TITLE PAGE

- Korean Journal for Food Science of Animal Resources -

Upload this completed form to website with submission

ARTICLE INFORMATION	Fill in information in each box below
Article Type	Review article
Article Title	The impact of plant-based non-dairy alternative milk on the dairy industry
Running Title (within 10 words)	
Author	Young W. Park1
Affiliation	1 Georgia Small Ruminant Research & Extension Center, Fort Valley State University, The University System of Georgia, Fort Valley, GA 31030 USA
Special remarks – if authors have additional information to inform the editorial office	
ORCID (All authors must have ORCID) https://orcid.org	
Conflicts of interest List any present or potential conflict s of interest for all authors. (This field may be published.)	The authors declare no potential conflict of interest.
Acknowledgements State funding sources (grants, funding sources, equipment, and supplies). Include name and number of grant if available. (This field may be published.)	This work was accomplished by the funding of USDA/NIFA, Evan-Alan Project No. GEOX 3225.
Author contributions (This field may be published.)	The article is prepared by a single author.
Ethics approval (IRB/IACUC) (This field may be published.)	This work was accomplished by the funding of USDA/NIFA, Evan-Alan Project No. GEOX 3225.

CORRESPONDING AUTHOR CONTACT INFORMATION

For the corresponding author (responsible for correspondence, proofreading, and reprints)	Fill in information in each box below
First name, middle initial, last name	parky@fvsu.edu
Email address – this is where your proofs will be sent	
Secondary Email address	
Postal address	Georgia Small Ruminant Research & Extension Center, Fort Valley State University, The University System of Georgia, Fort Valley, GA 31030 USA
Cell phone number	+1-478-825-6376
Office phone number	+1-478-827-3089
Fax number	

Title: **The impact of plant-based non-dairy alternative milk on the dairy industry: A review**

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.

Key words: 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 (Sosulski et al., 1978; Sethi et al., 2016; Park, 2018). Worldwide, plant-based non-dairy milk alternatives such as soy, almond and oat milk are the fast growing segment 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 trend 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., 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 are 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 (Korhonen and Pihlanto, 2007; Park et al., 2007; Park, 2009; Ibrahim and Gyawali, 2013). 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, 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://vegangreenplanet.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 (Sethi et al., 2016; Park, 2018).

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 (Lee and Beuchat, 1992; Cruz et al. 2007; Sethi et al., 2016; Park, 2018). 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 el. 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 (Sethi et al., 2016; Park, 2018). 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, antithrombotic, cytomodulatory, immunomodulatory and opioid-like activities (FitzGerald and Meisel, 2003; Mulvihill, and Ennis, 2003; Pan et al., 2006; Korhonen, 2009; 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

193 long chain fatty acids (Jenness, 1980; Park, 1994; 2006; Park and Haenlein, 2017), (b) play
194 beneficial roles on cholesterol metabolism including hypocholesterolic action, inhibition of
195 cholesterol deposition and dissolution of cholesterol in gallstones (Haenlein, 1992; Park, 2006),
196 (c) have the unique metabolic function by providing energy to growing children, and (d) can be
197 used for treatment of lipid malabsorption patients suffering from steatorrhea, chyluria,
198 hyperlipoproteinemia, and in case of intestinal resorption, coronary bypass, childhood epilepsy,
199 premature infant feeding, cystic fibrosis and gallstones (Greenberger and Skillman, 1969;
200 Tantibhedhyangkul and Hashim, 1975; Haenlein, 1992; Park, 1994; Park and Haenlein, 2017).
201 MCTs also may help reduce appetite, assist with weight loss and improve blood cholesterol
202 levels more than other fats (Han et al., 2007). Coconut oil contains antioxidant (vitamin E) and
203 high levels of MCTs, especially in lauric acid, which has bioactive functions including boosting
204 immune system and maintaining the elasticity of the blood vessels (Han et al., 2007; Sethi et al.,
205 2016). However, coconut oil also contains saturated fats, such as palmitic and stearic acids.
206 The lipid component of milk fat globule membrane (MFGM) is rich in phospholipids,
207 glycosphingolipids, and cholesterol. Approximately 30% of the total lipid weight of MFGM is
208 made up of phospholipids. The phospholipids have the three most prominent components as
209 sphingomyelin (SM), phosphatidylcholine (PC), and phosphatidylethanolamine (PE), which
210 represent up to 85% of total phospholipids (Kanno, 1990). Phospholipids and sphingolipids play
211 central roles in cerebral neurogenesis and migration during fetal development, as well as
212 promoting neuronal growth, differentiation, and synaptogenesis during the first year of life
213 (Vance et al., 2000; Hirabayashi et al., 2008). These reports prove that natural milk exhibits a
214 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 antiappetitizing 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 hypertenson, 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 (Loser, 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 (Schlimme et al., 2000; Korhonen and Pihlanto, 2007; Michaelidou, 2008).

Acknowledgement

This work was accomplished by the funding of USDA/NIFA, Evan-Alan Project No. GEOX 3225.

References

1. Cruz N, Capellas M, Hernandez M, Trujillo AJ, Guamis B, Ferragut V. 2007; Ultra high pressure homogenization of soymilk: microbiological, physicochemical and microstructural characteristics. Food Res Int 40:725–732.

2. Das A, Chaudhuri UR, Chakraborty R. 2012; Cereal based functional food of Indian subcontinent: a review. J Food Sci Technol. 49(6):665–672.

3. FitzGerald, R. J. and Meisel, H. 2003; Milk protein hydrolysates and bioactive peptides. In: Advanced dairy chemistry. Vol. 1: Proteins, edited by P.F. Fox and P.L.H. McSweeney, pp. 675-698. Kluwer Academic/Plenum Publishers,New York, USA.

4. Galvez FC, Resurreccion AV, Koehler P. 1990; Optimization of processing of peanut beverage. J Sens Stud 5:1–17.

5. Greenberger, N.J. and Skillman, T.G. 1969; Medium chain triglycerides. Physiologic considerations and clinical implications. New Engl. J. Med. 280:1045-58.

6. Grobbee, D. E., and Hofman, A. 1986; Effect of calcium supplementation on diastolic blood-pressure in young-people with mild hypertension. *Lancet, 2*(8509), 703-707.

7. Haenlein, G.F.W. 1992; Role of goat meat and milk in human nutrition. Proc. V. Int'l Conf. Goat. New Delhi, India. Vol. II: Part I. Pp. 575-580.

8. Han JR, Deng B, Sun J, Chen CG, Corkey BE, Kirkland JL, Ma J, Guo W. 2007; Effects of dietary medium-chain triglyceride on weight loss and insulin sensitivity in a group of moderately overweight free-living type 2 diabetic Chinese subjects. Metabolism, Jul;56(7):985-91.

9. Hirabayashi, Y and Furuya, S. 2008; Roles of l-serine and sphingolipid synthesis in brain development and neuronal survival. Progress in Lipid Research. **47** (3): 188–203.

10. Ibrahim, S.A. and Gyawali, R. 2013. Lactose Intolerance. In: Milk and Dairy Products in Human Nutrition. Y.W. Park and G.F.W. Haenlein. Eds. Wiley-Blackwell Publ. Oxford, UK. pp. 246-260.

11. Jenness, R. 1980; Composition and characteristics of goat milk: Review 1968-1979. J. Dairy Sci. 63:1605-1630.

12. Kanno, C. 1990; Secretory membranes of the lactating mammary gland. Protoplasma. 159 (2-3): 184–208.

9. Korhonen, H.J. .2009; Bioactive components in bovine milk. In: Bioactive Components in Milk and Dairy Products. Y.W. Park, Ed. Wiley-Blackwell Publishers, Ames, Iowa and Oxford, UK. Pp. 15-42.

13. Korhonen, H. and Pihlanto, A. 2007; Bioactive peptides from food proteins. In: Handbook of

food products manufacturing: health, meat, milk, poultry, seafood, and vegetables, *e*dited by Y.H.Hui, pp. 5-38. John Wiley & Sons, Inc. Hoboken, NJ, USA.

14. Larqué, E., M. Sabage-Molina and S. Zamora. 2007; Biological significance of dietary polyamines. Nutrition 23(1):87-95. DOI: 10.1016/j.nut.2006.09.006

15. Lee C, Beuchat LR. 1992. Chemical, physical and sensory characteristics of peanut milk as affected by processing conditions. J Food Sci 57(2):401–405.

16. Loser, C. 2000; Polyamines in human and animal milk. British J. Nutrition. 84:555-558.

17. Michaelidou,A. 2008; Factors influencing nutritional and health profile of milk and milk products. Small Ruminant Res. 79:42-50.

18. Mulvihill, D.M. and Ennis, M.P. 2003; "Functional milk proteins: production and utilization." In Advances in Dairy Chemistry, Vol 1: Proteins, edited by P.F. Fox and P.L.H. McSweeney, pp. 1175-1228. Kluwer Academ**ic**/Plenum Publishers, New York, USA.

19. Pan, Y., Lee, A., Wan, J., Coventry, M.J., Mixchalski, W.P., Shiell, B. and Roginski, H. 2006; Antiviral properties of milk proteins and peptides. International Dairy Journal 16: 1252-1261.

20. Park, Y.W. 1994; Hypo-allergenic and therapeutic significance of goat milk. Small Rumin. Res. 14: 151-159.

21. Park, Y.W. 2006; Goat Milk- Chemistry and Nutrition. In: Handbook of Milk of Non-Bovine Mammals. Y.W. Park and G.F.W. Haenlein, eds. Blackwell Publishers. Ames, Iowa and Oxford, England. Pp. 34-58.

22. Park, Y.W. 2009; Bioactive components of goat milk. In: Bioactive Components in Milk and Dairy Products. Y.W. Park, Ed. Wiley-Blackwell Publishers, Ames, Iowa and

Oxford, England. Pp. 43-82.

23. Park, Y.W. 2018; Recent Trend in the Dairy Industry. J. Adv. Dairy Res 2018, 6:4. DOI: 10.4172/2329-888X.1000e134.

24. Park, Y.W. and G.F.W. Haenlein. 2017; Therapeutic and Hypo-Allergenic and Bioactive Potentials of Goat Milk, and Manifestations of Food Allergy. In: Handbook of Milk of Non-Bovine Mammals. Second Ed., Park, Y.W. and G.F.W. Haenlein, and W.L. Wendorff (Eds). Wiley-Blackwell Publishers. Oxford, England. Pp. 151-180.

25. Park, Y.W., M. Juárez, M. Ramos, and G.F.W. Haenlein. 2007. Physico-chemical characteristics of goat and sheep milk. Small Ruminant Res. 68:88-113.

26. Pihlanto, A. and Korhonen, H. 2003; "Bioactive peptides and proteins". In Advances in Food and Nutrition Research, edited by S.L.Taylor, pp. 175-276. Elsevier. San Diego, USA.

27. Regester, G.O., Smithers, G.W., Mitchell, I.R., McIntosh, G.H. and Dionysius, D.A. 1997; Bioactive factors in milk: Natural and induced. In: Milk composition, production and biotechnology. R. Welch, D. Burns, S. Davis, A. Popay and C. Prosser, Eds. CAB International. Pp. 119-132.

28. Schaafsma, G., van Beresteyn, E. C. H. and Raymakers, J. A. 1987; Nutritional aspects of osteoporosis. World Review of Nutrition and Dietetics 49, 121-159.

29. Schlimme, E., Martin, D., Meisel,H.,2000; Nucleosides and nucleotides and natural bioactive substances in milk and colostrum. Br. J. Nutr. 84, S59-S68.

30. Sethi,S., S. K. Tyagi, and R.K. Anurag. 2016; Plant-based milk alternatives an emerging segment of functional beverages: a review. J Food Sci Technol. 53(9): 3408–3423.

31. Shetty, V., A. Hegde, S. Nandan, and S. Shetty. 2011; Caries Protective Agents in Human Milk and Bovine Milk: An *in vitro* Study. J. Clinical Pediatric Dentistry: 35 (4): 389-392.

32. Sorenson, W., Slattery, M.S., and Ford, M. 1988; Calcium and colon cancer: a review.

Nutrition and Cancer 11:135-145.

33. Sosulski FW, Chakrabotry P, Humbert ES. 1978; Legume-based imitation and blended milk products. Can Inst Food Sci Technol J 11(3):117–123

34. Tantibhedhyangkul, P., and S.A. Hashim. 1975; Medium-chain triglyceride feeding in premature infants: Effect on fat and nitrogen absorption. Pediatrics 55:359-70.

35. TMR. 2019; Global Industry Analysis, Size, Share, Growth, Trends, and Forecast, 2019–2029. Transparency Market Research. Albany, NY.

36. Valencia-Flores DC, Herna´ndez-Herrero M, Guamis B, Ferragut V. 2013; Comparing the effects of ultra-high-pressure homogenization and conventional thermal treatments on the microbiological, physical, and chemical quality of almond beverages. J Food Sci 78(2):E199–E205

37. Vance, J. E.; Campenot, R. B.; Vance, D. E. 2000; The synthesis and transport of lipids for axonal growth and nerve regeneration. Biochimica et Biophysica Acta (BBA) – Molecular and Cell Biology of Lipids. **1486** (1): 84–96.

38. Zahra AK, Varidi M, Varidi MJ, Pourazarang H. 2014. Influence of processing conditions on the physicochemical and sensory properties of sesame milk: a novel nutritional beverage. LWT Food Sci Technol 57(1):299–305.

39. Zhang, X. and Beynen, A. 1993; Lowering effect of dietary milk-whey protein v. casein on plasma and liver cholesterol concentrations in rats. Brit. J. Nutr. 70:139-146.

40. Zimecki, M. and Kruzel, M.L. 2007; Milk-derived proteins and peptides of potential therapeutic and nutritive value. J. Experimental Therapy and Oncology 6: 89-106.

351 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	Daltons	
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	150.000-1000.000	Specific immune protection through antibodies and complement system, potential precursor for bioactive peptides
Glycomacro-peptide	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 - 2mg/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); N.A.= not announced				

352