

# DESIGNER MILK: AN INNOVATIVE APPROACH TOWARDS HEALTH SUSTAINABILITY

## Abstract

Designer milk is an innovative approach to suit customer needs and preferences which can be achieved as a result of biotechnological changes by manipulation at genetic level or alteration in nutritional composition of milk. Reducing lactose content, eliminating  $\beta$ -lactoglobulin, increasing portion of unsaturated fatty acid, decreasing fat content and humanized milk can offer a great advantage for nutritional and health status. Designer milk may be utilized either by health and nutritional purpose or by development in processing technologies. Various benefits of designer milk has gained interest among dietitians, physicians, food technologist which plays important role in the management of nutritional deficiencies and establishing different value added products

**Keywords:** Milk, Designer, Fortified, Humanized Milk, Nutritional, Alteration, Processing

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## I. INTRODUCTION

Designer Milk is a result of one of the innovative approach to suit customer needs and preferences which can be achieved by manipulation at genetic level or alteration in nutritional composition of milk (Umaraw et al., 2015).

Designer milk also refers to fortified, enriched, functional milk in which existing nutritional compositions are enhanced to provide additional health benefits (Rajasekaran et al., 2013). It also enhances immune response and lowers the risk of specific disease. Designer milk may be utilized for progress in human health as well as to the development in processing technologies. The changes in the biotechnological aspects to develop designer milk not only provide health benefit from its nutritive value but also helps in the treatment of medical conditions like cancer, diabetes and osteoporosis among others and hence, creating a field of interest of physicians, dietitians, chemists, biotechnologists and food technologists. Advancements in the biotechnological techniques like genetic engineering, rDNA technology and transgenic animals fulfill the needs of people from health and a nutritional point of view (Sabikhi et al., 2007). Transgenic animals like mice are generally used in trials for developing properties variants of milk by altering compositional values of milk. The designer milk may be rich in few components and may lack the other components, which provides advantages to a growing population of the country. For instance, designer milk could possess

1. The greater proportion of unsaturated fatty acids.
2. Reduced lactose content for lactose intolerant people
3. Decreased level of  $\beta$ -lactoglobulin in milk composition containing nutraceuticals and therapeutic benefits.
4. Humanized infant milk formula with oligosaccharides content.
5. Reduced fat content (Saturated fat) to lower cholesterol

Genetic manipulations at different levels provide opportunity for progress at a molecular level of the lactation process of cattle. Milk being complete food for every group of society needs to be designed in a way so that its properties could match the challenging needs of people facing issues like phenylketonuria, lactose intolerant, milk allergies and others. Changes in the protein and fatty acid profiles, low fat %age, no  $\beta$ -lactoglobulin and others are the key features of designer milk (Kumar et al., 2015; Sabikhi et al., 2004)

Designer milk will help us to establish value added products with different health significance. Various forms of designer milk and their health significance are listed below:

**Table1: Some Designer Milk and their Health Benefits**

Parameter	Health Significance	References
Vitamin D and A fortified milk	Prevent iron deficiency, Improves bone health, Reduce obesity , Fulfills vitamin D and A insufficiency	Khadgawad et al., 2013; Itkonen et al., 2018
Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) fortified milk	Improves RBC, Reduces cholesterol, Growth and neural developments in children, Higher cognitive function, Improves bone health	Ichinose et al., 2020; Huertas et al., 2010; Bautisa et al., 2010
Selenium enriched milk	Anticarcinogenic, Antioxidant, Anti inflammatory, Antimicrobial, Antimutagenic, Maintains homeostatis	Pecoraro et al., 2022; Pophaly et al., 2014; McIntosh et al., 2012
Conjugated Linoleic Acid (CLA) enriched milk	Anticarcinogenic, Antiatherogenic, Antiadipogenic, Antidiabetogenic, Anti-inflammatory, Bone health	Mccrorie et al., 2011; Siurana et al., 2016
Omega 3 fatty acid enriched milk	Anticarcinogenic, Anti inflammatory, Neurological development, Autoimmune	Shahidi et al., 2018; Swanson et al., 2012
Phytosterol enriched milk	Reduces cholesterol level, Anticarcinogenic, Antioxidant	Goh et al., 2021; Ribas et al., 2017
Micro nutrient fortified milk	Increases hemoglobin level, Increase serum ferritin in blood	Wang et al., 2017; Kuriyan et al., 2016
Humanized milk	Age growth, Weight gain	Umaraw et al., 2015
Casein enriched milk	Antihypertensive, Energy balance	Singh et al., 2016
Calcium enriched milk	Bone health	Cormic et al., 2021
Leutin fortified milk	Anticarcinogenic, Antioxidant	Becerrat et al., 2021
Fiber enriched milk	Lowers cholesterol, Bowl health	Arora et al., 2015
Phospholipids enriched milk	Anticarcinogenic, Anti inflammatory	Huang et al., 2020
Probiotic and Prebiotic fortified milk	Improves digestion, Anticarcinogenic	Malik et al., 2018

**Alteration in milk constituents at different levels are:**

## II. ALTERATION OF FAT COMPOSITION

Ideal milk fat for human should contain less than 10% Polyunsaturated Fatty Acids (PUFA), less than 8% Saturated Fatty Acids (SFA) and more than 82% Monounsaturated Fatty Acids (MUFA) (Lata et al., 2021). The bovin rumen inhabits the microbes that are rich in bioactive fatty acids. Fat composition can be altered by disrupting fat synthesis in mammary gland. Designer milk includes production of low fat mainly low saturated fat and

increased linoleic acid in fat which can be achieved by genetic modification or change in feed of milk producing animals. Health benefits like anticancer, antioxidant, lowering cholesterol, reduce risk of heart diseases, prevent obesity, neural development etc can be achieved by changes in fat composition.

Grass feeding cattles possesses high Conjugated Linoleic Acid (CLA) in milk enhancing the proportion of omega 6 to omega 3 fatty acids as fatty acid composition of rumen microbiota is changed (Benbrook et al., 2018). High Conjugated Linoleic Acid (CLA) has beneficial effects like anti-diabetic, anti-carcinogenic, inhibiting ovary, breast, prostate cancer, immunity enhancement, improve bone mineralization etc. Feeding of unsaturated fat like canola oil in encapsulated/protected from protects biohydrogenation in rumen leading to increase in linoleic and linolenic acids (Stanton et al., 2020). Also protected supplement decreases palmitic acids. Reduction in fat synthesis can be done by the reduction of Acetyl COA carboxylase that decreases fat synthesis. Milk produced with 2% less fat reduced the feed cost by 22% in 1kg of milk. (Umraw et al., 2015)

### III. ALTERATION OF PROTEIN COMPOSITION

Milk contains casein and whey protein. Casein includes  $\alpha$ S<sub>1</sub>,  $\alpha$ S<sub>2</sub>,  $\beta$  and  $\kappa$  casein. Whey protein exhibits bioactive potential consisting of  $\alpha$ -lactalbumin and  $\beta$ -lactoglobulin. In General,  $\alpha$ ,  $\beta$ ,  $\kappa$  are the major protein constituting more than 78% protein.  $\alpha$ S<sub>1</sub> casein when increased by 20% can produce better quality cheese. Increasing  $\beta$ - casein content in milk protein reduces rennet clotting time and increases syneresis. Introduction to copy of casein gene can increase protein and serve as a great advantage to dairy industry.

Protein sequencing genes can be added to milk yielding animals in order to enhance protein composition to provide nutritional and medicinal properties of milk. Genetic modification through molecular cloning of milk protein by altering nucleotide sequences can be of great advantage in terms of functional food. By modification in genetic material transgenic cattle's are able to produce high  $\beta$ -casein by 10-18% and twice of  $\kappa$ -casein (Brophy et al., 2003). Efficient cleavage of  $\kappa$ -casein by chymosin produce better quality cheese,  $\beta$ -casein binds calcium phosphate and maintains/ control milk calcium level. Other manipulations include thermostability of casein.  $\beta$ -lactoglobulin tends to function as a retinal binding protein that absorbs vitamin A in animal gut. Mutagenesis modifies  $\alpha$ -lactalbumin, which helps the group of people suffering from phenylketonuria and makes it consumable by them.

Transgenic animals have also been able to produce increase level of milk protein by 12-18% and milk casein by 20-30% (Umraw et al., 2015). Higher  $\kappa$ -casein results in better cheese making and greater heat stability. Amino acid in milk can also be increased by supplementing leucine and phenylalanine in feed. Other changes in protein can be at molecular level by producing a exact copy of protein genes by modification in nucleotide sequences. These would be able to produce better quality cheese by decreasing storage time and efficiently modifying the chymosin cleavage site of  $\alpha$ s<sub>1</sub> casein.  $\beta$ -lactoglobulin is considered as a major cause of allergies therefore removing  $\beta$ -lactoglobulin and adding casein genes can have a positive effect on reducing allergies and thermal stability of milk casein. The effects of genetic engineering on casein can also help in the production of milk products like ice cream, softy, whipped toppings by the property of forming and emulsion.

#### IV. ALTERATION OF LACTOSE COMPOSITION

Lactose enzymatic hydrolysis by  $\beta$ -galactosidase are glucose and galactose which gets absorb in the human blood. As human grows from child to old age there is a reduction in beta galactosidase which affects digestion and leads to malabsorption (Verma et al., 2012). Lactose intolerance becomes a major issue in nearly 70% of the world's population limiting the nutritional source of many population groups (Suri et al., 2019). Lactose content in milk is reduced by changes at genetic level by either removing the  $\alpha$ -lactalbumin or adding lactase enzyme ( $\beta$ -galactosidase) in milk.  $\alpha$ -lactalbumin gene replacement can be an innovative approach to suppress the  $\alpha$ -lactalbumin gene and thereby producing low lactose milk.

#### V. HUMANIZED INFANT MILK FORMULA

Mother's milk is the complete food. It can be also called as designer food for infants containing all the food requirements. Unavailability of mother's milk due to various reasons can be substituted by modifications in cow's milk. This enhances the resemblance to human milk in terms of composition thus introducing the term humanized infant formula. Lactoferrin is the most important constituents in human milk but present in very less amount in cow's milk. So these human lactoferrin genes can be added to bovine milk protein by application of genetic engineering. Humanized milk produced by genetic alterations can be best possible solution for infant food, which improve health and nutrition of the growing babies. Major changes in humanized milk are in the protein or fat component and introduction of oligosaccharides.  $\beta$ -lactoglobulin is generally absent in mother's milk, so in order to develop humanized milk this  $\beta$ -lactoglobulin is suppressed as it can be a cause of allergies in growing infants. Such kind of infant formulas are made which are healthy and nutritionally rich and possessing similarities with that of human milk. To enhance mineral utilisation and reduce renal osmolar content in infants, adjustments in calcium phosphorus ratio and reduction in total ash content should be carried out. Introduction to probiotic bacterial organism like *Bifidobacterium bifidum* can help the growing babies to digest their food easily by enhancing gut microbes of infants. Also increasing the content of lactoferrin and immunoglobulin helps in more of iron absorption and provides resistance to entry of pathogenic bacteria. Lactoferrin also known as iron binding protein is very less in cow milk when compared to as human milk which contains 10 times more lactoferrin than that of cow milk. It contains antimicrobial properties thus helping premature infants to fight against various diseases. Innovation in terms of humanized milk is taken into consideration so as to provide mimic of human milk for infants who are deprived of mother's milk. Human lipase can be produced through transgenic Technology stimulated by bile salts in bovine milk produced lipase can be introduced as infant formula increasing the digestibility of lipids in premature infant. Allergies in children are mainly due to the presence of  $\beta$ -lactoglobulin contents which are absent in human milk thus reducing the content of  $\beta$ -lactoglobulin in milk protein can be an effective solution towards humanized milk. The shelf life of humanized infant formula is also higher due to antimicrobial activities in the milk.

#### VI. CONCLUSION

Designer milk can be innovative approach and a healthy solution towards food nutrition and value addition. Applications of biotechnological tool can help researchers to design nutritional and medicinal enriched milk by modification in the milk composition.

Designer milk helps dairy industry to produce more milk of right quality serving various needs and demands of all age group people. Designer milk plays an important role in food development technique by designing milk in such a way where milk is fully utilized to serve every human kind. Designer milk of the current generation holds a promising future.

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