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FORTIFICATION OF DAIRY PRODUCTS AND THEIR HEALTH BENIFITS

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Abstract;

Fortification may be defined as the addition of one or more essential nutrients to food whether or not it is normally contained in the food in order to prevent or correct a demonstrated deficiency of one or more nutrients in the population or specific population group. With the help of the fortification process we should able to provide the food stuffs with the better nutrition quality and in balanced manner. It may got its importance in those areas where the problem of the malnutrition is prevalent. This may also be helpful in combating the micronutrient deficiency and thus helps in alleviating the "hidden hunger" .Currently the fortification is a broader concept due to several reasons

1. It maintains the nutritional quality f foods, keeping the adequate and correct or prevents specific nutritional aspects (deficiencies)
2. It increases the added nutritional value of a product and provides certain technological functions in food processing.

According to (***Bonner et al., 1999)*** fortification is the adding one or more essential nutrients to a food and increasing their concentration higher than normal. The main focus of the international community so far has been on three most prevalent deficiencies via Vitamin A, Iodine and Calcium as well as iron. Fortification of food products with natural resources such as fruits and cereals is one of the best way to improve the overall nutritional value of the food product with minimal side effects .Among the various food stuffs milk is one of the basic food that is to be fortified ,it is to be fortified with the mineral salts such as Ca, Fe, Sc .Although these minerals are essential but they can be toxic if added in excessive quantity beside it is fortified with fibre,fruits and vegetables, isoflavones ,fortification with *w-3-Fatty acids*

Key words:

Fortification, minerals, milk, calcium, Zinc, selenium,w-3-Fatty acids, fibre and isoflavones.

Introduction;

As we already know that milk in its natural form is almost unique as it is balanced source of man's dietary need .In the modern times the consumers may show valuable interest in their personal health and expect that whatever they eat should provide all the basic nutrients and are capable of preventing the illness. For such purposes the consumption of the fermented products especially the fermented milk has increased significantly around the world .Now a days the food industry try to incorporate the various ingredients into cultured dairy products to enhance their value ***(Deeth and Tamime1981)***

The fermentation is a chemical controlled process in which enzymes breakdown organic substances into smaller compounds, so that the fermented product being produced is more digestible, stable, flavored as well as increased its nutritional quality .The process of fermentation is carried out by the molds, bacteria or yeasts. Whenever such organisms grow fermentation takes place automatically ***(Yousef and carlstrom, 2003)***.Among fermented products yogurt is one of the main product produced by Streptococcus thermophilus and Lactobacillus delbruecki spp. Bulgaricus. The history of producing yogurt as a fermented product has been traced in the Middle East and spread all over the world. As compared to milk, yogurt is more nutritious and is an excellent source of protein, calcium, phosphorous, riboflavin, thiamine, and vitamin B12, Foliate Niacin, Magnesium and Zinc. Since lactose in milk is converted to lactic acid during fermentation and due to lactose fermenting bacteria in yogurt, lactose intolerant people can consume yogurt without any adverse effect. Moreover the fermented product will cause a slight reduction in stomach pH which reduce the risk of pathogen transit and the effect of low gastric juice secretion problem ***(J.O'Connell and Fox 2001)***

Fortification of Dairy products with mineral salts;

Fermented products especially dairy products are good source of proteins and calcium but poor in the iron content as well as some other mineral salts (Blank 1981) .

Principle of fortification;

There are four key principles of food fortification

- ✓ Fortification should not adversely affect the odouor,texture,taste or appearance
- ✓ The nutrient should be absorbed by the body resulting in an increase in bioavailability.
- ✓ The demand for the food should be constant and unaffected by fortification.
- ✓ There should be a demonstrable positive effect on the consumer's health of adding the nutrient.

Technology;

The technology required to fortify milk products is simple. All the minerals and vitamins that are to be fortified needed to be available in the dry powder form. As several nutrients are added to milk, fortificants are ideally added as a premix, a homogenous mixture of desired amount of fortificants (vitamins and minerals) concentrated in a small amount of the food to be fortified. Premixes ensure the addition of correct amounts and uniform homogenizations of the micronutrients in the final product .The mineral products that are to be fortified are generally of the three types

- ✓ Mineral salts(soluble)
- ✓ Elemental minerals
- ✓ Mineral protein complexes

Among the above mentioned mineral products mineral salts are most commonly used .Those salts, which have oxidation state of two $(Fe^{2+}, Fe^{3+}, Zn^{2+}, Zn^{3+})$ because due to their complete solubility in water.

Elemental minerals (iron) are obtained by reduction with hydrogen or carbon monoxide, by electrolysis or by the carbonyl process. These compounds are powders with varying particle size and are poorly soluble or insoluble in water and are chemically inert. As this form of minerals is insoluble in neutral liquids it can only be used to fortify solid dehydrated foods.

Mineral proteins (casein and whey proteins) or phosphopeptides [Casein phosphopeptides (CPP)] complexes include, for example CPPs-Zn complexes and also iron bound to amino acids such as phosphoserine, aspartate and glutamate. The preparation of iron can also vary. Thus, FeSO4 microencapsulated with lecithin has the same bioavailability as FeSO4, but has the advantage of being coated with phospholipid membrane. Similar, lipid microcapsule of FeSO4 alone or with ascorbic acid have been developed to fortify cheese and other foods with high moisture content.

Mineral stability;

The process of fortification depends upon the number of the factors including the stability of micronutrients added to the foods. In order to select the fortificants we should consider the following factors that affecting the fortificants stability. In general the minerals are less sensitive than vitamins to physical and chemical factors .Nevertheless, they are reactive in nature and must be selected after considering possible interactions with milk proteins, potential adverse effects on the sensory properties of milk and the bioavailability of mineral form .on exposing to heat and light minerals do not loose their stability whereas iron fortification to bovine milk does not change its distribution after pasteurization. It has also been reported that gastrointestinal iron loss is increased in infants fed heat –treated milk .Minerals such as copper, Iron and Zinc are also affected by moisture, and may react with other food components such as proteins and carbohydrates for example calcium may react with proteins, particularly when foods are heat processed resulting in sedimentation and gelation. The heat stability of milk depends on the type of calcium salt used and the type of milk

Concentration of minerals and trace elements in yogurt and fermented milk

Yogurt and fermented milk	Yogurt of whole milk	Yogurt of semi skimmed milk	Fermented milk	Yogurt with semi skimmed milk and fruit sugars	Yogurt of whole milk with fruit sugars	Yogurt of goat milk and semi skimmed milk	Yogurt of ewe's milk
Calcium Mg/100g	161mg	142mg	144mg	111mg	110mg	112mg	150mg
Sodium	68mg	53mg	61mg	35 mg	43mg	36mg	150mg
magnesium	11mg	13mg	13mg	10mg	12mg	13mg	16mg
Phosphorous	95mg	98mg	105mg	82mg	80mg	103mg	140mg
potassium	217mg	176mg	182mg	116mg	140mg	159mg	190mg
iodine	15mg	20mg	20mg	11mg	15mg	ND	ND

Calcium fortification;

Calcium an essential nutrient required of critical biological functions such as nerve conduction, muscle contraction, mitosis, blood coagulation and structural support of the skeleton, activation of enzyme reactions, stimulation of hormone secretions. Scientific study shows that high dietary calcium intake and its bioavailability are associated with the reduced risk of osteoporosis, hypertension, colon cancer, kidney stones obesity, polycystic ovary syndrome, and premenstrual syndrome.

Milk and dairy products are the best natural sources of calcium. On an average the cow's milk contain 1.20 g of calcium per litre. Most of the calcium in the milk is in the form of the colloidal as well as in the form of the caseinate -phosphate complex and is readily released during digestion in vivo; hence its bioavailability is high .Calcium bioavailability is influenced both by exogenous and endogenous factors .Level of calcium intake ,vitamin D status, phytates, lipids, salt type ,phosphopeptides and other proteins, lactose , phosphorus and caffeine are among the exogenous factors influencing the Intestinal calcium absorption.

Calcium in milk is more easily absorbed by the intestine than calcium from the vegetables and cereals. Phytates present in the cereals, beans and pulses, oxalates present in leafy vegetables, and long chain saturated fatty acids and dietary fibre can reduce the bioavailability of calcium by forming insoluble calcium complexes .For the fortification of dairy products several commercial calcium salts have been used. Among them the following supplementary salts used are as follows.

- ✓ Calcium salts from animals and vegetables origin such as milk calcium (mainly calcium phosphates)and seaweed calcium (comprised mainly of calcium carbonate)
- ✓ Inorganic salts such as calcium carbonate, calcium chloride and calcium phosphate.
- ✓ Organic salts such as tri calcium citrate, calcium lactate, gluconate and calcium gluconate

Calcium fortified dairy products

Fortified product	Calcium salt	Quantity of salt	Claim	Reference
Milk	**Ca chloride, dehydrate Ca lactate tetra hydrate,Ca gluc onate monohydrate and Ca carbonate**	**50-75-100mg/10ml**	**Sensory quality ,heat stability and in vivo absorbability**	***Gaucheron F.iron fortification in dairy industry. Trends in Food science and Technology 2000,11:403-409***
Soy milk	**Calcium chloride**	**25mM**	**investigate Ca ,pH absolute viscosity, particle diameters and dry sediments content of Ca-fortification**	***Van Der Hee Rm, Miret S, Slettendaar M et al. Calcium absorption form fortified ice cream formulations compared with Ca absorption from milk .Journal of the American Dietetic Association 2009,109:830-835***
Yogurt	**Ca lactate , Ca gluconate**	**400-600-800mg/100g(ca lactate) 600-800-1000 mg(Ca gluconate)**	**Investigate the change in chemical ,microbial and organoleptic properties of fortified yogurt**	***Kirshenbaum B. Mineral metabolism disorders n chronic kidney diseases .JAMA 2011,305:1138-1139***
Cheese	**Calcium chloride**	**0.02-0.03-0.05%**	**Effect of calcium addition on yield of cheese manufactured**	***Smith MT.Lolars Jc, Savaiano DA et al. Absorption of calcium form milk and yogurt The American Journal of Clinical Nutrition 1985,42:1197-1200***
Whole milk	**Calcium gluconate monohydrate**	**166mg/100g**	**The milk promotes healthy bones and teeth, growth and repair vision and skin**	***Rosenberg L.Sowmya Rao R, Palmer Jr et al. Calcium channel blockers and the risk of cancer JAMA .1998,279:1000-1004***

Depending upon the form of the salt used, calcium fortification can affect the colour texture, stability, flavor and processing characteristics of dairy products (***Singh et al.)*** studied the heat stability and calcium bioavailability of calcium-fortified milk and found that fortification of milk with calcium lactate or gluconate and stabilized with disodium phosphate improved its sensory acceptance.The main challenge for dairy product manufacturers is to provide products with high calcium content and good taste . As a result, micronized tricalcium citrate has replaced inorganic and organic salts for the fortification of the dairy products. An important explaination is that in case of milk matrix, a highly dispersible calcium salt had advantages over highly soluble alternatives .The organic salts with high bioavailability and more neutral taste profile, tricalcium citrate (21% calcium) is clearly one of the most economic options for calcium fortification and is currently the first choice for milk products.

Zinc fortification:

Zinc as a trace element of human nutrition .Signs of Zinc deficiency in humans were first described in the year 1960s ***(Nielsen FH.Trace mineral deficiencies.In Berdenier CD, Duryer J, Feldmen EB, eds. Handbook of Nutrition Research 2000; 20:737-755)*** .Most of the Zinc (85%) is found in skimmed milk while about 15% of the zinc is in the fat in natural milk.While zinc fortification deficiency has become a global problem affecting developed and developing countries ***(Salgueiro M.J, Zubillaga MB. Lysinonek AE et al. Zinc as an essential micronutrients a review .Nutrition Research 2000; 20:735-755).***Several Zinc compounds are available for fortification including zinc sulphate, zinc oxide, acetate, Zinc chloride***(Abd-Rabou N|S , Zaghloul AH, Selet Fl et al. properties of Edam cheese fortified by dietary zinc salts. Journal of American Science 2010; 6:441-755).***Out of these Zinc oxide and Zinc sulphate should provide theoretically, more reliable absorption than zinc oxide because of its great solubility, but is more expensive ***(importance of zinc for human health, international Association of Infant food Manufactures. http://www.ifm.net/industry /zinc .htm.Accessed July 29,2011)***.

Abd –Rabou et al., who studied the properties of Edam cheese fortified by dietary Zinc salts, observed that all the properties of Edam cheese samples were increased generally during ripening period. The high remarked scores for cheese fortified with zinc salts indicated that they were perceived to be more tasty, with better than the addition of zinc acetate or zinc chloride improved the organoleptic properties of Edam cheese and accelerated its ripening process ***(Abu-Rabou NSW Zubillaga MB, Lysionek AE et al. Properties of Edams cheese fortified by the Zinc salts .Journal of American Science 2010; 441-446)***

Selenium fortification;

Selenium as a trace mineral may got its importance recently when it shows some health benefits .Chemically it is metalloid in nature which shows both metallic and non metallic properties .***The revised 1989 Recommended Dietary Allowance (RDAs) for selenium, started in microorganisms are as follows***

Sno	Quantity required	Age group
.1	10mg	Infants under 6 months
.2	15mg	Infants of age group (6-12 months)
.3	20mg	Age group (1-6 years)
.4	30mg	Age group (7-10 years)
.5	40mg	Males (11-14 years)
.6	45mg	Females (11-14 years)
.7	50mg	Both males and females(15-18 yrs)
.8	70mg	Males above(19)
.9	55mg	Females (above 19 years)
.10	65mg	During pregnancy
.11	75mg	During lactation

Milk and other dairy products are poor in the selenium (Se).As its concentration varies in the cows varies from (2-1270μg^{-1}depending upon the availability of this element in the food and geographical area ***(Alexo Pc, Nobrega JA.Direct determination of iron and selenium in bovine milk by graphite furnace atomic absorption spectrometry. Food Chemistry 2006, 385189-196)***

Several forms of Se occur in the human diet .Selenium is usually present in the animal foods and plants as selenoproteins containing seleno-amino acids for example Selenocystine and Selenomethionine, and other inorganic species, for example Se (Iv) and Se (VI***) (Muniz –Naverio O, Dominguez-Gonzalez R, Bermejo-Barrera A et al. Study of the bioavailability of selenium in cow's milk after a supplementation of cow feed with different forms of selenium. Analytical and Bioanalytica Chemistry 2006, 385:189 -196)***

Fortification with fibre;

As we know that the yogurt is without fibre content. Fibre is a component of the cell wall of the fruits ,grains and vegetables(***Lunn and Butriss,2007)*** .The fibre is added to the yogurt so that its water holding capacity may gets increased ,reduce the lipid retention ,improve textural properties and structure as well as reduce the caloric content by acting as a bulking agent ***(Larrauri, 1999)*** .The fibre may have some health benefits as it prevents or decreases hypertension, hypercholesterolemia, obesity ***(Bam and Seidell,2007)*** ,gastrointestinal disorders (***Elia and Cummings,2007)*** coronary heart disease (Mann,2007) ,diabetes (Anderson et al.2004) and cancer(***Bingham et al., 2003***).The maximum acceptable amount of date fiber in fortified yogurt with potential beneficial health effects is 3% . The addition of 1.32% oat fiber improved the body and texture of unsweetened yogurt and decreased the overall flavor quality ***(Fernandez et al., 1998)***.in one experiment ,pectin and raspberry concentrate was incorporated in commercial stirred yogurt samples, increasing the consistency and it was found that yogurt with pectin was more shear stable in comparison with yogurt with raspberry concentrate ***(Ramaswamy and Basak 1992).***in another study , seven types of insoluble dietary fibers form five different sources such as soy, rice, oats, corn, and sugar beet) were used to fortify sweetened plain yogurt. Fibre addition caused acceleration I the acidification rate of the experimental group yogurts, and most of the fortified yogurts also showed increase in their apparent viscosity. However, soy and sugar beet fibers caused a significant decrease in viscosity due to partial synersis .in general , fiber addition led to lower overall flavor and texture scores as a grainy flavor and a gritty texture were intense in all fiber –fortified ,except those with the soy oat fiber, which gave the best results .Similarly β-glucan was used to prepare low fat yogurt and as the amount of β-glucan increased a corresponding increase in yogurt consistency and firmness as well as a decrease in synersis was reported .Recently (Palacios et al., 2005) prepared yogurt system from whole milk , with Calcium (50 mg of calcium/100mL of yogurt) and three levels of fiber from two wheat-bran sources in comparison with a plain yogurt ,the presence of fiber and calcium augmented the consistency , diminished the synersis and the pH was higher.

Fortification with w-3-Fatty acids;

Milk fat composition in dairy products can be altered by reducing the ratio of saturated to unsaturated fatty acids and increasing the contents of fatty acids that are more desirable for human nutrition, such as the ***w-3*** polyunsaturated fatty acids **(PUFAs).**The importance of w-3-Fatty acids like alpha linolenic has been widely publicized because they are precursors of important long-chain fatty acids, such as eicosapentaaenoic acid **(EPA)** and docosohexanoic acid **(DHA)** which cannot be synthesized in the human body .According to ***(Kim and Liu,2002)*** the DHA fortified drinks are targeted at school children in Japan ,increased level of healthy fatty acids in dairy products can be efficiently achieved by the use of the selected bacteria during manufacturing, or the substitution of milk fat by oils with high levels of PUFAs.However, replacement of milk fat by oils with high levels of PUFAs yielding yogurt with less firmness and high synersis ***(Barrantes et al., 1996),***or the substitution of milk fat by oils with high levels of PUFAs.However , replacement of milk fat by oils with high levels of PUFAs yielding yogurt with less firmness and high synersis ***(Barrantes et al., 1996)***

Fortification with isoflavones;

Isoflavones are part of diphenol compounds called “phytoestrogens,” which are considered as functional ingredients ***(Mason.,2001).***They are structurally and functionally similar to estradiols, the human estrogen, but much less potent. Due to this similarity they were suggested to have preventive effects for many kinds of hormonal diseases ***(Uzzan &Labuza, 2004)*** .They occur mainly in plants mostly in soybean. In nature they usually occur as glycosides and once deconjugated by the intestinal micro flora, the isoflavones can be absorbed into the blood.***(Setchell, 1998)*** they have possible protective action against various cancers.**(Setchell,1998)** Osteoporosis and menopausal symptoms and high levels of blood cholesterol although the epidemiological evidence seems convincing , no recommended daily intake has been published ***(Mason,2001)***

Fortification with fruits and vegetables'

The secondary metabolites of plants help them to get adapt easily in the changing environment and protect themselves from microbial attacks and resist both biotic and a biotic stresses. Out of these compounds phenolic have received 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 ***(Ostertag et al,. 2010)*** .The major source of phenolic compounds is fruits ***(Record et al., 2001)*** .It has been suggested that fruit juices and their extracts have the potential to b used as functional ingredients in the food industry including dairy sector ***(corrison et al., 2005) (Wallace et al., 2008)*** . But due to unavailability of fruits and vegetables throughout the season and economical factors will force researchers to look for alternative strategies for the bio production of natural compounds similar to anthocyanin and phenolic acids ***(Blando et al., 2004)***

Milk is well known source of foliates (5-7mg/100g) Most HPLC studies indicate 5-methyltetrahydrofolate (5-MTHF) as the major form of foliate in milk ***(Forssen et al., 2000)*** .Heat treatment such as pasteurization and UHT processing are known to reduce the foliate content ***(Wigertz et al., 1996)*** .However milk processing can lead to a positive effect when milk fermentation is applied. The fermented milk products are reported to contain higher amounts of foliate. This high level is result of the production of additional foliates by the bacteria. However many bacteria synthesize this cofactor by themselves from a simple precursors, but some autotrophic bacteria, including many lactic acid bacteria, have a strict growth requirement for folic acid .The production and consumption of foliates by applied microorganisms will be probably the most important factor in determining the folate level in fermented milk products. The lactobacillus species does not produce the folate with the exception of ***Lactobacillus planetarium***. ***Streptococcus thermophilus*** is reported to produce the folate .Some other lactic acid bacteria-***Lactococcus lactis, Leuconostoc lactis, Bifidobacterium** l**ongum*** were recognized as folate producers .Some well known vitamin B12 producers such as strains of propionibacteria, are able to increase the folate level as well. The fruits and the berries will produce the folate in the range of few µg to approx. 100µg/100g.The highest concentrations of about 50-100µg/100g are found in frozen concentrated orange and grapefruit juices and in strawberries ***(Witthoft et al. 1999).***

Conclusion;

Mal nutrition is a global phenomenon that affects both developing and industrialized countries with serious health and economical implications. Food fortification has been recognized as an important, continuous and self sustaining strategy to improve the health and nutrition status of the millions of people. As it ensures a safest method by which manufacturers can deliver health promoting nutritionally dense food products .Among the various fermented products the dairy products are the most commonly consumed healthy and nutritious foods around the world therefore it offers an appropriate potential to convey nutritious ingredients to human diet. Dairy products are inexpensive and consumed in moderate amounts so they are obvious vehicles for dietary mineral fortification and other bioavailable ingredients that are essential for the human health .The fortification of the fermented dairy products is considered as an emerging technology as is considers the issue of the role of the fermented dairy products in the quality of the life and in risk of the chronic diseases. The risk associated with the fortification is minimal except if good manufacturing practice is not followed. Improved understanding of interactions between food ingredients and health ingenuity of food technologists in food formulations and fabrications will contribute to the advance in fortification of fermented dairy products. Milk is fortified with Ca, Fe, Zn and Sc as well as fibers, flavonoids and fruits polyphenols and many other things. Fortification of milk is beneficial to consumers and provides opportunity for marketing of the dairy products. The consumers benefits from healthy products that are tasty and appealing and can be advertised as having high mineral content. However the fortification cannot prevent micronutrient deficiency if

- ✓ The targeted population has little or no access to the fortified food.
- ✓ Micronutrient deficiency is severe.
- ✓ Co-incident infection increases the metabolic demand for micronutrients.

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