dietitianCE

Continuing Education for Nutrition Professionals

Antioxidant Properties of Milk and Dairy Products

attributed to the difference in amino acid profile [17]. Antioxidant activities of superoxide dismutase, catalase and glutathione peroxidase, casein and certain peptides are well established [18].

Antioxidant properties of whey proteins

In recent years, utilization of whey in food and nonfood applications is mounting across the globe. Whey protein has higher biological value and despite the fact that about 30–35% of the whey is still discarded [19]. In food industries, whey proteins are used as emulsifying, gelling and bulking agent. Antioxidant activity of whey protein is scientifically established and antioxidants of whey can efficiently inhibit the lipid oxidation [20]. Antioxidant activity of whey protein is due to the chelation of transition metals by lactoferrin and scavenging of free radicals by sulphur containing amino acids [21]. Whey proteins boost the level of glutathione peroxidase which is regarded as one of the most significant water soluble antioxidant system [22]. Whey proteins have antioxidant activity and addition of whey protein in soybean oil emulsion increased the oxidative stability [12]. Antioxidant characteristics of salmon oil emulsion increased as a function of addition of whey protein [20]. Food containing whey proteins have better antioxidant activity. Lactoferrin and casein can inhibit lipid peroxidation, generation of peroxide radicals, thiobarbituric acid reacting substances, uptake of oxygen and iron oxide free radicals [23]. Casein fraction, composition of whey proteins and amino acids profile of cow, buffalo, sheep and goat milk have been presented in Tables 1, 2 and 3, respectively.

Antioxidant characteristics of carotenoids

Carotenoids are lipophilic molecules with a tendency to accrue in membrane or lipoproteins [24]. Milk fat globule membrane is considered as the most volatile site for auto-oxidation [24]. β-carotene is regarded as preventive antioxidant, it can quench singlet oxygen and one molecule of β-carotene can quench 250 to 1000 molecules of singlet oxygen [26]. Carotenoids act as scavengers of singlet oxygen and other reactive oxygen species [25]. Among the various antioxidant systems in milk, carotenoids act a scavenger of singlet oxygen and peroxyl radicals [27]. Dairy lipids may suffer from oxidation, which leads to the negative impact on quality and sensory characteristics of finished products. Auto-oxidation and light induced oxidation is affected by a complex interaction of pro and

Table 1 Casein fraction of cow, buffalo, goat and sheep milk

Parameters	Cow	Buffalo	Sheep	Goat
TPC (g/L)	27.8	49.2	59.4	33.4
αS_1-casein (%)	37	90	33	99
αS_2-casein (%)	7	13	14	8.52
β-casein (%)	42	28	30	63
γ-casein (%)	6	22	9	18
κ- casein (%)	9	7	14	8

TPC Total Protein Content
Source of Data
Cow Milk: [104]
Buffalo Milk: [105]
Sheep Milk: [104]
Goat Milk: [104]

Table 2 Composition of whey proteins in cow, buffalo, goat and sheep milk

Parameters	Cow Milk	Buffalo Milk	Sheep Milk	Goat Milk
Whey proteins (g/L)	6.46	6.46	10.76	6.14
β- Lactoglobulin (%)	59.3	59.3	61.1	54.2
α- lactalbumin (%)	16.2	16.2	10.8	21.4
Immunoglobulin's (%)	15.0	15.0	20.0	11.5
Serum albumin/lactoferrin (%)	9.5	9.5	8.1	12.8

Source of Data
Cow Milk: [104]
Buffalo Milk: [105]
Sheep Milk: [104]
Goat Milk: [105]

Table 3 Amino acids profile of cow, buffalo, sheep and goat milk

Amino Acid (g/100 g)	Cow Milk	Goat Milk	Buffalo Milk	Sheep Milk
Aspartic acid	7.8	7.4	7.13	6.5
Threonine	4.5	5.7	5.714	4.4
Serine	4.8	5.2	4.65	3.4
[a]Glutamic acid	23.2	19.3	21.4	14.5
Proline	9.6	14.6	12.0	16.2
[a]Cystine	0.6	0.6	0.586	0.9
Glycine	1.8	2.1	1.93	3.5
Alanine	3.0	3.6	3.03	2.4
[a]Valine	4.8	5.7	6.760	6.4
[a]Methionine	1.8	3.5	0.928	2.7
[a]Isoleucine	4.2	7.1	5.714	4.6
[a]Leucine	8.7	8.2	9.792	9.9
[a]Tyrosine	4.5	4.8	3.858	3.8
Phenylalanine	4.8	6.0	4.713	4.3
[a]Histidine	3.0	5.0	2.73	6.7
Lysine	8.1	8.2	7.497	7.8

[a]Amino acid has antioxidant activity in milk and dairy products
Source of Data
Cow Milk: [106]
Goat Milk: [107]
Buffalo Milk: [108]
Sheep Milk: [107]

antioxidants. Photo-oxidation is predominantly inhibited by β-carotene, it absorbs light that would otherwise be absorbed by riboflavin, which may give rise to quality related issues. β-carotene absorbs light in a concentration dependent manner [28]. Results of an earlier investigation regarding the migration of carotenoids from milk to cheese and butter have shown that concentration of carotenoids was intensified in cheese and butter [29].

Antioxidant characteristics of ascorbic acid, vitamin E and minerals

Nutraceuticals and functional food ingredients that are beneficial to vascular health may represent useful compounds that are able to reduce the overall cardiovascular risks [30]. Ascorbic acid is one of the most strong and least toxic natural antioxidant. It is the main water soluble antioxidant present in milk and free radical scavenging activity of ascorbic acid is due to low oxidation-reduction potential (330 mV). Ascorbic acid is the major water-soluble antioxidant in milk and can act as strong free radical scavenger [31]. Ascorbic acid can scavenge superoxide anion radicals, alkoxyl radicals and singlet oxygen [31]. Ascorbic acid can scavenge superoxide, iron oxide, nitric oxide and alkoxyl radicals [32]. Ascorbic acid significantly inhibited the degradation of riboflavin in cream in presence of 1000 Lux light for four days [33]. Ascorbic acid and tocopherol were added in milk to enhance the flavor and photo-oxidative stability. Ascorbic acid and tocopherol supplemented samples revealed better flavor and photo-oxidative stability as compared to non-supplemented samples [34]. Ascorbic acid significantly inhibited the degradation of riboflavin in light exposed milk, antioxidant activities were mainly attributed to the scavenging effect on singlet oxygen [35]. A study was conducted to determine the effect of tocopherol and vitamin C against the development of atopy in infants. Increased concentration of vitamin C in breast milk reduced the risk of atopy in infants [36]. Ascorbic acid is extremely helpful for the infants as it plays a pivotal role in the formation of neuro transmitters, synthesis of carnitine and improves the absorption of iron. Human and cow milk contains about 40 and 20 mg/Liter [37, 38]. Oxidation of ascorbic acid depends upon temperature, light, oxygen and amount of catalysts. Vitamin A and E are regarded as primary lipid soluble antioxidants and main job of these vitamins is to protect the polyunsaturated fatty acids and associated bio-chemical compounds from peroxidation (Table 4). α-tocopherol can be considered one of the most important lipid-soluble antioxidants in milk, due to it is presence in milk fat globule membrane [39]. It can act as a preventative, chain breaking antioxidant and quencher of singlet oxygen in milk [40]. Milk can develop off flavor as a result of photo-oxidation and contamination with copper. The existence of antioxidants in milk can inhibit the free radical mechanism by donating the proton and thus inhibit the onset of auto-oxidation. Vitamin E can inhibit the activity of plasmin; a proteolytic enzyme and secondly it can directly scavenge the free radicals [41]. Among the tocopherols, α-tocopherol is regarded as more powerful scavenger of free radicals and antioxidant activity of β-, γ- and δ-tocopherol is about 80–90% less than α-tocopherol [42]. γ-tocopherol is of high functional value as it can trap the nitrogen oxide species. It helps the body to prevent cardiovascular diseases and cancers. The concentration of vitamin E in cow milk has been reported about 0.9 mg/mL while summer milk possessed higher concentration than winter milk. Concentration of vitamin in human milk ranges from 3 to 13 mg/mL [43]. Addition of 100 mg α-tocopherol/kg milk fat and 100 mg ascorbyl palmitate/kg milk fat to UHT milk decreased the concentration of hexanal during the storage period of 4 weeks [34]. Khan et al. [44] studied the effect of vitamin E supplementation on oxidative stability of sheep butter and supplementation of sheep butter with 60 mg/kg efficiently inhibited the lipid peroxidation and raised the shelf stability. Antioxidant activity of zinc and selenium for the inhibition of superoxide dismutase is scientifically proven [45]. Glutathione and selenium enhanced the functional value and antioxidant capacity of milk [46]. Mineral content of cow, buffalo, goat and sheep milk have been presented in Table 5.

Table 4 Vitamin content of cow, buffalo, goat and sheep milk

Vitamins	Cow Milk (mg/100 g)	Buffalo Milk (mg/100 g)	Goat Milk (mg/100 g)	Sheep Milk (mg/100 g)
Vitamin A[a]	46	69	185	146
Vitamin E[a]	0.21	0.19	0.03	–
Thiamine	0.05	0.05	0.068	0.08
Riboflavin	0.17	0.11	0.21	0.37
Niacin	0.09	0.17	0.27	0.416
Pantothenic acid	0.37	0.15	0.31	0.408
Vitamin B_6	0.04	0.33	0.046	0.08
Vitamin B_{12}	0.45	0.40	0.665	0.712
Biotin	2.0	13	1.5	0.93
Vitamin C[a]	0.09	2.5	1.29	4.16
Vitamin D	2.0	2.0	1.33	1.18

[a]Vitamin possesses antioxidant activity
Source of Data
Cow Milk: [37]
Buffalo Milk: [107]
Goat Milk: [108]
Sheep Milk: [107]

Table 5 Mineral content of cow, buffalo, goat and sheep milk

Minerals	Cow Milk	Buffalo Milk	Goat Milk	Sheep Milk
Calcium	122 (mg/100 g)	112 (mg/100 g)	134 (mg/100 g)	195–200 (mg/100 g)
Phosphorus[a]	119 (mg/100 g)	99 (mg/100 g)	121 (mg/100 g)	124–158 (mg/100 g)
Potassium	152 (mg/100 g)	92 (mg/100 g)	181 (mg/100 g)	136–140 (mg/100 g)
Magnesium	12 (mg/100 g)	8 (mg/100 g)	16 (mg/100 g)	18–21 (mg/100 g)
Sodium	58 (mg/100 g)	35 (mg/100 g)	41 (mg/100 g)	44–58 (mg/100 g)
Zinc[a]	530 (μg/100 g)	410 (μg/100 g)	56 (μg/100 g)	520–747 (μg/100 g)
Iron[b]	80 (μg/100 g)	161 (μg/100 g)	7.22 (μg/100 g)	72–122 (μg/100 g)
Copper[b]	60.58 (μg/100 g)	35 (μg/100 g)	5.13 (μg/100 g)	40–68 (μg/100 g)
Manganese	20 (μg/100 g)	27 (μg/100 g)	3.2 (μg/100 g)	5.39 (μg/100 g)
Iodine	2.1 (μg/100 g)	4 (μg/100 g)	2.2 (μg/100 g)	10.41 (μg/100 g)
Selenium[a]	0.96 (μg/100 g)	6 (μg/100 g)	1.33 (μg/100 g)	3.14 (μg/100 g)

[a]Chemical constituents has antioxidant activity in milk
[b]Chemical constituent has pro-oxidant activity
Source of Data
Cow Milk: [46]
Buffalo Milk: [107]
Goat Milk: [109]
Sheep Milk: [107]

Enzymatic antioxidants

Superoxide dismutase

Superoxide dismutase (SOD) catalyzes the removal of superoxide free radicals (O_2^-) and safeguards the cells from harmful effects by the following reaction.

$$20_{2^-} + 2H \rightarrow H_2O_2 + O_2$$

Catalase, glutathione peroxidase or other reducing agents converts H_2O_2 to H_2O, hydrogen peroxide formed from O_2^- and oxidases is eliminated by catalases and peroxidases [47]. Cytosolic Cu/Zn-SOD, mitochondrial Mn-SOD and extracellular EC-SOD are the major forms of SOD [48]. SOD can inhibit lipid peroxidation. In cow milk SOD is exclusively present in skim milk fraction, with a concentration of 0.15 mg to 2.4 mg/L [49]. Human milk has 2.0 to 2.3 time higher concentration of SOD than cow milk.

Glutathione peroxidase (GSHPx)

GSHPx is a selenium encompassing enzyme that provides protection against lipid peroxidation. It catalysis the breakdown of H_2O_2 and organic hydroperoxides (R-OOH) by glutathione (γGlu.Cys.Gly) as per following chemical reaction [50].

$$ROOH + 2GSH \rightarrow ROH + GSSG + H2O$$

More than 90% of GSHPx exists in milk as extra cellular enzyme and it is only enzyme which fixes selenium (about 30% of the total. Its concentration varies among the mammals and concentration is in the order of human > caprine > bovine [51]. Concentration of GSHPx in cow milk ranges from 12 to 30 U/mL and its activity is mainly dependent upon the concentration of selenium. Antioxidant activity and selenium content decreases with the progression of lactation [52].

Catalase

Milk catalase is a heme protein and molecular weight of catalase is 200 kDa with isoelectric pH of 5.5. This enzyme is stable in a wide range of pH 5–10 and however, it rapidly loses activity out this pH range [53]. Most of the catalases contain heme and catalase causes the dismutation of H_2O_2 (a chemical reaction in which H_2O_2 causes oxidation of the other H_2O_2 molecules, consequently, one is converted to O_2 and the other two are converted to tow molecules of H_2O) [54]. A polarographic method showed that average catalase activity in cow milk was 1.95 U/mL [55]. Concentration of catalase in human milk is approximately ten times greater than cow milk [56].

Oxidative stability of milk and milk products

The oxidative stability of milk and dairy products is of concern to the dairy industry. Oxidation in milk can result in strong off-flavors and in deterioration of the nutritional quality of milk. The oxidative stability of milk and dairy products is the result of a delicate balance between the anti- and pro-oxidative processes in milk. Oxidative stability of milk and dairy products depends upon fatty acid composition (Tables 6 and 7), contamination with metal ions, concentration of tocopherols and carotenoids [57]. Processing, packaging, storage conditions and period have a pronounced effect on the extent of natural antioxidants, which is directly connected with oxidative stability of pasteurized milk and dairy products [58].

23. Chen J, Lindmark-Mansson H, Akesson B. Optimisation of a coupled enzymatic assay of glutathione peroxidase activity in bovine milk and whey. Int Dairy J. 2000:347–51.
24. Stahl W, Sies H. Antioxidant activity of carotenoids. Mol Asp Med. 2003; 24:345–51.
25. Lindmark-Mansson H, Akesson B. Antioxidative factors in milk. Br J Nutr. 2000;84:103–10.
26. Kim HJ, Min DB. Chemistry and reactions of singlet and triplet oxygen in lipid oxidation. In: Kamal-Eldin A and Min DB. Lipid Oxidation Pathways. Urbana, IL: AOCS Press. 2003;1–30.
27. Young AJ, Lowe GM. Antioxidant and prooxidant properties of carotenoids. Arch Biochem Biophys. 2001;385:20–7.
28. Mortensen G, Sorensen J, Stapelfeldt H. Comparison of peroxide value methods used for semihard cheeses. J Agric Food Chem. 2002;50:5007–11.
29. Panfili G, Manzi P, Pizzoferrato L. Influence of thermal and other manufacturing stresses on retinol isomerization in milk and dairy products. J Dairy Res. 1998;65:253–60.
30. Scicchitano P, Cameli M, Maiello M, Modesti PA, Muiesan ML, Novo S, et al. Nutraceuticals and dyslipidaemia: beyond the common therapeutics. J Funct Foods. 2014;6:11–32.
31. Choe E, Min DB. Mechanisms of antioxidants in the oxidation of foods. Comp Rev Food Sci Food Safety. 2009;8:345–58.
32. Hosaka S, Obuki M, Nakajima J, Suzuki M. Comparative study of antioxidants as quenchers or scavengers of reactive oxygen species based on quenching of MCLA-dependent chemiluminescence. Luminescence. 2005;20:419–27.
33. Huang D, OU B, Prior RL. The chemistry behind antioxidant capacity assay. J Agric Food Chem. 2005;53:1841–56.
34. Van Aardt M, Duncan SE, Marcy JE, Long TE, O'Keefe SF, Nielsen-Sims SR. Aroma analysis of light-exposed milk stored with and without natural and synthetic antioxidants. J Dairy Sci. 2005;88:881–90.
35. Whited LJ, Hammond BH, Chapman KW, Boor KJ. Vitamin a degradation and light oxidized flavor defects in milk. J Dairy Sci. 2002;85:351–4.
36. Hoppu U, Isolauri E. Vitamin C in breast milk may reduce the risk of atopy in the infant. European J Clinical Nutri. 2004;59:123–8.
37. Singh M. Role of micronutrients for physical growth and mental development. Indian J Pediatr. 2004;71:59–62.
38. Humma N, Sameen A, Zahoor T, Anjum M. Composition and physico-chemical characteristics of buffalo milk with particular emphasis on lipids, proteins, minerals, enzymes and vitamins. J Animal and Plant Sci. 2013;23:62–74.
39. Jensen SK, Nielsen KN. Tocopherols, retinol, β-carotene and fatty acids in fat globule membrane and fat globule core in cow's milk. J Dairy Res. 1996;63:565–74.
40. O'Connor TP, O'Brien NM. Lipid oxidation. In: Fox PF, McSweeney PLH, editors. Advanced dairy chemistry: volume 2: lipids. New York: Springer; 2006. p. 557–600.
41. Politis I. Reevaluation of vitamin E supplementation of dairy cows: bioavailability, animal health and milk quality. Animal. 2012;6:1427–34.
42. Hosseinian FS, Li W, Tsopmo A, Friel JK, Beta T. Evaluation of antioxidant capacity and aroma quality of breast milk. Nutrition. 2009;25:105–14.
43. Moltó Puigmartí C, Castellote AI, López-Sabater MC. Ultra-high-pressure liquid chromatographic method for the analysis of tocopherols in human colostrum and milk. J Chromatography A. 2009;1216:4388–94.
44. Khan GA, Nadeem M, Abdullah M, Ilyas M. Effect of vitamin E on storage stability of sour cream butter made from sheep milk. Carpathian J Food Sci Tech. 2011;3:21–5.
45. Geissler C, Powers H. Human nutrition London. UK: Churchill Livingstone. 2011:509–32.
46. Sretenović LJ, Aleksić S, Petrović PM, Miščević B. Nutritional factors influecing improvement of milk and meat quality as well as productive and reproductive parameters of cattle. Biotechnol Anim. 2007;5–6:217–226.
47. Fox PF, McSweeney PLH. Dairy Chemistry and Biochemistry. First edition. Blackie Academic and Professional, Thomson Science, London. 1998;1:265–340.
48. Matés JM. Pérez-Gómez C, Núñez de Castro I. Antioxidant enzymes and human diseases. Clin Biochem. 1999;32:595–603.
49. Fang YZ, Yang S, Wu G. Free radicals, antioxidants and nutrition. Nutrition. 2002;18:872–9.
50. Torres A, Farré R, Lagarda MJ, Monleón J. Determination of glutathione peroxidase activity in human milk. Nahrung. 2003;47:430–3.
51. Fox PF, Kelly AL. Indigenous enzymes in milk: overview and historical aspects - part 2. Int Dairy J. 2006;16:517–32.
52. Quiles JL, Ochoa JJ, Ramirez-Tortosa MC, Linde J, Bompadre S, Battino M. Coenzyme Q concentration and total antioxidant capacity of human milk at different stage of lactation in mothers of preterm and full-term infants. Free Radic Res. 2006;40:199–206.
53. Abbas H, Hassan F, Enab A, Gawad A. Physicochemical characteristics of goat's milk. J Life Sci. 2014;11:307–17.
54. Silanikove N, Merin U, Leitner G. Physiological role of indigenous milk enzymes: an overview of an evolving picture. Int Dairy Sci. 2006;16:533–45.
55. Niklowitz P, Menke T, Giffei J, Andler W. Coenzyme Q10 in maternal plasma and milk throughout early lactation. Biofactors. 2005;25:67–72.
56. Tijerina-Sáenz A, Innis SM, Kitts DD. Antioxidant capacity of human milk and its association with vitamins a and E and fatty acid composition. Acta Paediatr. 2009;98:1793–8.
57. Nielsen JH. Lund-Nielsen T and Skibsted L. Higher antioxidant content in organic milk than in conventional milk due to feeding strategy. 2004:1–2.
58. Zygoura P, Moyssiadi T, Badeka A, Kondyli A, Savvaidis I, Kontominas MG. Shelf life of whole pasteurized milk in Greece: effect of packaging material. Food Chem. 2004;87:1–9.
59. Halliwell, B. Antioxidants in human health and diseases. Annu Rev Nutr. 1996;1–2;33–50.
60. Zulueta A, Esteve MJ, Frigola A. ORAC and TEAC assays comparison to measure the antioxidant capacity of food products. Food Chem. 2009;114: 310–6.
61. Chen J, Lindmark-Mansson H, Gorton L, Akesson B. Antioxidant capacity of bovine milk as assayed by spectrophotometric and amperometric methods. Int Dairy J. 2003;13:927–35.
62. Liang JH. Kinetics of fluorescence formation in whole milk powders during oxidation. Food Chem. 2000;71:459–63.
63. Fenaille F, Mottier P, Turesk RJ, Ali S, Guy PA. Comparison of analytical techniques to quantify malondialdehyde in milk powders. J Chromatogr A . 2001;921:237–245.
64. Lim CW, Norziah MH, Lu HFS. Effect of flaxseed oil towards physicochemical and sensory characteristic of reduced fat ice creams and its stability in ice creams upon storage. Food Res Int. 2010;17:393–403.
65. Chapman KW. Sensory evaluation of milk. In Griffiths MW. Improving the safety and quality of milk. Cambridge, Uk: Woodhead Publishing Limited. 2010;159–180.
66. Dzomba P, Ngoroyemoto N, Musarurwa R. Antioxidant capacity and microbial attributes of raw cow milk fortified with Hypotrigonasquamuligera honey. Global J Medi Res Microbio Patho. 2013;13:9–12.
67. Haug M, Laubach C, Burke M, Harzer G. Vitamin E in human milk from mothers of preterm and term infants. J Pediatr Gastroenterol Nutr. 1987;6:605–9.
68. Hernández Galán L, Cardador Martínez A, Picque D, Spinnler HE, López Del Castillo Lozano M, Martín Del Campo Barba ST. Angiotensin converting enzyme inhibitors and antioxidant peptides release during ripening of Mexican Cotija hard cheese. J Food Res. 2016;5(3):85–91.
69. Gupta A, Mann B, Kumar R, Sangwan RB. Antioxidant activity of Cheddar cheeses at different stages of ripening. Inter J Dairy Tech. 2009;62:339–47.
70. Balakrishnan G, Agrawal R. Antioxidant activity and fatty acid profile of fermented milk prepared by Pediococcus pentosaceus. J Food Sci Technol. 2014;51:4138–42.
71. Najgebauer-Lejko D, Grega T, Tabaszewsa M. Yoghurts with addition of selected vegetables: acidity, antioxidant properties and sensory quality. Acta Sci Pol Technol Aliment. 2014;13:35–42.
72. Srivastava P, Prasad SGM, Ali MN, Prasad M. Analysis of antioxidant activity of herbal yoghurt prepared from different milk. The Pharma Innovation J. 2015;4:18–20.
73. Brignac B, Aryana KJ. Influence of various antioxidants on the characteristics of plain yogurt. Food Nutri Sci. 2012;3:1277–80.
74. Matter AA, Mahmoud EAM, Zidan NS. Fruit flavored yoghurt: chemical, functional and rheological properties. Inter J Enviro Agric Res. 2016;2: 57–66.
75. Lin MY, Yen CL. Reactive oxygen species and lipid peroxidation product-scavenging ability of yogurt organisms. J Dairy Sci. 1999;82:1629–34.
76. Songisepp E, Kals J, Kullisaar T, Mändar R, Hütt P, Zilmer M, Mikelsaar M. Evaluation of the functional efficacy of an antioxidative probiotic in healthy volunteers. Nutri J. 2005;4:22.

77. Park YW, Nam MS. Bioactive peptides in milk and dairy products: a review. Korean J Food Sci Anim Resour. 2015;35:831–40.
78. Aleksandrova V, Chikov G, Velikova G, Dimitrov M, Dimov SG. *In vivo* antioxidant activity evaluation of peptides produced during the fermentation of yoghourt-like dairy products. Bulg J Agri Sci. 2013;19:97–100.
79. Alimi D, Abidi A, Sebai E, Rekik M, Maizels RM, Dhibi M, Akkari H. *In vivo* nematicidal potential of camel milk on *Heligmosomoides polygyrus* gastro-intestinal nematode of rodents. Institute of Parasitology, *SAS, Košice*. 2018;5:1–7.
80. Padghan PV, Mann B, Sharma R. *In-vivo* studies of antioxidant activity of fermented milk (Lassi) by *Lactobacillus acidophilus* and standard dahi culture. J Phar & Phytoche. 2018;7:25–30.
81. Huma N, Rafiq S, Sameen A, Pasha I, Khan MI. Antioxidant potential of buffalo and cow milk Cheddar cheeses to tackle human colon adenocarcinoma (Caco-2) cells. Asian-Australas J Anim Sci. 2018;31:287–92.
82. Larsson SC, Andersson SO, Johansson JE, Wolk A. Cultured milk, yogurt, and dairy intake in relation to bladder cancer risk in a prospective study of Swedish women and men. Am J Clin Nutr. 2008;88:1083–7.
83. Thirabunyanon M, Boonprasom P, Niamsup P. 2009. Probiotic potential of lactic acid bacteria isolated from fermented dairy milks on antiproliferation of colon cancer cells. Biotechnol Lett. 2009;31:571–6.
84. Larsson SC, Bergkvist L, Wolk A. High-fat dairy food and conjugated linoleic acid intakes in relation to colorectal cancer incidence in the Swedish mammography cohort. Am J Clin Nutr. 2005;82:894–900.
85. Rayes AAH, El-Naggar SMM, Mehanna NS. The effect of natural fermented milk in the protection of liver from cancer. Nutr Food Sci. 2008;38:578–92.
86. Aune D, Lau R, Chan D, Vieira R, Greenwood D, Kampman E, Norat T. Dairy products and colorectal cancer risk: a systematic review and meta-analysis of cohort studies. Ann Oncol. 2012;23:37–45.
87. Alvarez-León EE, Román-Vinas B, Serra-Majem L. Dairy products and health: a review of the epidemiological evidence. Br J Nutr. 2006;96:94–9.
88. Cho E, Smith-Warner SA, Spiegelman D, Beeson WL, van den Brandt PA, Colditz GA, Folsom AR, Fraser GE, Freudenheim JL, Giovannucci E. Dairy foods, calcium, and colorectal cancer: a pooled analysis of 10 cohort studies. J Natl Cancer Inst. 2004;96:1015–22.
89. Hjartåker A, Thoresen M, Engeset D, Lund E. Dairy consumption and calcium intake and risk of breast cancer in a prospective cohort: the Norwegian women and cancer study. Cancer Cause Control. 2010;21: 1875–85.
90. Rodrigues L, Teixeira J, Schmitt F, Paulsson M, Månsson HL. Lactoferrin and cancer disease prevention. Crit Rev Food Sci. 2008;49:203–17.
91. Tsuda H, Kozu T, Iinuma G, Ohashi Y, Saito Y, Saito D, Akasu T, Alexander DB, Futakuchi M, Fukamachi K, Xu J, Kakizoe T, Iigo M. Cancer prevention by bovine lactoferrin: from animal studies to human trial. Biometals. 2010;23: 399–409.
92. Tsuda H, Sekine K, Ki F, Iigo M. Cancer prevention by bovine lactoferrin and underlying mechanisms—a review of experimental and clinical studies. Biochem Cell Biol. 2002;80:131–6.
93. Parodi P. A role for milk proteins and their peptides in cancer prevention. Curr Pharm Des. 2007;13:813–28.
94. Mehra R, Marnila P, Korhonen M. Milk immunoglobulins for health promotion. Int Dairy J. 2006;16:1262–72.
95. O'Sullivan TA, Hafekost K, Mitrou F, Lawrence D. Food sources of saturated fat and the association with mortality: a meta-analysis. Am J Public Health. 2013;103:31–42.
96. Qin LQ, Xu JY, Han SF, Zhang ZL, Zhao YY, Szeto IM. Dairy consumption and risk of cardiovascular disease: an updated meta-analysis of prospective cohort studies. Asia Pac J Clin Nutr. 2015;24:90–100.
97. Alexander DD, Bylsma LC, Vargas AJ, Cohen SS, Doucette A, Mohamed M, Irvin SR, Miller PE, Watson H, Fryzek JP. Dairy consumption and CVD: a systematic review and meta-analysis. Br J Nutr. 2016;115:737–50.
98. von Ruesten A, Feller S, Bergmann MM, Boeing H. Diet and risk of chronic diseases: results from the first 8 years of follow-up in the EPIC-Potsdam study. Eur J Clin Nutr. 2013;67:412–9.
99. Pal S, Ellis V. The chronic effects of whey proteins on blood pressure, vascular function, and inflammatory markers in overweight individuals. Obesity (Silver Spring). 2010;18:1354–9.
100. Xu JY, Qin LQ, Wang PY, Li W, Chang C. Effect of milk tripeptides on blood pressure: a meta-analysis of randomized controlled trials. Nutr. 2008;24:933–40.
101. Boelsma E, Kloek J. Lactotripeptides and antihypertensive effects: a critical review. Br J Nutr. 2009;101:776–86.
102. Tong X, Dong JY, Wu ZW, Li W, Qin LQ. Dairy consumption and risk of type 2 diabetes mellitus: a meta-analysis of cohort studies. Eur J Clin Nutr. 2011; 65:1027–31.
103. Aimutis WR. Bioactive properties of milk proteins with particular focus on anticariogenesis. J Nutr. 2004;134:989–95.
104. Borková M, Snášelová J. Possibilities of different animal milk detection in milk and dairy products – a review. Czech J Food Sci. 2005;2:41–50.
105. Rafiq S, Huma N, Pasha I, Sameen A, Mukhtar O, Khan MI. Chemical composition, nitrogen fractions and amino acids profile of milk from different animal species. Asian-Australias J Anim Sci. 2016;29:1022–8.
106. Medhammar E, Wijesinha-Bettoni R, Stadlmayr B, Nilsson E, Charrondiere UR, Burlingame B. Composition of milk from minor dairy animals and buffalo breeds: a biodiversity perspective. J Sci Food Agric. 2012;92:445–74.
107. Barlowaska J, Litwinczuk Z, Krol J. Nutritional value and technological suitability of milk from various animal species used for dairy production. Compr Rev Food Sci Food Saf. 2011;10:291–302.
108. Ren DX, Zou CX, Lin B, Chen YL, Liang XW, Li JX. A comparison of milk protein, amino acid and fatty acid profiles of river buffalo and their F_1 and F_2 hybrids with swamp buffalo in China. Pakistan J Zool. 2015;47:1459–65.
109. Helaly L, Rashed S, Bdaiwi L. A comparative study of oxidant and antioxidant levels between human milk with other type of ruminant milk. J Iraqi National Chem. 2013;49:86–99.
110. Nadeem M, Abdullah M, Hussain I. Inayat. Modification of fatty acid profile of cow milk by calcium salts of fatty acids and its use in ice cream. J Food Sci Technol. 2015;52:1061–7.
111. Abdel M. Present status of the world goat populations and their productivity. King Faisal University, Al-Ahsa. Saudi Arabia Lohmann Information. 2010;42:160–95.
112. Talpur FN, Memon NN, Bhangar MI. Comparison of fatty acid and cholesterol content of Pakisani buffalo breeds. Pak J Analyt Environ Chem. 2007;8:15–20.
113. Ruiz de Gordoa JC, Bustamante M, Arranz J, Virto M, Barrón LJR, Beltrán de Heredia I, Amores G, Abilleira E, Nájera AI, Ruiz R, Albisu M, Pérez-Elortondo FJ, Mandaluniz N. Increase in water-soluble total antioxidant capacity of sheep's milk as a result of increased grazing time. Options Méditerranéennes. 2011;99:267–271.
114. Smet K, Raes K, De Block J, Herman L, Dewettinck K, Coudijzer K. A change in antioxidative capacity as a measure of onset to oxidation in pasteurized milk. Int Dairy J. 2008;18:520–30.
115. Najgebauer-Lejko D, Sady M. Estimation of the antioxidant activity of the commercially available fermented milks. Acta Sci Pol Technol Aliment. 2015; 14:387–96.
116. Antone U, Zagorska J, Sterna V, Jemeljanovs A, Berzins A, Ikauniece D. Effects of dairy cow diet supplementation with carrots on milk composition, concentration of cow blood serum carotenes, and butter oil fat-soluble antioxidative substances. Agron Res. 2015;13:879–91.
117. Sivakumar GM, Dhanalakshmi B, Nareshkumar C, Pugazhenthi TR. Antioxidant activity of herbal extract on khoa. Ind J Vet Anim Sci Res. 2014; 43:445–51.
118. Yilmaz-Ersan L, Ozcan T, Akpinar-Bayizit A, Sahin S. The antioxidative capacity of kefir produced from goat milk. Int J Chem Eng Appl. 2016;7:22–6.
119. Roy T, Deepak D. Antioxidant properties of milk oligosaccharides from various ruminants. Int J Pharm Bio Sci. 2014;5:400–8.
120. Balakrishnan G, Agrawal R. 2012. Antioxidant activity and fatty acid profile of fermented milk prepared by Pediococcus pentosaceus. J Food Sci Technol. 2012;51:4138–42.
121. Vankudre M, Balpande A, Athale M. Comparative analysis of α-amylase inhibition and antioxidant activity of whey from cow and buffalo milk fermented with lactobacillus species. Biosci Biotech Res Comm. 2015;8:25–8.
122. Puppel K, Kuczyńska B, Nałęcz-Tarwacka T, Grodzki H. Influence of linseed variety on fatty acid profile in cow's milk. J Sci Food Agric. 2017;93:2276–80.
123. Hernandez-Ledesma B, Amigo L, Ramos M, Recio I. Release of angiotensin converting enzyme-inhibitory peptides by simulated gastrointestinal digestion of infant formulas. Int Dairy J. 2004;14:889–98.
124. Kurćubić VS, Vujić JM, Iličić MD, Vranić D, Vesković-Moračanin SM, Mašković PZ. Effect of plant extracts of Kitaibelia vitifolia on antioxidant activity,

chemical characteristics, microbiological status and sensory properties of Pirotski Kachkaval cheese. Hemi indust. 2015;69:85–93.
125. Ullah R, M. Nadeem, M. Imran, M. Tayyab and R. Sajid. Antioxidant characteristics of ice cream supplemented with sugarcane (*Saccharum officinarum* L.) juice. Food Sci Biotec. 2015;24:1227–1232.
126. Nadeem M, Abdullah M, Javid MT. Evaluation of functional fat from interesterified blends of butter oil and *Moringa oleifera* oil. Pak J Nutri. 2012; 11:725–9.
127. Nadeem M, Abdullah M, Hussain I, Javid A, Zahoor Y. Antioxidant potential of *Moringa oleifera* leaf extract for the stabilization of butter at refrigeration temperature. Czech J Food Sci. 2013;31:332–9.
128. Nadeem M, Mahmud A, Imran M. Khalique. Enhancement of the oxidative stability of whey butter through almond (*Prunis dulcis*) peel extract. J Food Process Preserv. 2015;39:591–8.
129. Nadeem M, Abdullah M, Hussain I. Improvement of the oxidative stability of butter oil by blending with Moringa oleifera oil. J Food Process Preserv. 2014;38:1491–500.
130. Khan IT, Nadeem M, Imran M, Ajmal M, Ali S. Antioxidant activity, fatty acids characterization and oxidative stability of Gouda cheese fortified with mango (Mangifera indica L.) kernel fat. J Food Sci Technol. 2018;55(3):992–1002. https://doi.org/10.1007/s13197-017-3012-y Epub 2018 Feb 5.
131. Nadeem M, Ullah R, Ullah A. Improvement of the physical and oxidative stability characteristics of ice cream through interesterified *Moringa oleifera* oil. Pakistan J Sci Indust res. Ser B: biol sci. 2016;59:38–43.
132. Rashidinejad A, Birch EJ, Everett DW. Antioxidant activity and recovery of green tea catechins in full-fat cheese following gastrointestinal simulated digestion. J Food Comp Anal. 2016;48:13–24.
133. Branciari R, Ranucci D, Trabalza-Marinucci M, Codini M, Orru M, Ortenzi R, Forte C, Ceccarini MR, Valiani A. Evaluation of the antioxidant properties and oxidative stability of pecorino cheese made from the raw milk of ewes fed Rosmarinus officinalis L. leaves. Int J Food Sci Tech. 2015;50:558–65.
134. Rashidinejad A, Birch EJ, Sun Waterhouse D, Everet DW. Effects of catechin on the phenolic content and antioxidant properties of low-fat cheese. Int J Food Sci Technol. 2013;48:2448–55.
135. Mahajan D, Bhat ZF, Kumar S. Pine needles (Cedrus deodara (Roxb.) loud.) extract as a novel preservative in cheese. Food Packag Shelf Life. 2016;7:20–5.
136. Olmedo RH, Nepote V, Grosso NR. Preservation of sensory and chemical properties in flavoured cheese prepared with cream cheese base using oregano and rosemary essential oils. LWT-Food Sci Tech. 2013;53:409–17.
137. Hala M, Ebtisam E, Sanaa I, Badran M, Marwa A, Said M. Manufacture of low fat UF-soft cheese supplemented with rosemary extract (as natural antioxidant). J Amr Sci. 2010;6:570–9.
138. Caleja C, Barros L, Antonio AL, Ciric A, Soković M, Oliveira MBP, Santos-Buelga C, Ferreira IC. Foeniculum vulgare mill as natural conservation enhancer and health promoter by incorporation in cottage cheese. J Funct Food. 2015;12:428–38.
139. Smith-Palmer A, Stewart J, Fyfe L. The potential application of plant essential oils as natural food preservatives in soft cheese. Food Microbiol. 2001;18:463–70.
140. Caleja C, Ribeiro A, Barros L, Barreira JC, Antonio AL, Oliveira MBP, Barreiro MF, Ferreira IC. Cottage cheeses functionalized with fennel and chamomile extracts: comparative performance between free and microencapsulated forms. Food Chem. 2016;199:720–6.