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Review article

WHEY APPLICATIONS IN PLANTS

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Abstract

The recent advances in biotechnology and engineering fields have made a set of new products which are coherent with environmental values and can be produced from agricultural and other renewable resources. In the framework of getting freed from petroleum dependency, the fact that many petroleum-based products can be replaced with their renewable counterparts has placed the bio-based products in the research priorities of not only developed but also developing countries. It has been demonstrated that renewable/clean energy, different industrial chemicals, and other value-added products can be produced from different biomass sources including wastes. This approach considers wastes not only in terms of their treatment/ disposal, but also as a valuable resource for energy production and bio-product formation. The uncontrolled disposal of the municipal and agro-industrial wastes and wastewaters not only results in significant environmental and public health problems such as global warming, acidification, oxygen depletion, eutrophication, odor, etc. but should also be regarded as an economical loss**.**

Key words : Whey, Industrial wastes, Organic liquids, Acidic whey, Antioxidant wastes.

Introduction

The current use of whey, as well as its preparations, is made possible thanks to numerous studies in this area. Whey derived from cow's milk, as well as sheep ,goat or camel milk can be processed. Production of whey powder has recently increased in the European Union from 1,950,000 t in 2011 to 2,200,000 t in 2014 (EWPA, 2015). Whey is a coproduct of many familiar processed milk products. In general, there are two types of whey: sweet whey and acid whey. Sweet whey is a coproduct of cheese production, and the dairy processing industry has been handling large amounts of sweet whey in the region for many decades. Acid whey is a coproduct of foods such as Greek style yogurt, cottage cheese and cream cheese.

Types of Whey and its utilities

A. Sweet whey is the liquid by-product generated from making hard cheeses. Sweet whey is valuable to the food industry and is often turned into protein powders for use in sports drinks, nutrition bars, and other foods

B. Acid whey is the liquid by-product left over after yogurt has been strained or centrifuged to produce thick and creamy Greek yogurt. Acid whey is also a by-product of making cream cheese and Quark, a dairy product made by heating acidified milk and straining the curds. Acid whey contains low amounts of proteins compared with sweet whey and therefore is considered less valuable as a raw material for the food industry. Work is underway to make protein and lactose extraction from acid whey more economical and to create nutritional food products from acid whey

In some cases, companies are also investing in anaerobic digesters that rely on microbes to break down acid whey into methane that can be used to generate electricity, Work is also underway to turn yogurt acid whey into animal feed and industrial-grade ethanol. Acid whey contains smaller amounts of proteins when compared with sweet whey, which is leftover from making hard cheeses. But acid whey contains significant amounts of lactose, galactose, calcium phosphate, and lactic acid (Alsaed *et al.*, 2013).

Characteristics and composition of Whey

Whey is the basic by-product of cheese manufacturing. It is the liquid remaining after the precipitation and removal of milk casein during cheese manufacturing and although there are hundreds of types of cheese, all cheese has to undergo the same basic processes, producing this liquid cloudy water, known as whey. Cheese-whey represents about 85-95% of the milk volume and retains 55% of milk nutrients. The most abundant of these nutrients are lactose (4.5-5% w/v), soluble proteins (0.6-0.8% w/v), lipids (0.4-0.5% w/v) and mineral salts (8-10 w/v of dried extract). Cheese-whey salts include NaCl and KCl (more than 50%), calcium salts (primarily phosphate) and others. Besides those, cheese-whey also contains lactic (0.05% w/v) and citric acids, non-protein nitrogen compounds like urea and uric acid, B group vitamins and so on (Coton, 1976; Marahwa and Kennedy, 1988). There are two main types of cheese-whey; acid and sweet. Acid whey has a pH less than 5 and sweet, whey has a pH above 5 (6-7 mainly). The type of the whey produced depends on the procedure used for casein precipitation. Acid wheys have higher ash and lower protein contents than sweet wheys. Thus, their use in alimentation is more limited than that of sweet whey, because of their acidic flavour and high saline content (Mawson, 1994).

Table 1 : Chemical analysis of cheese-whey constitutions (Harone and Ibrahim, 2003).

Whey constituents	Concentration (%)
Water content	89.60
Total solids	10.40
Ash	0.98
Protein	0.90
Fats	0.30
Lactose	5.90
Ca^{2+}	0.07
Na^{+}	0.05
Mg^{2+}	0.06

Use of Whey in plant protection

Researches focused on the use of alternative method to avoid the undesirable effects of the insecticides. In 1940s several investigators suggested the use of milk as spraying or dipping of seedlings for reducing the incidence of virus infections. Recent studies demonstrated the effectiveness of milk in reducing infection of tobacco mosaic virus (TMV) in pepper, tomato, and tobacco (Childs *et al*., 2003). Whey represents a rich and heterogeneous mixture of secreted proteins with wide ranging nutritional, biological and food functional attributes. The main constituents of whey are a-lactalbumin (ALA), b-lactoglobulin (BLG) and two small globular proteins that account for approximately 70-80% of total whey protein. Historically, whey has been considered a waste product and disposed of in the most cost-effective manner, or processed into relatively low value commodities such as whey powder and various grades of whey protein concentrate/isolate (WPC, WPI). Nowadays, whey proteins and their derivatives are widely used in the food industry due to the excellent functional and nutritive properties adding to the commercial value of the processed foods (Crisp *et al*., 2001). The biological components of whey proteins, including b-lactoglobulin, a-lactalbumin, lactoferrin, lactoperoxidase, immunoglobulins and glycomacropeptides, demonstrate a wide range of immune enhancing properties, and act as antioxidant, antihypertensive, antitumer, antiviral, antimicrobial and chelating agent. They also improve muscle strength and body composition and prevent cardiovascular, cancer diseases and osteoporosis (Crisp *et al*., 2006). In spite of their high biological properties, native whey proteins are not hydrolyzed easily by means of digestion enzymes as pepsin and trypsin, due to disulfide bonds in the protein molecules. The poor digestibility of whey proteins is considered to be the reason for their allergenicity (EWPA, 2015). Therefore, modification of whey proteins to enhance or alter their biological and functional properties may increase its applications. Whey protein modification can be accomplished by chemical, enzymatic, or physical techniques (Finstein *et al*., 2004). Acetylation, succinylation, esterification, amidation, phosphorylation and thiolation are chemical modifications that induce significant alterations of the structure and functional behavior of whey proteins. Relatively small alterations of structure, brought about through chemical derivatization, often can be reflected in significant changes of physical and biological properties [Galston et al,1990]. Many studies concerned with the antiviral activity of native and modified whey proteins in human (González Siso, 1996). Other studies focused on the use of native and modified whey proteins fractions (a-lactalbumin, b-lactoglobuline and lactoferrine) to control plant viruses. The results in many research in tomato,pepper, eggplant,cucumber and pumpkin indicated that native or modified whey proteins fractions can be used for controlling the viruses in the infected plants.

Use Whey in postharvest treatment

The increasing growth in the consumption of fresh fruits and vegetables over the last century has driven commercial demand for improving the storage/transit conditions to manage postharvest disease proliferation

and also maintain the quality (i.e. flavour, colour, nutritional aspects, firmness, 'shelf-life' and processing attributes) of fresh produces. Flavour and appearance were the most important attributes of fresh fruits and vegetables, but now consumers are more concerned about food safety and nutritional value. Currently chemical treatments (mainly, 100–200 mg/L chlorine) are used to sanitise fresh produce. However, there are growing health and environmental concerns over current practices, mainly due to the risk of generating potentially harmful (carcinogenic) by-products and residues. There are also growing practical concerns over the increasingly poor control achieved over a spectrum of spoilage organisms. As a consequence, there is considerable interest in alternative, safe, but effective, sanitising agents for use in the fresh produce industry (Siso, 1996). Several researchers have attempted to find the best compromise between extended shelf-life and maintenance of nutritional value. However, none have yet gained widespread acceptance by the industry. Nowadays, there is a renewed growing interest in the use of natural products for the preservation of fresh fruits and vegetables. Research and commercial applications have shown that natural components could replace traditional washing agents (Martin-Diana *et al*., 2006). Whey permeate is a by-product of the production of whey protein concentrate from cheese whey. The main components of whey permeate are water, lactose, peptides and minerals. Whey is used as a fermentation feedstock for the production of lactic acid, acetic acid, propionic acid, ethanol and single cell protein, etc. (Abdel-Rahman and Abo-Hamed, 1992).

Whey as plant nutrient

Over the last few years, several studies were carried out concerning the beneficial properties of whey *i.e.* its nutritional value and pharmacological properties like as antimicrobial, antiviral and anti-oxidant properties. It can offer a kind of protection against cancer and heart diseases and assists at the enhancement of immune defence (Charu *et al*., 2012). One ton of cheese resulted in the production of about 8 tons of liquid whey (Abed AL-Hussain and Muhammed, 2016). A few number of investigators mentioned that whey was used on some crops as nutritive or resistance to some diseases. In this regard, when whey was sprayed at different concentrations (25-100%) with nutrient elements on tomato and okra and potatoes caused significant increases of vegetative growth, yield and fruit quality. Aliphatic polyamines *i.e.*, spermidine, spermine and their obligate di-amine precursor putrescine are polycationic compounds of low molecular weight that have been proposed to be a new category of plant growth regulators or secondary hormonal messenger. They are implicated in a wide range of plant physiological processes such as morphogenesis, flower differentiation and initiation, pollen viability, root growth, somatic embryogenesis, anti-senescence, and biotic/a biotic stress responses. Polyamines have been suggested to be associated with cell division. Therefore, they can be utilized to regulate fruit development.

Whey to Correct pH in alkaline soil

Because whey is acidic, with a pH between 4.0 and 6.1, it can be used to correct pH in soils too alkaline for specific plants. Cottage cheese whey is the most strongly acidic, so it's the most effective at lowering pH. Soils high in calcium carbonates cannot grow acid-loving plants such as azalea (*Rhododendron* spp.) unless the pH is lowered. These plants prefer a soil pH of pH 4.5 to 5.5, so watering them with whey not only supplies needed nutrients but also provides a healthier pH. Azaleas are hardy in U.S. Department of Agriculture plant hardiness zones 4 through 9, depending on the variety (Prasad *et al.*, 2000).

Whey as fungicides

Crisp *et al*. (2006) suggested that whey extracts are potential alternatives to sulfur and synthetic fungicides for the control of powdery mildew in grapevines. The present reserches provides relevant information about the potential of whey to control powdery mildew in many vegetables plants. The results show the ability of whey to prevent the build up of powdery mildew when applied directly to the plants. However, complementary studies are needed to characterize the modes of action of whey, and to establish the ideal concentrations and application frequency of whey in vegetables plants grown under commercial conditions. Many researches recommended that growers who wish to use whey against mildew should conduct initial tests on a small scale in the target crop. The characteristics of whey such as electrical conductivity and pH need to be considered in order to avoid phytotoxicity. Whey may also have value for controlling other pathogens and pests , including virus vectors. Inaddition, the effects in other non-target organisms such as the natural microflora of the phylloplane should be considered.

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