological studies have shown a relationship between dairy consumption and decreased blood pressure. Over the course of an 8-week intervention period, individuals who had been fasting had improvements in a number of cardio-metabolic risk factors, such as 24-hour blood pressure, arterial reactivity, blood lipids, and a number of vascular function markers (Fekete, Á. A. *et al*., 2016) [33]. Compared to animal and dairy proteins, which result in undesirable byproducts, whey protein has a high Protein Efficiency Ratio, making it the optimal protein to consume in cases of renal failure (Gangurde *et al*., 2011) [28].

Conclusion

A possible substitute for high-fat foods seems to be protein-based fat. As a result, it can avoid several health risks caused by dietary fats, including obesity, cardiovascular problems, diabetes, and chronic diseases. Because plant proteins contain fewer amino acids than animal proteins and have different nutritional characteristics, research suggests that they may be beneficial for lowering cholesterol and heart disease. Moreover they provide only 4 calories per gram as compared to fat which provides 9 calories per gram. In order to ensure a nutritious diet, plant proteins can be substituted for carbohydrates and lipids in diets with low amounts of animal proteins. When combined with polysaccharides in an emulsion, other animal proteins including collagen and gelatin sources have been found to function better as fat substitutes.

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