The Nutraceutical Effects OF Dairy Products Fortification With Plant Components: A Review

Nadia A. Abou-zeid (Ph.D, M.Dairy , B. Agric)

Dairy Science and Technology Department, Faculty of Agriculture ,Menoufia University, Shebin El-kom, Egypt

ABSTRACT: Nutrition scientists have mentioned that fortification of dairy products using plant resources (vegetables ,fruits, cereal, seeds , etc.) is one of the best ways to improve the overall nutrient intake of dairy products with minimal side effects. However, growing interest in the nutraceutical properties of dairy products has directed the attention of researchers to improve the quality of dairy products. Plant for example , soybean seed contains an array of nutritionally important constituents, many of them were previously dismissed as antinutrients, but more recent investigations proved that they have prevented many diseases. Therefore ,incorporation of plant ingredients(dietary fiber, phenolic compounds ,phytosterols, Isoflavones, and extra)in dairy products might have conferred several nutritional advantages .

I. INTRODUCTION

Plant callus/cell cultures were shown to possess a promising potential for the production of nutraceutical components These components exhibit several advantages .In the recent years, interest towards foods containing natural food components that improve the well-being of the general public, has increased. Those components, termed nutraceuticals or functional compounds, have been clinically proven to prevent the occurrence of certain diseases as long as they are consumed at recommended levels on a daily basis. Over the past 10 years, efforts have increased to develop suitable vehicles by which nutraceuticals are delivered to the human body. Dairy fortification is one of the most important processes for improvement of the nutrients quality and quantity in food. It can be a very effective public health intervention due to the high consumption rate of dairy products. For the above mentioned, dairy products fortified with one or more of plant component could be the best nutraceutical food. This review describes a well-rounded picture of the current understanding of structural, functional, and nutritional properties of plant components which could be used for dairy products fortification and highlights the recent progresses in production of value-added nutraceuticals plant component to dairy product via dairy products properties.

II. LITERATURE SURVEY

Plant contains an array of nutritionally important constituents. (Nestle 2013). Many of them were previously dismissed as antinutrients, but more recent findings suggest they might have significant roles in disease prevention, Jelena Medic et al 2014.

1- Dietary fiber :

A- Definition of plant fiber:

Plants contain compounds including cellulose, hemicellulose, lignin and pectin collectively known as dietary fiber, that the enzymes in your intestines cannot digest.

Dietary fiber has long history, its term originating with Hipsley (1953) who coined dietary fiber as a non-digestible constituents making up the plant cell wall and further its definition has seen several revisions. Botanists define fiber as a part of the plant organs, chemical analysts as a group of chemical compounds, consumer as a substance with beneficial effects on human health and for the dietetic and chemical industries dietary fiber is a subject of marketing. Later dietary fiber was defined as a ubiquitous component of plant foods and includes materials of diverse
Dietary fiber is resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary fiber includes polysaccharides, oligosaccharides, lignin and associated plant substances. During the year 2001, Australia New Zealand Food Authority (ANZFA) defined dietary fiber as that fraction of the edible part of plants or their extracts, or analogous carbohydrates, that are resistant to digestion and absorption in the human small intestine, usually with complete or partial fermentation in the large intestine. The term includes polysaccharides, oligosaccharides and lignins. The panel on the definition of dietary fiber constituted by National Academy of Science during the year 2002 defined the dietary fiber complex to include dietary fiber consisting of non-digestible carbohydrates and lignin that are intrinsic and intact in plants, functional fibers consisting of isolated, non-digestible carbohydrates which have beneficial physiological effects in humans and total fiber as the sum of dietary fiber and functional fiber.

B-Classification of dietary fiber:

Dietary fiber is classified into two categories such as water-insoluble/less fermented fibers: cellulose, hemicellulose, lignin and the water-soluble/well fermented fibers: pectin, gums and mucilages (Anita and Abraham 1997 & Tungland and Meyer 2002).

Chau and Huang 2003 reported that fiber-rich fractions (FRFs) including soluble and insoluble dietary fibers (SDF and IDF), alcohol-insoluble solid (AIS), and water-insoluble solid (WIS) were isolated from the peel of Citrus sinensis L. cv. Liucheng. The peel was rich in insoluble FRFs (IDF, AIS, and WIS: 476-515 g kg(-1) of peel), which were mainly composed of pectic substances and cellulose, and also contained pectic polysaccharide-rich SDF (94.1 g kg(-1) of peel). These insoluble FRFs had water-holding capacities (15.5-16.7 mL g(-1)), oil-holding capacities (2.35-5.09 g g(-1)), cation-exchange capacities (454-997 mequiv kg(-1)), and swelling properties (14.6-21.1 mL g(-1)) much higher than those of cellulose. These results recommended the consumption of these peel insoluble FRFs of desired physicochemical properties as sources of food fibers or low-calorie bulk ingredients in food applications requiring oil and moisture retention.

C-Important Of Fortified Dairy Products with Dietary Fibers:

Milk, defined as the fluid secreted by the mammary glands of mammals, contain no fiber. Dairy products have recently come under fire from researchers showing the detrimental effects of saturated fat and cholesterol in the body. Researchers reported positive effects of fiber in the diet. Fortification of dairy products using natural resources (fruits, cereal, etc.) is one of the best ways to improve the overall nutrient intake of food with minimal side effects. Consumption of products containing high fiber may prevent or decrease hypertension, hypercholesterolemia, obesity [Van Dam and Seidell2007], gastrointestinal disorders [Elia and Cummings2007], coronary heart disease [David et al 1990, Pereira et al 2004 and Mann 2007], diabetes [Anderson et al 2004], [Venn and Mann 2004], [Au et al 2013], and cancer [Bingham et al 2003 and Pereira et al 2004]. Legumes represent, together with cereals, the main plant source of proteins in human diet. They are also generally rich in dietary fibre and carbohydrates. Minor compounds of legumes are lipids, polyphenols, and bioactive peptides. Fortifying yogurt or dairy products with fiber is of increasing interest to create functional foods with health benefits and improve their functionality. Fortifying yogurt with dietary fiber would complement its healthy properties Estrella Fernández-Garí a, 1998. Inulin is a prebiotic fiber that is fermented in the lower intestine by the beneficial bacteria, Bifidobacterium. Because inulin is a lower calorie carbohydrate, it is beneficial in formulating reduced and low calorie foods. Inulin has little or no impact on blood sugar making it a quality sugar substitute in low-glycemic foods.
D-Effect of plant fiber fortification on dairy products properties:

The importance of food fibers coupled with the fact that milk and milk products are devoid of dietary fiber has led to the successful development of various dietary fiber fortified dairy products such as yoghurt (Fernandez-Gracia et al. 1998; Chau and Huang 2003; Staffolo et al. 2004; Garcia-Perez et al. 2005; Kip et al. 2006; Aryana et al. 2007 and Guggisberg et al. 2009), cheese (Buriti et al. 2007, 2008 and Cardarelli et al. 2008), ice cream (Singh et al. 2005; Akalin et al. 2008 and Ahmadi et al. 2012), dairy dessert (Tarrega and Costell 2006), lactic beverage (de-Castro et al. 2009; Villegas and Costell 2007).

Estrella Fernandez-Garcia and McGregor 1997 Fortified sweetened plain yogurt with insoluble dietary fiber from five different sources (soy, rice, oat, corn and sugar beet). Fiber addition caused acceleration in the acidification rate of the experimental group yogurts, and most of the fortified yogurts also showed increases in their apparent viscosity. Soy and sugar beet fibers caused a significant decrease in viscosity due to partial syneresis. In general, fiber addition led to lower overall flavor and texture scores. A grainy flavour and a gritty texture were intense in all fiber-fortified yogurts, except in those made with oat fiber. Oat fiber gave the best results; differences with controls in terms of flavor quality scores not being statistically significant. The evolution of organic acids during the fermentation and cold storage of control and oat fiber-fortified yogurts showed a similar pattern; only acetic and propionic acids were found in significantly higher amounts in the fiber fortified product.

Calorie-reduced yogurts that were fortified with 1.32% oat fiber were prepared from lactose-hydrolyzed milk, alone and supplemented with 2 and 4% sucrose or with 1.6, 3.6, and 5.5% fructose. Fiber addition improved the body and texture of unsweetened yogurts but lowered overall scores for body and texture in yogurts sweetened with sucrose Estrella Fernández-Garfa1998.

The maximum acceptable amount of date fiber in fortified yogurt with potential beneficial health effects is 3%. Many researchers evaluated the effect of dietary fiber on dairy products and yogurt quality. The addition of 1.32% oat fiber improved the body and texture of unsweetened yogurt and decreased the overall flavor quality [Fernández et al. 1998].

Fiber of various sources is added to dairy products because of its water-holding capacity and its ability to increase the production yield, reduce the lipid retention, improve textural properties and structure, and reduce caloric content by acting as a bulking agent Larrauri 1999.

McDello Staffolo et al. 2004 studied the effects of different dietary fibers on sensory and rheological properties of yogurts fortified with these fibers. Commercial fibers from apple, wheat, bamboo or inulin were used. Rheological characterization was performed by dynamic, shear and compression–extrusion assays. Storage time and type of fiber were significant factors for instrumental analysis. Syneresis and pH did not show any difference, while only apple fiber yogurt showed color differences compared to control. An untrained sensory panel analyzed consumer acceptability. Even though fibers modified certain rheological characteristics of the plain yogurt, the panelists awarded the supplemented yogurts scores indicating acceptability. Native inulin, such as Oliggo-Fiber® Instant inulin, is an extremely versatile product for fiber fortification. As a soluble source of fiber, it can be easily incorporated into dairy products, including yogurt, ice cream and cheese. It also allows for fiber fortification into beverages, such as meal replacements, dairy-based beverages.

Date fiber (DF), a by-product of date syrup production, is a good source of dietary fiber. The effect of fortification with DF on fresh yogurt quality was investigated by Hashim et al. 2009. Control yogurt (without fiber), yogurt fortified with 1.5, 3.0, and 4.5% DF, and yogurt with 1.5% wheat bran (WB) were prepared. Yogurt fortified with up to 3% DF had similar sourness, sweetness, firmness, smoothness, and overall acceptance ratings as the control yogurt. Sensory ratings and acceptability of yogurt decreased significantly when increasing DF to 4.5% or using 1.5% WB. Flavoring yogurt fortified with 4.5% DF with vanilla did not improve flavor or overall acceptance ratings. Thus, fortifying yogurt with 3% DF produced acceptable yogurt with beneficial health effects.
Chen et al. 2010 reported that a pudding, and a low-fat ice cream, that have been fortified with soluble soybean polysaccharide at levels of 4%, and 2%, respectively were within acceptable ranges of rheological parameters and other physical stability measurements and were judged to be acceptable by sensory analyses.

Deepika Yadav et al. 2012 reported that soymilk is a well known protein enriched biofunctional food, but its acceptability was reduced due to the presence of complex sugars which gives soymilk beany flavor. However, fermentation had proven earlier reduction of such off-flavor in soymilk. Thus, soymilk was supplemented with 4% skim milk powder, 1.5% inulin and 10% strawberry pulp and fermented with combination of yoghurt culture NCDC-262 and L. acidophilus NCDC-195 (1:2) at 42oC for 6h. The yoghurt thus formed was evaluated for its antioxidative potential by ABTS, DPPH and FRAP method and was found to show 92% ABTS inhibition, 983.15 µM of TEAC, 54% DPPH reduction and 1364.25 µM FRAP reduction. Thus, soy based probiotic yoghurt can be nutritionally beneficial nutraceutical with persuasive antioxidative potential.

Replacement of skim milk powder with white sweet lupin flour up to 25% in ice milk did not affect the organoleptic properties and improved the nutritional value (El Sisi et al. 2014) Microbial production of value-added nutraceuticals was reported by Jian Wang et al. 2016.

Sajad Ahmad Wani, Pradyuman Kumar 2016 reported that Fenugreek (Trigonella foen-graecum) is a legume and it has been used as a spice throughout the world to enhance the sensory quality of foods. It is known for its medicinal qualities such as anti diabetic, anticarcinogenic, hypocholesterolemic, antioxidant, and immunological activities. Beside its medicinal value, it is also used as a part of various food product developments as food stabilizer, adhesive, and emulsifying agent. More importantly it is used for the development of healthy and nutritious extruded and bakery product. The above-mentioned studies on fenugreek suggest that the functional, nutritional and therapeutic characteristics of fenugreek can be exploited further in the development of healthy products.

Dibazar et al. 2016 study the effect of grape fiber and Lactobacillus Fermentum viability, physicochemical and sensorial properties in yoghurt during storage, using response surface methodology (RSM). Amounts of grape fiber, and storage time were in the range of 0-1.2%, 0-1% and 3-21 day, respectively. The results indicated that Lactobacillus Fermentum increased by increasing grape fiber during storage significantly. Moisture and syneresis of samples reduced significantly by increasing the amounts of fiber. Flavor scores decreased as grape fiber increased significantly, using 0.9% grape fiber and 12 day storage were found as optimum conditions for producing probiotic kiwi fruit yogurt.

2-Omega-3 and omega-6 fatty acids:

The group of poly-unsaturated fatty acids (PUFAs) is divided into two groups: omega-3 (n-3) and omega-6 (n-6) poly-unsaturated fatty acids (PUFA). Two PUFAs are called “essential fatty acids” since they cannot be synthesized in the human body and are vital for physiological integrity. Therefore, they must be obtained from the diet. One is linoleic acid (LA, C18:2n-6) and belongs to the n-6 family. The other one is α-linolenic acid (LNA, C18:3n-3) belonging to the n-3 family. These essential parent compounds can be converted in the human body to long-chain (LC) fatty acids, but humans cannot interconvert n-3 and n-6 fatty acids. LA can be converted to arachidonic acid (AA, C20:4n-6) and further on to longer chain derivates, and LNA to eicosapentaenoic acid (EPA, C20:5n-3) in a first step and docosahexaenoic acid (DHA) (C22:6n-3) in a next step. Omega-3 is considered an essential nutrient since it is the precursor of EPA and DHA, which cannot be synthesised in the human body (Awaish et al. 2005). Eicosapentaenoic acid and DHA are essential for development of the brain, concentration, and the learning ability of children, as well as promoting health in the general population (Milner and Alison 1999). α-Linolenic acid α-Linolenic acid are hypotriglyceridemic, improves cardiovascular function [Sugano 2006]

ALA is found in flax seed and various vegetable oils and nuts (Gruenwald 2009). Flaxseed is the most abundant source of α-linolenic acid (ALA). Its content in flaxseeds accounts for 53% of total FA (Bloedon and Szapary 2004). Moreover, fatty acid profile of flaxseed is characterised by an excellent ratio of ω 3 ω 3 FA. The excess of short- and medium-chain saturated FA and low level of unsaturated ω 3 FA in human diet are a common pattern observed in the Western countries. It is also considered as an atherogenic factor and the primary cause of cardiovascular diseases (Adkins and Kelley 2010).
3-Phenolic compounds:

Phenolics have significant attention in recent years due to their antioxidant, anti-inflammatory, anti-mutagenic and anti-clotting power which has been correlated with a declined risk of cardiovascular diseases and cancer development. [Fresco et al 2010]. The major dietary source of phenolic compounds is fruit [Record et al 2001]. It has been suggested that fruit juices [Coisson et al 2005], powders [Wallace, M. Giusti (2008)] and extracts have the potential to be used as functional ingredients in the food industry including dairy sector.

Plant callus/cell cultures were shown to possess a promising potential for the production of mainly anthocyanin and other phenolic in grapes [Hiroyuki et al 2002], carrots [Gläßgen et al 1992] and Cherries [Blando et al 2004]. These in vitro cultures exhibit several advantages over fresh fruit extracts such as possibility of continuous production of natural compounds [Blando et al 2004]. Grape seed is a by-product derived from the industries, and it contains a high amount of polyphenols, mainly proanthocyanidins [Correddu et al 2016].

4- Phytosterols:

Phytosterols is safe food ingredients [Engel and Schubert 2005; Taşan et al. 2006]; plant sterols and stanols have many applications as food additives and food ingredients [Osslund et al. 2003]. Phytosterols include sterols and stanol esters which are steroid alcohols. The phytosterols have shown potential in inhibiting cancers of the, lung, ovaries, stomach and breasts [Woyengo et al. 2009]. Plant stanols effectively reduce the absorption of all sterols from the digestive tract, hence also decreasing serum cholesterol levels. Jones et al. (1999) mentioned that added 1.7 g/day of phytosterols in the diet of hypercholesterolaemic men had the effect of lowering blood cholesterol. Daily consumption of low-fat milk containing 1.6 g phytosterols reducing Low Density Lipoprotein (LDL) levels by 8% after 6 weeks [Hansel et al. 2007]. The European Food Safety Association (EFSA) and USA Food and Drug Administration (FDA) have accepted plant sterols as food ingredients [EFSA 2009, FDA 2009].

Phytosterols are plant-originated fractions found in vegetable oils, seeds, nuts, cereals and beans (Clifton et al. 2004). The major phytosterols in nature are β-sitosterol, campesterol and stigmasterol (Mensink et al. 2002). β-sitostanol, campestanol and stigmastanol are saturated phytosterols that have no double bond in the ring structure. Phytosterols and stanols are structurally identical to cholesterol, but they are distinguishable by the presence of additional methyl or ethyl groups in their side chain (Abumweis et al. 2006). Phytosterol-enriched dairy products (high or low in fat) seem to be as effective as nondairy products in reducing serum LDL cholesterol (Clifton et al. 2004). However, no significant change in high-density lipoprotein cholesterol (HDL-C) and fat-soluble vitamins was observed (Westrate and Meijer 1998; Gylling and Meittinen 1999). A daily intake of 1.7 g of phytosterols and stanols is recommended to achieve optimal cholesterol-lowering action (Awaishel et al. 2005).

Dorothy Mackerras et al. 2013 mentioned that Phytosterols are an example of a functional food. Small amounts of phytosterols are found naturally in foods such as unrefined olive oil. More recently they have been extracted from “tall oils” which are by-products of wood pulp. Tall oils are not a traditional food in Australia and New Zealand and so phytosterols derived from them are classed novel food ingredients by FSANZ. Specific permissions following pre-market safety assessment are required before they can be added to foods.

Phytosterols have shown no inhibitory effects on growth and acid development by yoghurt starter cultures and had a positive effect on viability of single and mixed probiotic strains upon incubation and chilled storage (Awaishel et al. 2012). Soy Phytosterols is Hypocholesterolemic

5- Isoflavones:

Isoflavones can be found in many foods but the best known source is the soy bean (Messina 1999). Red clover is another source of isoflavones. As red clover is not suitable for direct consumption, the isoflavones extracted from red clover are used as supplements in the food industry. Isoflavones are secondary vegetable substances, which can act as oestrogens in the body and have protective functions. Soy isoflavones is Weak estrogenic activity [Sakai_andkogiso]

Isoflavones have potent antioxidant properties, comparable to that of the well known antioxidant vitamin E. The antioxidant power of isoflavones can reduce the long-term risk of cancer by preventing free radical damage to DNA. Genistein is the most potent antioxidant among the soy isoflavones, followed by daidzein. In nature, isoflavones usually occur as glycosides and, once deconjugated by the intestinal microflora, the isoflavone can be adsorbed into the blood (Awaisheh et al. 2005). It should be borne in mind that most isoflavones show poor solubility in water and lead to flavour defects such as bitterness and a beany taste.

6- Sphingolipids:


7-Phospholipids Hypocholesterolemic [Sugano 2006], reduces fat accumulation in the liver [Jimenez et al 1990], maintain brain functions (memory and learning abilities) [Linoleic acid Essential fatty acid, hypocholesterolemic Sugano 2006].

8- Lectins:

Lectins are anticarcinogenic [Sugano 2006 and Friedman and Brandon 2001].

9- Trypsin:

Trypsin was reported as inhibitor Anticarcinogenic [Sugano 2006 and Friedman and Brandon 2001].

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