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Review

Mango based dairy beverage-bespoke for multi antioxidants

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Abstract

As a result of the fast development of the food and drink industry and technology, the variety of products presented to the markets has been increased dramatically. In addition, there have been improvements in ingredient technology, the spread of international tastes, and a drive to create and sell foods and drinks that offer consumers nutritional benefits. Functional foods are those foods or food components that are scientifically recognized as having physiological benefits beyond those of basic nutrition. Among functional foods, dairy-based functional foods account for nearly 43% of the market. These products are enriched with functional food components originating from dairy and nondairy sources. It is a well established fact that food milk proteins and other ingredients may have nutritional and antioxidative benefits with different physiological effects. Incorporation of fruit in dairy beverage may have added effect on the functionality. Fruits rich in antioxidants and other functional ingredients may have a pronounced positive health effect on humans. As the dairy sector is continuously expanding all over the world, these fruit based functional dairy beverages may offer bases for the development of novel functional beverages in these markets.

Key words: Mango, milk, functional, dairy, beverage, antioxidant.

INTRODUCTION

Antioxidants are widely used in dietary supplements and have been investigated for the prevention of diseases such as cancer, coronary heart disease and even altitude sickness; plants and animals maintain complex systems of multiple types of antioxidants, such as glutathione, vitamin C, vitamin A, and vitamin E as well as enzymes such as catalase, superoxide dismutase and various peroxidases. Insufficient levels of antioxidants, or inhibition of the antioxidant enzymes, cause oxidative stress and may damage or kill cells. The relevant literature available on the use of fruit incorporation in dairy based beverage, heat treatments of milk and beverage and role of Maillard reaction products as antioxidants is discussed under the following headings

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Composition of Milk

Milk and milk products are nutritious food items containing numerous essential nutrients, but in the western societies the consumption of milk has decreased partly due to claimed negative health effects. The content of oleic acid, conjugated linoleic acid, omega-3 fatty acids, short- and medium chain fatty acids, vitamins, minerals and bioactive compounds may promote positive health effects.

The milk constituents are predisposed by the breed/species of animal, season, stage of lactation, microbial quality and genetics. The macro-constituents of milk (protein, lipids, and lactose) and some of its low molecular mass species, especially calcium, phosphate, citrate and pH are the major determinant for technological properties (Fox et al., 2000). Bovine milk contains the nutrients needed for growth and development of the calf, and is a resource of lipids, proteins, amino acids, vitamins and minerals. It contains immunoglobulins, hormones, growth factors, cytokines, nucleotides, peptides, polyamines, enzymes and other bioactive peptides. The lipids in milk are emulsified in globules coated with membranes. The proteins are in colloidal dispersions as micelles. The casein micelles occur as colloidal complexes of protein and salts, primarily calcium. Lactose and most minerals are in solution. Milk Composition has A dynamic nature, and the composition varies with stage of lactation, age, breed, nutrition, energy balance and health status of the udder.

Minerals, Vitamins and Antioxidants

Milk contains many minerals, vitamins and antioxidants. The antioxidants have a role in prevention of oxidation of the milk, and they may also have protective effects in the milk-producing cell, and for the udder. Most important antioxidants in milk are the mineral selenium and the vitamins E and A. As there are many compounds that may have antioxidative function in milk, measurement of total antioxidative capacity of milk may be a useful tool (Lindmark and Akesson, 2000).

Calcium

The calcium concentration in bovine milk is about 1 g/l. Dairy products provide more than half of the calcium in the typical American diet (Insel et al., 2004), and daily intake of milk and milk products thus has a central role in securing calcium intake. In human nutrition adequate calcium intake is essential.

Selenium

The selenium concentration in body fluids and tissues are directly related to selenium intake. Selenium is important in human health; it has a role in the immune- and antioxidant system and in DNA synthesis and DNA repair (Dodig and Cepelak, 2004). Selenoprotein P is an antioxidative defense enzyme having similar function as the selenoenzyme Phospholipid hydro peroxide glutathione peroxidase inside the cells and it also protects LDL towards Peroxidation (Saito et al., 2004).

Iodine

Iodine is an essential component of the thyroid hormones. These hormones control the regulation of body metabolic rate, temperature regulation, reproduction and growth. The recommended iodine intake is 150 µg/d for adults (Insel et al., 2004). Accordingly, a daily intake of 0.5 litres milk with an average content of 160 µg iodine/l meets about 50% of the requirement. However, it is important to underline the great seasonal variation in iodine content of milk.

Magnesium

Magnesium is ubiquitous in foods, and milk is a good source, containing about 100 mg/l milk. Magnesium has many functions in the body, participating in more than 300 reactions.

Vitamin E

Vitamin E concentration in milk is about 0,6 mg/l , but may increase 3–4 folds by proper feeding regimes. Recommended intake is 15 mg/day (Insel et al., 2004). Vitamin E is not a single compound; it includes tocoferols and tocotrienols. In whole milk, alpha-tocopherol is the major form of vitamin E (>85%); gamma-tocopherol and alpha-tocotrienol are present to a lesser extent, about 4 % each of the sum of tocoferols and tocotrienols (Kaushik et al., 2001).

Vitamin A

Milk is a good source of retinoids, containing 280 µg/l. Recommended daily intake is 700-900 µg/day (Insel et al., 2004). Vitamin A has a role in vision, proper growth, reproduction, and immunity, cell differentiation, in maintaining healthy bones as well skin and mucosal membranes (Insel et al., 2004).

Folate

Bovine milk contains 50 ug folate/l. Studies indicate that 5-methyl-tetrahydrofolate is the major folate form in milk (Forssen et al., 2000). Recommended intake of folate is 400 µg/day for adults. Many scientists believe that folate deficiency is the most prevalent of all vitamin deficiencies (Insel et al., 2004).

Riboflavin

Milk is a good source of riboflavin, 1.83 mg riboflavin/l milk. Daily recommended intake is 1.1 and 1.3 mg for women and men, respectively (Insel et al., 2004). Riboflavin is part of two important coenzymes participating in a numerous metabolic pathways in the cell. It has a role in the antioxidant performance of glutathione peroxidase and DNA repair via the ribonucleotide reductase pathway.

Vitamin B_1

Milk is also a good source of vitamin B, being 4.4 µg/l. The daily recommendation is 2.4/g (Insel et al., 2004). Vitamin B 12 is found only in animal foods, and plays a central role in folate and homocysteine metabolism, by transferring methyl groups. Vitamin B deficiency may cause megaloblastic anaemia and breakdown of the myelin sheath.

Health Benefits of Milk

Researchers at department of Studies in Food Science and Nutrition, University of Mysore and Department of Protein Chemistry and Technology, CFTRI, Mysore formulated a beverage with hydrolysed whey protein concentrate (WPC), skim milk powder, cocoa, liquid glucose, sugar and vegetable fat and analyzed for physico-chemical properties, sensory attributes and keeping quality. Results showed that protein content of WPC was 75.6 % which decreased slightly on enzyme treatment (69.6 %). The *in vitro* protein digestibility of untreated WPC was 25 % and increased in all treated samples to varying degrees (69-70%).

Masson *et al.* (2011) concluded that dairy base containing of raw skim milk and reconstituted whey powder were pressurized by Ultra-high pressure homogenization (UHPH) at levels of 150, 200 and 250 MPa and inlet temperature of 15, 20 and 25 ºC. Dairy base was inoculated with probiotic lactic culture, incubated and allowed to ferment. Pineapple juice, previously sweetened with sugar or aspartame was added. The results showed that pressurized beverage at 150 MPa/15 ºC were similar to controls. The changes in the physicochemical properties of the beverages increased as the storage time and temperature increased. The degree of change was affected by the composition of the product (Cano-Ruiz and Richter, 1997).

The fruit based dairy beverages are highly nutritional and possess therapeutic value. Tandon et al. (2010) preserved mango pulp of mangro cv. Rumani blended either with Mallika or Dashehari pulp in the ratio of 9:1, 8:2 and 7:3 and stored under ambient conditions. The pulp samples were analysed for various chemical parameters at 0, 6 and 12 months of storage. The RTS (ready-to-serve) beverage was prepared at each interval and evaluated organoleptically. Results revealed that addition of Mallika or Dashehari pulp improved the colour of Rumani pulp significantly by increase in yellowness index and total caroteinoids content. The best pulp blend for beverage preparation was observed to be 7:3 after 12 months of storage. The pulf of Dashehari was better over Mallika for blending with Rumani. Common commercial beverage additives like citric acid (CA), BHT, EDTA, Ascorbic acid (AA), milk (bovine, soy and rice) and citrus juice (orange, grapefruit, lemon and lime) were formulated into finished tea beverages at incremental dosages. Samples were then subjected to *in-vitro* digestion simulating gastric and small intestinal conditions with pre and post-digestion catechins profiles assessed by HPLC. Results showed that catechins stability in green tea was poor with <20 % total catechins remaining post-digestion. Teas formulated with 50 % bovine, soy and rice milk increased total catechins recovery significantly (Green et al., 2007).

Health Benefits of Milk

Living organisms have sophisticated and well-known antioxidant defense systems against ROS including glutathione peroxidase, superoxide dismutase, catalase and low molecular weight antioxidants. Apart from them, there are less known but also important lactoperoxidase (LPO), against free radical damage either directly or indirectly (Halliwell and Gutteridge, 1990). In average, milk contains about 33 g total lipid (fat).

Antioxidants in Milk
Antioxidative Enzymes in Milk

Superoxide Dismutase (SOD)
SOD catalyses the dismutation of superoxide anion to hydrogen peroxide. There are three types of SOD which contain either manganese, copper/zinc or iron (Fridovich, 1986) and in bovine milk Cu/Zn-SOD is found (Dahl et al., 1979).

Catalase
Catalase is a large enzyme, containing haem-bound iron in its active site. Catalase has a very high capacity to destroy H_2O_2 and in terms of molecules of H_2O_2 degraded per minute per molecule of enzyme, it is one of the most active enzymes known (Gutteridge and Halliwell, 1994).

Glutathione Peroxidase
Glutathione peroxidase removes H_2O_2 and other peroxides at a high rate. Its seleno group is oxidised by the peroxide and then reduced by glutathione (GSH), which is converted into oxidised glutathione (GSSG) (Gutteridge and Halliwell, 1994).

Non-enzymatic Antioxidants in Milk

Lactoferrin
Several functions have been proposed for lacto- ferrin, including: iron-binding, a role in iron absorption, bacteriostatic or bacteriocidal action, and a role as a growth factor (Hambraeus and LoÈ nnerdal, 1994).

Vitamin E

Vitamin E consists of eight vitamers and a-tocopherol is the major one in bovine milk. α-Tocopherol is an important lipid-soluble antioxidant and acts as a radical scavenger. The tocopheryloxy radical formed is relatively stable and can be reconverted into tocopherol by reduction with ascorbic acid (Helen and Kesson, 2000).

Carotenoids

Like tocopherols, carotenoids are fat-soluble compounds and their concentration is influenced by the total fat concentration in dairy products. They function as singlet oxygen scavengers and may also react with other reactive oxygen species. Ollilainen et al. (1989) found 0.17 mg/kg of b-carotene in whole milk (3.9 % fat) and 0.10 mg/kg in milk with 1.9 % fat.

Composition of Mango

Mango (*Mangifera indica* L.) is a seasonal fruit grown in tropical regions and is regarded as one of the most important fruits of Asia. India stands first in the list of mango producing (39.1% of the world production of 34.9 MMT) and exporting (23% of the world export of 1.2 MMT) countries, which contributes significantly to its foreign income and agro-rural development (http://faostat.fao.org/site/291/default.aspx). India is known as the country of origin of mango and is blessed with thousands of cultivars of this National fruit (Salvi and Gunjate, 1988). The nutritional importance of mango is mainly due to its high amounts of b-carotene, a carotenoid which provides various health benefits, including pro-vitamin A and antioxidant activity. Among other carotenoids, b-carotene provides the highest level of provitamin A activity (Harnkarnsujarit and Charoenrein, 2011). The energy value per 100 g (3.5 oz) is 250 kJ (60 kcal), and that of the apple mango is slightly higher (79 kcal per 100g). Mango contains a variety of phytochemicals and nutrients. The fruit pulp is high in prebiotic dietary fiber, vitamin C, diverse polyphenols and provitamin A carotenoids (Ajila and Rao, 2008).

In mango fruit pulp, the antioxidant vitamins A and C, Vitamin B_6 (pyridoxine), folate, other B vitamins and essential nutrients, such as potassium, copper and amino acids, are present. Mango peel and pulp contain other phytonutrients, such as the pigment antioxidants – carotenoids and polyphenols – and omega-3 and -6polyunsaturated fatty acids (USDA, 2010).

Mango peel contains pigments that may have antioxidant properties (Berardini et al., 2005) including carotenoids, such as the provitamin A compound, beta-arotene, luteinand alpha-carotene(Gouadoetet al., 2007). Polyphenols such as quercetin, kaempferol, gallic acid, caffeic acid, catechins, tannins, and the unique mango xanthonoid, mangiferin, any of which may counteract free radicals in various disease processes as revealed in preliminary research. Phytochemical and nutrient content appears to vary across mango species (Rocha et al., 2007). Up to 25 different carotenoids have been isolated from mango pulp, the densest of which was beta-carotene, which accounts for the yellow-orange pigmentation of most mango species. Peel and leaves also have significant polyphenol content, includingxanthonoids, mangiferin and gallic acid (Barreto et al., 2008)

The mango triterpene, lupeol, is an effective inhibitor in laboratory models of prostate and skin cancers (Saleem et al., 2004). An extract of mango branch bark called Vimang, isolated by Cuban scientists, contains numerous polyphenols with antioxidant properties in vitro and on blood parameters of elderly humans (Pardo et al., 2006).

The pigment euxanthin, known as Indian yellow, is often thought to be produced from the urine of cattle fed mango leaves; the practice is described as having been outlawed in 1908 due to malnutrition of the cows and possible urushiol poisoning. This supposed origin of euxanthin appears to rely on a single, anecdotal source, and Indian legal records do not outlaw such a practice **(**Finlay and Victoria, 2003).

The impact of harvest stages and storage conditions over the postharvest quality of mango (Langra and Samar Bahisht Chaunsa) varieties were investigated by Baloch and Bibi, (2012). The fruit was harvested at 80 (early stage), 95 (mid stage) and 110 (late stage) days after the fruit setting and designated as samples I, II, and III, respectively. The harvested fruit was stored under three different storage conditions till its ripening. Significant variations were observed in quality characteristics by varying harvest stage, storage conditions and their combinations. The contents of vitamin C and acidity were highest in sample I and sugar contents in sample III of the fruit. The weight loss was highest and shelf life was longest for sample I and waste percentage was lowest for sample II. The waste percentage, weight loss, pH, total soluble solids, carotenoids and total sugar increased the percentage of acidity and vitamin C was decreased with storage time/ripening process, irrespective of maturity stages. The ripening rate was increased and the shelf life was decreased with the increase in storage temperature. The skin color, total soluble solids, sugar contents and carotenoids were well correlated.

Antioxidants in Mango

Mango peel and seed have a great deal of antioxidant activity (Maisuthisakul and Gordon, 2009) because they are rich in bioactive compounds such as phenolic compounds (quercetin, quercetin Oglycosides, isoquercetrin quercetrin galactoside, 3,4 dihydroxy benzoic acid, ellagic acid, mangiferin, isomangiferin, homomangiferin, mangiferin 3-C-6-O-p hydrybenzoic acid, xanthones), carotenoids, tocopherols (α, γ) and sterols (β-sitosterol, D-avenasterol, campesterol, stigmasterol) (Ribeiro et al., 2008).

Vitamin A

The form of vitamin A in mangoes, known as beta carotene, provides potent antioxidant benefits, according to "American Dietetic Association Complete Food and Nutrition Guide", it is believed to guard against skin disorders, certain diseases and the adverse effects of aging.

Vitamin C

Deficient intake of the antioxidant vitamin C results in scurvy, a disease characterized by gum bleeding, loose teeth and excessive bleeding. Vitamin C also plays an important role in wound healing. While large doses in dietary supplement form can contribute to kidney stones, diarrhea and iron overload, Natural food sources, such as mangoes, provide safe, nutritious options to Vitamin C.

Mangiferin

Although mangiferin is a lesser-recognized nutrient in the general public, it has been deemed a "super-antioxidant" by scientists because of its superior disease-fighting properties. Mangiferin has inhibited tumor growth and reduced mucus buildup in rats and may guard against Parkinson's disease in humans and animals, according to a report published in "Comprehensive Reviews in Food Science and Food Safety" in Oct. 2008. Mango pulp contains 4.4 mg of mangiferin per kilogram.

Quercetin

Quercetin is an antioxidant and pigment that gives many flowers, vegetables and fruits their color. Quercetin acts as an antihistamine and anit-inflammatory, according to the University of Maryland Medical Center, and may lower your risk for cancer and heart disease. Mango pulp contains 22.1 mg of quercetin 3-galactoside per kilogram, 16 mg of quercetin 3-glucoside per kilogram and 5 mg of quercetin 3-arabinoside per kilogram.

Rocha et al. (2007) found differences among the four mango cultivars in the different components analyzed. The content of phenolic compounds ranged from 48.40 (Haden) to 208.70 mg/100 g (Ubá); total carotenoid from 1.91 (Haden) to 2.63 mg/100 g (Palmer); beta-carotene from 661.27 77.71 mg/100 g (Ubá). (Palmer) to 2,220 microg/100 g (Ubá) and total ascorbic acid ranged from 9.79 (Tommy Atkins) to 77.71mg/100 g (Ubá)

Dairy Beverage

Increased consumer demand for natural and healthy foods contributes to the interest of food industry in the production of dairy based functional foods including functional beverages (Masson et al., 2011). Beverages prepared from banana juice and whey in combination with edible extract of herbal medicinal plants have excellent medicinal nutritional properties along with therapeutic, prophylactic, antibacterial and organoleptic benefits (Ritika et al., 2010). Interactions between milk fat, carrageenan, and non fat milk solids were important in determining the apparent viscosity of the beverages and the rate of change observed during storage of a retort-sterilized dairy beverage (Cano-Ruiz and Richter, 1998). Fang et al. (2011) found that milk protein concentrate (MPC) was a newly developed dairy powder with wide range of applications as ingredients in the food industry, such as cheese, yogurt and beverage. MPC had relatively poor solubility as a result of their high protein content (40-90 wt %), with distinct dissolution behavior in comparison to skim milk or whole milk powders.

A process was described for the manufacture of an acidic dairy beverage containing a turbid fruit juice and/or vegetable juice. A beverage prepared by fermenting milk with lactic acid bacteria was mixed with the juice, a gum and soy fibre, and the mixture was heated to a temperature at which the gum melts. The beverage had good flavour and did not show protein aggregation or precipitation when stored for a long period (Yanagihara and Somoto, 2006). Cilla et al. (2009) tested the health-protective potential of 3 fruit beverages, Fb (grape-orange-apricot), FbM (Fb with skimmed milk) and FbMFe (FbM + Fe(II)), in healthy women. The influence of fruit beverage consumption (500 ml/day) on serum antioxidant capacity determined by ORAC and TEAC methods and erythrocyte superoxide dismutase (SOD) activity was assessed. Results demonstrated that intake of fruit beverages did not improve total antioxidant capacity. However, the induction of SOD found after fruit beverage consumption may be more effective than the effects of antioxidants present in these beverages. Fe added to FbM (FbMFe) showed induction of SOD activity, with no prooxidant effect, and could constitute a complementary source of Fe, because the regular consumption of FbMFe may be beneficial for women of fertile age.

Laparra et al. (2008) proposed that casein phosphopeptides (CPPs) have potential dietary antioxidants on designing new functional products. A fruit beverage, with/without milk, was subjected to in vitro digestion. Caco-2 cultures were pre incubated with soluble fractions or isolated CPPs, the latter obtained from skimmed milk. The mitochondrial activities (MTT test), intracellular GSH and GSH-reductase activity (GSH-Rd), cell cycle analysis and RNA distribution in cycle phases were studied after inducing oxidative stress status (5mM H_2O_2). MTT conversion was better preserved by soluble fractions of fruit beverages, either with or without milk. GSH concentration was equally decreased, and GSH-Rd was increased in all pre incubations. However, it failed to inhibit a decreased G1 cell population. CPPs produced RNA accumulation in the G2 phase, suggesting a modulating effect on cell response. They postulated that antioxidant effect derived from dietary CPPs on a biological system which can be synergistic with other antioxidant compounds derived from fruit beverage

Biological antioxidative activity of a single oral dose of a fruit-based beverage rich in polyphenols and ascorbic acid (study beverage; containing concentrated fruit juices and plant extracts) was studied in 6 subjects. Antioxidant status was assessed from FRAP, TEC and PCL assays; levels of total phenols and ascorbic acid were also determined in plasma and urine, together with renal excretion of hippuric acid (biomarker of polyphenol consumption) and malondialdehyde (MDA). Compared to control treatment (water consumption), intake of the study beverage resulted in significant 9.5 and 8.9-fold increases in plasma total phenol and ascorbic acid levels, respectively, within 10 h of ingestion. Results suggest that consumption of beverages rich in bioactive compounds such as polyphenols and ascorbic acid could reduce oxidative stress in vivo (Netzel et al., 2007).Fruits and vegetable antioxidants are recognised for their potential in promoting health and lowering the risk for cancer, hypertension and heart disease (Valko et al., 2006). The uses of natural antioxidants from plant extracts have experience growing interest due to some health professionals and consumers' concern about safety of synthetic antioxidants in food **(**Suhaj, 2006). Zheng and Wang (2001) stated that spices and herbs are an excellent source of phenolic compounds such as flavanoids, phenolic acid and alcohols, stilbenes, tocopherols, tocotrienols) ascorbic acid and caroteinoids which have been reported to show good antioxidant activity. An increase in the consumption of foods rich in antioxidants during the first years of life favors the nutritional rehabilitation of malnourished children, improves vitamin and antioxidant status (Perales et al., 2008). The sensory analysis showed that the beverages fortification of selected fruit juice beverages (Pineapple, Mango and Orange juice) with fructo oligosaccharides (FOSs), a low calorie prebiotic were acceptable up to 4 and 6 months storage at ambient and refrigeration temperature respectively (Renuka et al., 2009).

Sensory analysis of probiotic dairy beverages containing fruits or vegetables and stored in sterilized bottles at 5 ± 1°C for 10 days showed that the beverages had acceptable flavors, with scores higher than those achieved by the control (Salem et al., 2006). Perales et al. (2008) concluded that hesperedin, naringenin, carotenoids and ascorbic acid stand out as the main antioxidant compounds of orange juice, while grape juice contains benzoic acid and its derivatives, anthocyanins, malic acid and tannins. Chlorogenic acid, cumaric acid, epicatechin and tannins are present in apple juice. Beta-carotene and others carotenoids from fruits and vegetables have antioxidant properties and they prevent chronic disease *in vitro* and in animal models. Mixtures of carotenoids or associations with others antioxidants (e.g. vitamin E) can increase their activity against free radicals (Paiva and Russel, 1999). The phenolics are abundant bioactive compounds in our diet and are the main compounds responsible for the antioxidant capacity of fruits hence it becomes clear that the ultimate antioxidant potential of phenolics and their resulting *in vivo* bioactivity is dependent on their absorption, and metabolism within the body after digestion (Vinson et al., 2001). The intestinal absorption of antioxidant compounds from fruit juices is better than that of antioxidants coming directly from fruits. The synergistic activity of antioxidants present in fruits and fruits juices can result in increased antioxidant activity Perales et al. (2008). Zulueta et al. (2010) concluded that treatment by pulsed electric fields can be considered an alternative to traditional thermal preservation treatments, because the total concentration of carotenoids and vitamin A were preserved to a greater degree immediately after treatment and during storage. Duffy et al. (2001) found that benefit of high flavonoids intake may be greater for individuals with established coronary artery disease (CAD). Widowati et al. (2011) stated that there was an inverse relationship between tea consumption and cardiovascular disease. There was also convincing evidence that dietary intake of antioxidant flavonoids from tea and other sources such as onions, apples, red wine and broccoli, were associated with reduced cardiovascular risk. Increased consumption of fresh fruits and vegetables is associated with a lower incidence of disease, particularly of degenerative ailments linked to the ageing process, such as cancer, cardiovascular disease, and Alzheimer's disease. Their protective mechanisms are thought to be attributed to the presence of natural antioxidants, such as ascorbates, catechins, and flavanoids, which help to scavenge free radicals and reactive oxidants in the body Guan and Whiteman (2002).

Gutknecht (1992) developed a skim milk beverage containing 85 per cent skim milk and 15 per cent orange juice along with small amount of microcrystalline cellulose as stabilizer. Hassan and Ahmad (1998**)** prepared a ready-to-serve (RTS) beverage by blending 15 per cent milk with 30 to 45 per cent mango pulp, maintaining total soluble solids content at 18 ºB by the addition of sugar. Pellegrino (1994) studied the influence of milk fat content on formation of lactulose and furosine (potential indicator of severity of thermal processes) in milk and cream during large scale processing.

Fruit Incorporation in Dairy Based Beverage

Fruits and vegetables are important constituents of the diet and provide significant quantities of nutrients, especially vitamins, sugars, minerals, and fiber. Daily consumption of fruits and vegetables reduce the risk of cancer, heart disease, premature aging, stress, and fatigue primarily due to the integrated action of oxygen radical scavengers such as ß- carotene and ascorbic acid plus calcium and dietary fiber **(**Bhardwaj and Pandey, 2011). Shukla et al. (2004) prepared nutritious fruit beverages by blending juice/pulp from apples, guavas, bananas, litchis and mangoes at 10 to 40 per cent levels with whey and buttermilk. It was reported that mango pulp could be used up to 30 per cent level in whey and up to 20 per cent level in buttermilk, apple juice up to 20 per cent in whey and up to 30 per cent in buttermilk. Litchi juice, banana pulp and guava pulp could be used up to 30, 20 and 10 per cent level in milk by-products, respectively. The beverage containing 20 per cent apple juice in whey was found to be the best.

Gutknecht (1992) developed a skim milk beverage containing 85 per cent skim milk and 15 per cent orange juice along with small amount of mono crystalline cellulose as stabilizer. Ibrahim et al. (1993) manufactured guava milk beverage by adding 11 percent guava pulp and 3 to 5 percent sugar to buffalo skim milk, filtering and pasteurizing at 75 °C/5min in glass bottles. Flavour score increased with increasing guava pulp concentration up to 10 percent at all sugar levels. Hassan and Ahmed (1998) prepared a ready-to-serve (RTS) beverage by blending 15 per cent milk with 30 to 45 per cent mango pulp, maintaining the total soluble solids content at 18 °B by the addition of sugar.

Shukla et al. (2003) reported that banana or mango pulp could be used successfully up to 200g/L in separated and reconstituted skim milk. They also found that apple juice or guava pulp could be added at up to 300 and 100g/L to the milk products, respectively. Litchi juice could be blended up to 300g/L in separated milk and 200g/L in reconstituted skim milk. Charanjiv et al. (2006) used skim milk from buffalo and cow in combination with 10 to 30 percent levels of carrot juice to prepare flavored milk. The flavored milk was rated best at 20 percent of carrot juice incorporation. Grewal and Jain (1982) reported that addition of preserved mango to milk (1:4) did not alter the salt balance of the blend. By neutralizing the mango pulp with sodium bicarbonate or sodium hydroxide and after sterilization at 116 °C for 30 min, milk mango shake was acceptable with regard to color and flavor by a taste panel.

Effect of Thermal Processing on Milk

Thermal processing of milk is an essential step of milk processing adopted by the dairy industry. It helps to extend the shelf life and improve the quality of dairy products. Heat treatment affects the molecular structure of milk proteins at the interfaces of oil-in-water emulsions and in aqueous media (Raikos 2011). The heat treatments commonly used are pasteurization and sterilization. They cause denaturation of whey proteins (Farah 1986). During storage, sterilized beverage showed better resistance to photo-oxidation than unheated or pasteurized beverages. Severe heat treatments produced advanced, brown pigment, Maillard Reaction Products (MRP) known as melanoidins which enhance the antioxidant activity (Manzocco et al., 2001). In a study conducted by Roux et al. (2009) the impact of UHT treatment on a model infant formula was examined by assessing the advancement of Maillard reactions during thermal treatment via ohmic heating. The heating and holding steps of the heat treatment were carried out in a static batch ohmic heater equipped with a nitrogen counter-pressure system, allowing 5 temp. levels in the range 100-140°C to be attained. The results showed that Maillard reactions in the model infant formula were highly dependent on the time-temperature treatment. In compliance with other classical heating techniques, the selected chemical markers followed a pseudo-zero order of reaction under isothermal conditions. However, it was suggested that the contribution of the heating step can be significant as MRP could be detected from the 1st seconds of the UHT treatment. Streekstra (2009**)** described a novel method to prepare a thermally processed plant-based food product which contains less detrimental Maillard reaction side products <greater than or equal to>1 compound involved in Maillard reactions in thermally processed plant foods is removed by treating the plant based intermediate of the food product with an enzyme preparation containing <greater than or equal to>1 enzyme specifically acting on only 1 of the polysaccharide networks responsible for the macro-structural properties of the plant based intermediate.

Maillard Reaction Products as Antioxidants

Perales et al. (2008) found that the digestion of native milk proteins yield physiologically important bioactive peptides called casein ortho phosphor peptides. These along with casein hydrolysates in the bio accessible fraction fractions can prevent oxidation reactions through mechanisms that involve direct free radical scavenging and sequestering of potential metal pro-oxidants such as iron. The higher interaction between lactose and proteins in milk having higher pH value could lead to more Maillard Reaction Products (MRP) as well as more polymerisation of proteins (Gothwal and Bhavadasan, 1992). When foods are heat processed, the sugars and lipids react with the proteins they contain via the Maillard and related reactions to form a wide range of products. As a result, the sensory, safety, nutritional and health-promoting attributes of the foods are enhanced (Ames, 2009).

Maillard reaction is a very complex reaction between carbonyls and amines. These reactions usually produce a wide range of products with odors and colors with antiallergic, antmicrobial, cytotoxic and antioxidant properties. Maillard reaction products generated from casein-glucose model in food materials during processing and storage have strong antioxidant activity (Rao et al., 2011). The Maillard reaction occurs in three stages (early, intermediate and final stage), and its dependent upon factors such as reactants type and concentration, temperature, time, pH and water activity (Hwang et al., 2011). The Maillard-reaction-related modifications could account for the biochemical and insolubility properties of the lesions of Alzheimer disease through the formation of protein cross links (Smith et al., 1994). Milk with sugar at 6, 8 and 10 per cent levels, and sterilized at 1.05 kg/cm^2

showed no browning, though prolonged heating caused intense browning, as compared to samples with no added sugar in the retort sterilized beverages (Gothwal and Shukla, 1995).

Protein oligomers were introduced in to yogurt in amounts of 15-30% of the total protein by an enzymatic modification of proteins as well as by a dry matter increase of yogurt milk by sodium caseinate/pectin and total milk protein/lactose Maillard products. Results revealed that yogurt from protein/saccharide Maillard product enriched milk exhibited up to 4% reduced acidity, up to 27% increased acetic aldehyde content as well as up to 58 % decreased whey drainage (Hiller and Lorenzen, 2011).

The consumption of a diet rich in MRPs significantly increased plasma OR compared to the diet poor in MRPs by 35.5%. The study indicated that thermally processed foods rich in MRPs inhibit the LDL oxidation in vitro and had the ability to reduce oxidative modification of LDL in vivo (Dittrich et al., 2009). Maillard reaction products (MRPs) were prepared from casein-glucose by refluxing for 130 min at 102°C and initial pH 12.0 without pH control to investigate the characteristics of casein-glucose Maillard reaction and the antioxidant activity difference among different fractions of MRPs. Browning and intermediate products increased, however, the pH of the system decreased with increase in the heating time. Free amino group content decreased 78% during first 10 min and did not change nearly thereafter. MRPs of different molecular weight exhibited distinctly different antioxidant activities **(**Fenglin et al., 2009).

Maillard reaction products (MRPs) were prepared from aqueous model mixtures containing 0.2M glucose and 0.2M each of glycine, diglycine, and triglycine, heated at 100°C, for different times (10, 60, 120, 180 and 240 min), with an initial pH control set to 7.8. The browning and intermediate products of MRPs derived from the Glu-Diglycine model system were the most prominent. All MRP samples showed different absorptions in the UV-vis spectra, although they possessed similar shapes. The molecular weights of all MRP samples showed rising intensities as a function of the heating time, whereas the major peaks of each MRP sample were eluted at different retention times according to peptide chain lengths (Kim and Lee, 2009).

Hydroxy Methyl Furfurals

Hydroxy methyl furfural (HMF), also 5-(Hydroxymethyl) furfural, is an organic compound derived from dehydration of certain sugars. This yellow low-melting solid is highly water-soluble. The molecule consists of a furan ring, containing both aldehyde and alcohol functional groups. HMF has been identified in a wide variety of heat-processed foods including milk, fruit juices, spirits, honey, etc. HMF, which is derived from cellulose without use of fermentation, is a potential "carbon-neutral" feedstock for fuels and chemicals (Huber et al., 2006). Upon heating foods at high temperature, 5-hydroxy- methyl-2-furfuraldehyde (HMF) is naturally generated by two possible pathways: (1) caramelization, where the reducing carbohydrates, including maltose and maltotriose (Kroh, 1994), directly undergo 1-2 enolization, dehydration and cyclization reactions; and (2) the Maillard reaction, where the Amadori product, formed by reaction with the amino group of free amino acids or proteins, undergoes enolization and subsequent dehydration of the sugar moiety while releasing the amino acid intact (Friedman, 1996). Both caramelization and the Maillard reaction are responsible for the development of attractive colors and flavors in heat-processed foods.

CONCLUSION

The fruit based functional dairy beverage will be a healthier alternative for different vitamins, minerals, antioxidants and other functional ingredients. These refreshing and nutritive beverages proved to have market potential as far as functional, technological and sensory properties were concerned. The addition of mango stimulated the antioxidative effect of milk peptides. The beverages produced showed potential for commercialization, serving as a functional food product derived from milk mango and effective heat treatment with minimal additional cost to the dairy plant.

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