



REVIEW

The Impact of Plant-Based Non-Dairy Alternative Milk on the Dairy Industry

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Abstract Vegetarians have claimed and actively promoted the advantages of plant-based alternative milks as the best option for human nutrition and health, compared to the natural dairy milk. However, numerous scientific evidences and reports have demonstrated that the natural milk possesses more beneficial nutrients and bioactive components than artificially manufactured plant-derived milks. The biochemical and nutritional advantages and functionalities of natural dairy milk cannot be replaced by man-made or crafted plant-based beverage products. On the other hand, the tremendous increase in production and consumption of the plant-based alternative milks in recent years has led a serious business downturn in traditional roles and stability of the dairy industry, especially in the major dairy producing Western countries. Although plant-based milk alternatives may have some benefits on nutrition and health of certain consumers, the plant-derived alternative milks may not overshadow the true values of natural milk. Milk is not a high fat and high cholesterol food as animal meat products. Unlike plant-based alternative milks, natural milk contains many bioactive as well as antiappetizing peptides, which can reduce body weight. It has proven that taking low-fat, cultured and lactase treated milk and dairy products with other diversified nutritionally balanced diets have been shown to be healthier dietary option than plant-based milk/foods alone.

Keywords plant-based, non-dairy milk, consumption, economic impact, dairy industry

Introduction

Owing to the current sudden emergence of COVID-19, all economy of the globe seems to be severely damaged and upside down with no signs of foreseeable fast recovery for many segments of businesses around the world including the dairy industry. Even before the COVID-19 worldwide pandemic crisis, the dairy industry in recent years has experienced the unprecedented troublesome tidal wave that caused a great threat on its healthy survival of the traditional dairy business. The recent surge of market share of the plant-based non-dairy alternatives into the beverage industry has seriously dampened the prospect of steady growth of the traditional milk and dairy industry. This continuous trend of tremendous economic losses or business downfalls

of the dairy industry has placed many current dairy operations and farmers on the verge of bankruptcy of their businesses, including many large dairy corporations in the US and other Western countries.

The current trend of consumer inclination towards a healthy lifestyle in developed countries has turned tables for the dairy industry. The demand for plant-based milk alternatives has been a rising trend especially among the vegetarians. The plant-based milk products can also serve as an inexpensive alternative option to economically underserved populations of developing countries as well as those people living in the regions where cow's milk supply is insufficient (Sethi et al., 2016; Sosulski et al., 1978; Park, 2018). Worldwide, plant-based non-dairy milk alternatives such as soy, almond, and oat milk are the fast growing segments in newer food product development category of specialty beverage. Transparency Market Research (TMR) reported that the plant-based milk market was valued at approximately US\$14 Billion in 2019, and forecasted approximately 8% of its annual growth during the period of 2019-2029 (TMR, 2019).

The Recent Trend of Beverage Industry

The increasing shift in consumer preference for plant-based food products in daily diets may drive up the market of plant-based alternative milk. The plant-based milk market also has been promoted by active advocates of restoration of veganism, where food manufacturers are opting for alternative sources of plant-based materials. On the other hand, the recent trend of tremendous economic losses or business downfalls of the dairy industry has been largely attributed to the aggressive promotion or scientifically uncertain claims by vegetarian or vegan people against the true values of the natural dairy milk. This resultant outcome of increased growth in the plant-based milk business sector has driven the dairy industry into serious revenue losses in milk sales, which in turn has driven the dairy industry and dairy farmers into serious drawbacks and pressures on the survival of the dairy operations in the US and Western world.

Vegans and vegetarians have actively promoted the advantages of plant-based alternative beverages over natural dairy milk, which include better health for preventing lactose intolerance and cow's milk allergy due to the benefits of lactose free, cholesterol free and low calorie foods or to reduce dairy impact on the planet. However, most of these claims are missing the other side of scientific information, and also impartial and missing the true values of natural milk in human health and nutritional benefits. Although the plant derived milk alternatives contain some functional active components with health promoting properties which attract health conscious consumers (Sethi et al., 2016) as the vegan activists have promoted, the plant derived products are lacking in various nutritional components, such as immunoglobulins and many bioactive constituents in natural milk. Furthermore, the plant-based alternatives cannot replace the quality characteristics of cow's milk in terms of taste, flavor, appearance, stability, rheology, and nutritional values. The purposes of this article are to review: (i) the recent trends of increasing consumption of plant-based milk alternatives, (ii) the serious negative impact of plant-based alternative milks on the business sustainability of the dairy industry, and (iii) the misconception of plant derived milk products over the natural dairy milk on human nutrition and wellbeing.

Missing Points on the Natural Milk by Vegan People

The vegans and vegetarian activist groups believe that all plant-based milks are preferred over cow's milk by consumers who are lactose intolerant or allergic to cow milk proteins, since the common benefits of plant-based alternative milks are lactose free, cholesterol free and low in calories (Valencia-Flores et al., 2013). These claims appear to be reasonable and have good points, while these claims are applicable only for small percentage of milk and dairy consumers especially in most of

developed countries. In addition, there are some major points missing on the true values of the natural dairy milk by the vegans' claims, such as many types of bioactive components, milk enzymes, bioactive peptides, immunoglobulins, oligosaccharides, organic acids, lactoferrin, nucleotides, milk vitamins, and minerals, and so on. These partial lists of compounds in natural milk do not exist in plant-based alternative milk products.

Considering the overwhelming advantages of natural milk in human nutrition and wellbeing, those problems raised by the vegans cannot or should not prevent the consumers drinking the dairy milk. In fact, the dietary issues raised by the vegans can be easily corrected by taking balanced and diversified diets with fermented or lactate added milk and dairy products as the major parts of the diets (Ibrahim and Gyawali, 2013; Korhonen and Pihlanto, 2007; Park et al., 2007; Park, 2009). Vegan activists promote the advantages of plant-derived foods and denounce or ignore the major benefits of natural dairy milk, and thereby the advantages and nutritional importance of natural milk may be overshadowed by their claims. Although the plant-based alternative milks have some advantages over natural milk, those concerns raised by vegans on natural milk can be overcome: Lactose intolerance may be resolved by taking lactase treated or cultured milk products such as yogurts, and cow milk allergy can be alleviated by replacing A2 milk or less allergenic one such as goat milk, and cholesterol levels of natural milks (cow milk) are not significantly high to be detrimental to human health, and also milk cholesterol level is substantially low compared to those of animal meat products.

Furthermore, vegan activists claim that plant-based milk alternatives are the best nutritious, healthy and superior choice of milk for human consumption for nutrition, health and wellbeing of humanity, and refuse to take the natural dairy milk. Actually, the fact of the matter is that the statements in <https://veganganplanet.com/all/> made by the vegan people (Dairy is not healthy; The China study; Vegan green planet) appear to be misleading and contain scientifically uncertain information, which require solid scientific and clinical verifications. In addition, the vegans claim that plant-based milk products are nutritionally superior to the natural dairy milk because the plant alternative products are non-allergenic to consumers. On the other hand, quite a few people have allergy against plant derived foods such as soy and peanuts containing products.

Contrary to the vegans' probable biased and negative views, the natural dairy milk is the best choice of its kind, and plant-based alternatives cannot replace the superior nutritional and health values of the natural milk in human consumption. Plant-based alternative non-dairy milk products do not have immunoglobulins and cannot provide the newborn calf (or human infant) with the essential immunity that receive from the dam's (mother) colostrum of dairy species. Proteins contained in colostrum and normal milk are known to exert a wide range of nutritional, functional, and biological activities (Pihlanto and Korhonen, 2003; Zimecki and Kruzel, 2007). Because cow milk sets the bar—taste, texture, and nutrition—that all dairy-free plant alternatives attempt to let the dairy down or destroy the true values. Much of the nutrition in dairy milk comes naturally, whereas the plant-based alternative milks are artificially fabricated and not natural products (Park, 2018; Sethi et al., 2016).

Although numerous types of innovative food beverages from plant sources are being exploited for cow milk alternative, many of these faces certain types of technological issues; either related to processing or preservation (Sethi et al., 2016). In manufacture of plant-based non-dairy beverages, the quality plant-based milk product must be comparable to the composition and quality characteristics of cow's milk in regard to taste, flavor, appearance, stability, rheology, and nutritive value (Cruz et al., 2007; Lee and Beuchat, 1992; Park, 2018; Sethi et al., 2016). The technical issues involved in production of plant-base milk beverages are the disintegration of the plant ingredients, attaining the homogeneity of the particle size and its composition as close as possible to those in bovine milk. The quality of the final manufactured plant-based beverage alternatives undoubtedly depends on the quality of the raw material, the disintegration method, extraction, particle size, the rheological stability of the manufactured product and storage conditions of the products (Galvez et al., 1990; Zahra et al., 2014).

Majority of these milk alternatives lack nutritional balance when compared to bovine milk. However, they contain functionally active components with health promoting properties which attracts health conscious consumers (Park, 2018; Sethi et al., 2016). Anyway, plant sources such as nuts, cereals and legumes, are accepted as functional food and nutraceuticals due to presence of health promoting components such as dietary fibers, minerals, vitamins, and antioxidants (Das et al., 2012).

The Authentic Concept of “Milk”

Milk is the lacteal secretion from the mammary glands of mammals. This is the reason why dairy scientists do not recognize or call other alternative man-made fluid foods as a milk, such as plant-derived beverages. The true milk is the natural secretion from the mammary glands of mammals, and milk is known as nature's most complete food, and dairy products are considered the most nutritious foods (Park, 2009; Park and Haenlein, 2017).

No one can deny that a human fabricated food would be better than the natural original provision. The man-made plant-based milks cannot be the best, nor replaceable and comparable to the natural dairy milk in taste, flavor, appearance, stability, rheology, and nutrition. In biblical point of view in the beginning of the human history, milk was provided to human only from goats and/or cows, not from plant materials. Nevertheless, vegetarians advocate the plant-based alternative milks are the best choice of beverage milk over the natural dairy milk. This can seriously mislead the average consumers in purchasing option of milk products, and also can result in unequivocal severe damages to the traditional business sustainability and profitability of the dairy industry and its producers.

Advantages and True Values of Cow and Other Dairy Species Milks

Many advantages of dairy milk do not exist in the plant derived alternative milk products. Plant-based non-dairy milk products do not have immunoglobulins, and the newborn infants can only receive the essential immunity from the mother's milk, not from plant-based products. Proteins found in colostrum and normal milk are known to possess a wide range of nutritional, functional and biological functionalities (Pihlanto and Korhonen, 2003; Zimecki and Kruzel, 2007). Immunoglobulins (Ig) in colostrum of all lactating species possess the biological function of antibodies to provide passive immunity against invading pathogens, especially essential in newborn infants, while the plant-based non-dairy alternative milks do not have such Ig proteins.

Natural milk also contains various bioactive compounds, which are not found in plant-based alternative milk products. These milk bioactive constituents in the dairy milk include: caseins (α -, β -, κ -, γ -), whey proteins (α -lactalbumin, β -lactoglobulin, lactoferrin, immunoglobulins, glycomacropeptide), milk enzymes (lactoperoxidase, lysozyme), bioactive lipids [conjugated linoleic acid (CLA), phospholipids, cholesterol, and minor lipids], bioactive carbohydrates (lactose, lactose derivatives, oligosaccharides), other minor bioactives (growth factors, cytokines, milk hormones, nucleosides, and nucleotides, polyamines, organic acids), bioactive minerals, and vitamins, etc. (Korhonen, 2009; Park, 2009).

The multi-functional properties of major milk proteins and peptides have been characterized and proven for several decades (Mulvihill and Ennis, 2003; Park, 2009). As shown in Table 1, cow and other dairy species milk and colostrum contain a variety of bioactive proteins and constituents that are not present in plant-based milk products. In addition, many bioactive peptides are released after digestion, hydrolysis and fermentation of milk proteins. Various bioactive peptides exhibit different types of physiological functions in the human body such as gastrointestinal, cardiovascular, endocrine, immune, and nervous systems. Functionalities of these peptides include: antihypertensive, antimicrobial, antioxidative,

Table 1. Major bioactive proteins components and their biological activities of cow milk and colostrum

Protein	Concentration (g/L)		Molecular weight	Biological activity
	Colostrum	Milk		
Caseins (α_{s1} , α_{s2} , β , and κ)	26	28	14.000– 22.000	Ion carrier (Ca, PO ₄ , Fe, Zn, Cu), precursor for bioactive peptides immunomodulatory, anticarcinogenic.
β -Lactoglobulin	8.0	3.3	18.400	Vitamin carrier, potential antioxidant, precursor for bioactive peptides, fatty acid binding.
α -Lactalbumin	3.0	1.2	14.200	Effector of lactose synthesis in mammary gland, calcium carrier, immunomodulatory, precursor for bioactive peptides, potentially anticarcinogenic.
Immunoglobulins	20–150	0.5–1.0	150.000– 1,000.000	Specific immune protection through antibodies and complement system, potential precursor for bioactive peptides.
Glycomacropeptide	2.5	1.2	8.000	Antimicrobial, antithrombotic, prebiotic, gastric hormone regulator.
Lactoferrin	1.5	0.1	80.000	Antimicrobial, antioxidative, anticarcinogenic, anti-inflammatory, iron transport, cell growth regulation, precursor for bioactive peptides, immunomodulatory, stimulation of osteoblast proliferation.
Lactoperoxidase	0.02	0.03	78.000	Antimicrobial, synergistic effects with immunoglobulins, lactoferrin and lysozyme.
Lysozyme	0.0004	0.0004	14.000	Antimicrobial, synergistic effects with immunoglobulins, lactoferrin and lactoperoxidase.
Serum albumin	1.3	0.3	66.300	Precursor for bioactive peptides.
Milk basic protein	N.A	N.A	10.000– 17.000	Stimulation of osteoblast proliferation and suppression of bone resorption.
Growth factors	50 µg– 40 mg/L	<1 µg– 2 mg/L	6.400– 30.000	Stimulation of cell growth, intestinal cell protection and repair, regulation of immune system.

Data compiled from Pihlanto and Korhonen (2003), Korhonen and Pihlanto (2007) and Korhonen (2009).

NA, not announced

antithrombotic, cytocommodulatory, immunomodulatory, and opioid-like activities (FitzGerald and Meisel, 2003; Korhonen, 2009; Mulvihill and Ennis, 2003; Pan et al., 2006; Park, 2009).

Dairy milk, especially goat milk, contains high levels of short and medium chain fatty acids (MCT), which are not in the plant-based milk products. These short chain and MCT are important for human nutrition and wellbeing, since MCTs: (a) are more easily digestible than long chain fatty acids (Jenness, 1980; Park, 1994; 2006; Park and Haenlein, 2017), (b) play beneficial roles on cholesterol metabolism including hypocholesterolic action, inhibition of cholesterol deposition and dissolution of cholesterol in gallstones (Haenlein, 1992; Park, 2006), (c) have the unique metabolic function by providing energy to growing children, and (d) can be used for treatment of lipid malabsorption patients suffering from steatorrhea, chyluria, hyperlipoproteinemia, and in case of intestinal resorption, coronary bypass, childhood epilepsy, premature infant feeding, cystic fibrosis, and gallstones (Haenlein, 1992; Greenberger and Skillman, 1969; Park, 1994; Park and Haenlein, 2017; Tantibhedhyangkul and Hashim, 1975). MCTs also may help reduce appetite, assist with weight loss and improve blood cholesterol levels more than other fats (Han et al., 2007). Coconut oil contains antioxidant (vitamin E) and high levels of MCTs, especially in lauric acid, which has bioactive functions including boosting immune system and maintaining the elasticity of the blood vessels (Han et al., 2007; Sethi et al., 2016). However, coconut oil also contains saturated fats, such as palmitic and stearic acids.

The lipid component of milk fat globule membrane (MFGM) is rich in phospholipids, glycosphingolipids, and cholesterol. Approximately 30% of the total lipid weight of MFGM is made up of phospholipids. The phospholipids have the three most

prominent components as sphingomyelin (SM), phosphatidylcholine (PC), and phosphatidylethanolamine (PE), which represent up to 85% of total phospholipids (Kanno, 1990). Phospholipids and sphingolipids play central roles in cerebral neurogenesis and migration during fetal development, as well as promoting neuronal growth, differentiation, and synaptogenesis during the first year of life (Hirabayashi and Furuya, 2008; Vance et al., 2000). These reports prove that natural milk exhibits a variety of therapeutic functions in human nutrition and metabolism, which are not present in plant-based milk. These facts reveal that the claims of vegans on superiority of plant-based products and negative views on natural dairy milk are not convincing.

It has been reported that consumption of dairy milk also can prevent osteoporosis, cancers, dental caries and weight gain by antiappetizing peptide. High calcium in milk is important for development and maintenance of skeletal integrity and prevention of osteoporosis (Schaafsma et al., 1987), which is especially important for the elderly in maintaining bone strength. The role of calcium as a protective factor in the etiology of colon cancer has been well documented (Sorenson et al., 1988). Calcium is also believed to be associated with binding and removal of carcinogenic agents (bile salts, etc.) along the gastrointestinal tract (Regester et al., 1997). A low calcium intake is related to hypertension, and calcium supplementation reduced blood pressure in hypertensive patients (Grobbee and Hofman, 1986). The milk lactose has been shown to prevent of dental caries (Shetty et al., 2011). Milk has been shown to have antiappetizing and weight loss effects by high calcium and antiappetizing peptide (Zhang and Beynen, 1993).

Natural milk also has polyamines and nucleotides/nucleosides. Polyamines in milk, such as putrescine, spermidine, and spermine, exhibit a wide range of bio-functionality and possible therapeutic values (Michaelidou, 2008). Polyamines are considered as indispensable in various physiological and metabolic processes of cell differentiation and growth (Löser, 2000; Michaelidou, 2008; Park and Haenlein, 2017). The roles of these polyamines are closely related to stabilization of the negative charges of DNA and of the chromatin structure, the regulation of several transcriptional factors and protein synthesis (Larqué et al., 2007). Nucleotides and nucleosides are nonprotein components of minor milk constituents, while they can be considered as therapeutic agents, since they play significant biological roles on apoptosis by acting as anticarcinogens against malignant cells (Korhonen and Pihlanto, 2007; Michaelidou, 2008; Schlimme et al., 2000).

Conflicts of Interest

The authors declare no potential conflicts of interest.

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The article is prepared by a single author.

Ethics Approval

This article does not require IRB/IACUC approval because there are no human and animal participants.

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