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Nutritional Value and Antioxidant Activity of Camel's Milk

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ABSTRACT

Due to safety concerns, natural antioxidants have been of increasing interest so that the present investigation was undertaken to shed more light on the nutritional value and antioxidant properties of raw camel's milk (*Camelus dromedarius*). Eighty milk samples were tested for their physiochemical and antioxidant properties including fat, protein, lactose, gross energy, total antioxidant capacity, vitamin C, zinc, iron and copper. The results showed mean values for the percentage of fat, protein, lactose and gross energy of 4.3±0.09, 3.4±0.06, 4.04±0.06, 75.3±1.04, respectively. The obtained data showed higher content of total antioxidant capacity (3.6±0.14 mmol/l), vitamin C (8.4±0.44 mg/dl), zinc (0.33±0.01 mg/dl), iron (0.25±0.01 mg/dl) and copper (0.14±0.123 mg/dl) than that reported in previous studies on other types of milk. The study showed that nutritional contribution made by one cup of camel's milk can meet the daily requirement for human from gross energy, vitamin C, zinc, iron and copper with 10.5, 23.3, 7.5, 7.8 and 38.9 %, respectively. Among the antioxidant profile, the average concentration of the total antioxidant capacity (TAC) was 3.6±0.14 mmol/L. Significant correlations were observed between TAC and other milk parameters particularly ascorbic acid. The obtained data could be of value in understanding the reasons behind considering camel's milk as a functional food.

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Introduction

The relationship between diet and health is one of the keys for preventing diseases and promoting well-being. As a result in searching for effective dietary intervention strategies, a new class of food called functional food has evolved rapidly and many new terms such as nutraceutical and antioxidant have emerged in response. Functional food is defined as foods that provide health benefits beyond basic nutrition (IFIC, 2004); likewise, functional foods do more than meet minimum daily nutrient requirements if they are eaten regularly as part of a generally healthy diet (Wildman, 2006; Madsen, 2007). Camel's milk considered a whole food commonly used in hot and arid regions as an essential nutritional source, known to overcome autoimmune disorders, nutritional deficiencies and morbidities (Singh *et al.*, 2009; Habib *et al.*, 2013). It differs from bovine milk in composition and structure of its protein components, which influences its functional and biological properties (El-Hatmi *et al.*, 2007).

Camel's milk is a natural historic remedy successfully used as the treatment of many diseases. It was first mentioned by the prophet Mohammed (peace is up on him) in the Muslim Holy Scriptures (Khan, 1997) and further it had received research and popular interests for optimal infant, adult, and aging nutrition (Nikkhah, 2011). It has been introduced recently as new functional food in the European market (Faye and Bonnet, 2012). It's well tolerated by lactase-deficient patients who are allergic to cow milk (El-Agamy *et al.*, 2009); furthermore, Sayed *et al.* (2013) reported a positive modulating effect for camel's milk on alloxan-induced diabetic rats compared to cow's milk and recommended it as a nutraceutical supplement for diabetic patients.

Antioxidants are compounds in foods that scavenging, neutralizing, stabilizing, or deactivating, free radicals and terminate the chain reaction before vital molecules are damaged (Halliwell and Gutteridege, 2007). Antioxidants have received increased attention by nutritionists and medical researchers for their potential effects in the prevention of chronic and degenerative and aging diseases (Kaur and Kapoor, 2001; Young and Woodside, 2001).

Antioxidant compounds potentially present in milk can belong to different chemical families, such as enzymes (catalase, superoxide dismutase and glutathione peroxidase), trace

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elements (copper, zinc, and selenium) which are essential cofactors for enzymes' activity, vitamins (A, C, E) or even proteins and peptides (Andrei *et al*., 2005; Berger, 2006; Havemose *et al*., 2006; Andrei *et al*., 2010).

Although the nutritional benefit of camel's milk is widely accepted, its additional wide scope of antioxidant properties largely remains in the shadows of research. Against this background, the current study was carried out to give an overview on the nutritional and antioxidant activity of camel's milk through assessment of some macro-nutrients and their contribution to the energetic value in providing healthy food for human and evaluation of general and specific antioxidants present in camel's milk.

Materials and methods

Samples collection

Eighty samples of fresh raw camel's milk (*Camelus dromedarius*) collected from arid region in Egypt including Marsa Matroh, Aswan, Al-Salom, Halayeb and Shalateen. They were collected in clean plastic sampling bottles and kept in an icebox during transportation and subjected to analysis directly.

Determination of physicochemical parameters

Physicochemical parameters, including fat, protein, lactose, determined by the infrared milk analyzer (Lactoscan MCC) previously standardized for camel's milk (Aple Industries services–LaRoche SurForon, France), according to manufacturer's instructions. The gross energetic (GE) value of milk obtained as a calculated value from the overall percentage of fat, protein and carbohydrate multiplied by coefficient factors by the formula after Perrin (1958).

GE (Kcal/100 ml)= 5.86 (Protein %)+3.95 (Lactose %)+9.11 (Fat %)

Determination of antioxidant profile

Antioxidant profile compromised by measuring total antioxidant capacity (TAC), vitamin C and antioxidant minerals, including zinc, iron and copper. TAC for skim milk (aqueous phase) determined colorimetrically using a commercial test kit (Biodiagnostic Company for Biotechnology, Egypt) according to manufacturer's instructions. TAC assay was performed based on the reaction of antioxidants in camel's milk sample with a defined amount of exogenously provided hydrogen peroxide (H_2O_2). Thereafter, the residual H_2O_2 was determined colorimetrically by an enzymatic reaction, which involves the conversion of 3, 5, dichloro-2-hydroxylbenzen sulphonate to a colored product measured spectrophotometrically at 505 nm (Koracevic *et al*., 2001). Each skimmed milk sample analyzed in triplicate, and results expressed as mmol per liter. Total ascorbic acid (vitamin C) was determined using dinitrophenylhydrazine (DNPH) (Riemschneider *et al*., 1976). Antioxidant minerals, including iron (Fe), copper (Cu), and zinc (Zn) were determined in the digested milk samples using an atomic absorption spectrophotometer (Perkin-Elmer, Norwalk, CT) according to the method of AOAC (2000).

Statistical analysis

All determinations carried out in three replicates and data were expressed as mean ± standard error (SE). Correlations between different milk variables, including, TAC, ascorbic acid (AA), Cu, Zn, Fe, fat, protein and lactose assessed by Pearson's correlation test using Graph Pad Prism 5.0 software (Graph Pad, San Diego, Ca., USA).

Results

The results in Table 1 revealed that the mean values of energy contributors' fat, protein and lactose were of 4.3±0.09, 3.04±0.06 and 4.04± 0.06 %, respectively.

Moreover, it is evident from the present study that 100 ml of camel's milk provided about 75.3 Kcal of which proportionally about 39.3 Kcal (52%) came from fat, 20 Kcal came from protein (27%) and 16 Kcal (21%) came from lactose (Fig.1).

The results of antioxidant profile (Table 2) showed average content of total antioxidant capacity (3.6±0.14 mmol/l), vitamin C (8.4±0.44 mg/dl), zinc (0.33±0.01 mg/dl), iron (0.25±0.01 mg/dl) and copper (0.14±0.123 mg/dl), In addition, Contribution of camel's milk intake compared with recommended dietary allowances (RDA) for human were recorded in Table 3.

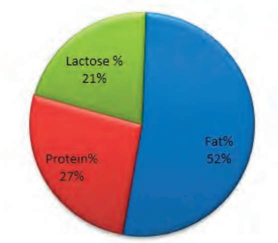

Fig. 1. The contribution of fat, protein and lactose to gross energy content of camel's milk samples (n=80)

Table 1. Physicochemical parameters of camel's milk

Milk constituents	Minimum	Maximum	Mean ± S.E
Fat %	2.82	5.98	4.3 ± 0.09
Protein %	2.14	4.73	3.4 ± 0.06
Lactose %	3.06	5.4	4.04 ± 0.06
Gross energy (Kcal/100ml)	54.7	97.2	75.3 ± 1.04

Table 2. Antioxidant profile of camel's milk samples (n=80)

Milk constituents	Minimum	Maximum	Mean ± S.E.
TAC (mmol/L)	1.17	6.6	3.60±0.14
Vit. C (mg/100ml)	3.2	18.9	8.40±0.44
Zinc (mg %)	0.17	0.53	0.33±0.01
Iron (mg %)	0.12	0.46	0.25±0.01
Copper (mg %)	0.09	0.21	0.14±0.12

TAC: Total antioxidants capacity

Table 3. Contribution of camel's milk (CM) intake compared with recommended dietary allowances (RDA) for human

Constituents	Amount present in camel milk (250 ml)	RDA/day*	Contribution of camel milk to RDA (%)
Gross energy (Kcal)	188.25	1800	10.5
Vitamin C (mg)	21.0	90.0	23.3
Zn (mg)	0.825	11.0	7.5
Fe (mg)	0.625	8.0	7.8
Cu (mg)	0.35	0.9	38.9

*Source: (DRIs) Dietary reference intakes (2001) recommended intake for individual, food and nutrition board, Institute of medicine, National academy of science.
*Serving size= 250 ml camel milk

Table 4. Correlation matrix between different camel's milk variable

	TAC	AAS	Zn	Fe	Cu	Fat	Protein	Lactose
TAC		0.292**	-0.142	-0.019	-0.054	-0.256*	0.232*	-0.051
AAS			0.156	0.114	0.160	-0.190	0.315**	-0.351**
Zn				0.322**	0.558***	0.110	-0.122	-0.076
Fe					0.401***	0.145	0.145	0.112
Cu						0.118	0.020	-0.019
Fat							0.0645	0.366***
Protein								0.492***

*: Significance $p < 0.05$ ** Significance $p < 0.005$
***:Significance $p < 0.0001$
- :Negative correlation + :Positive correlation
TAC: Total antioxidant capacity AAs: Ascorbic acid

The relationship between different milk parameters exposed in Table 4, professed that the TAC represented the highest positive correlation with ascorbic acid (P<0.005) in addition to significant negative correlation with fat (P<0.05).

Discussion

Camel's milk has high concentration of volatile fatty acids, and abundant source of protein rich in lysozome, lactoferrin, lactoperoxidase (LP) and immunoglobulins, which are essential for human nutrition and provide effective protection against several pathogens (Konuspayeva *et al.*, 2008). The energy content of camel's milk is an important index of its nutritional value to human. In the present study, the overall energy content supplied by camel's milk was varied between 54.7 and 97.2 Kcal/100 ml with an average value of 75.3 Kcal/100 ml. It was noticeable that calculating the gross energy of previously published camel's milk composition data (Shamsia, 2009; Nikkhah, 2011) using the equation after Perrin (1958), revealed similar results of the current study.

The antioxidative status of biological samples could be analyzed by determining of single components in the system or by measurement of total antioxidant capacity (TAC), which is a significant parameter to confirm the health function of foodstuffs (Kaur and Kapoor, 2001). The total antioxidant capacity of camel's milk, ranged between 1.17-6.6 mmol/L (Table 2). Despite recent studies suggest camel milk as a potential antioxidant therapy in Autism Spectrum Disorder (AL-Ayadhi and Elamin 2013); Available literatures comprise scanty knowledge about the TAC of raw camel's milk, compared with bovine and human milk. The obtained data of TAC in the current study (3.6±0.14 mmol/L) was higher than that obtained for bovine (2.24 mmol/L) and human (1.8 mmol/L) milk (Chen *et al.*, 2003; Turhan *et al.*, 2011).

The results of vitamin C depicted in Table 2 showed a minimum level of 3.2 and a maximum level of 18.9 mg/100 ml. Interestingly, the mean concentration of vitamin C of 8.4 mg/100 ml was dramatically higher than vitamin C content of cow (0.08 mg/100ml) and human (3.03mg/100ml) milk (Hidiroglou *et al.*, 1995; Ahmed *et al.*, 2004). In this connection, Haddadin *et al.* (2008) reported that camel's milk is a kind of exception because of its high concentration of vitamin C; About 30 times more than cow milk and 6 times more than human milk. From these data, it can be deduced that camel milk is rich in TAC and ascorbic acid and strongly suggested its usage as a dietary source of antioxidant and vitamin C, which are influential as immune stimulating mediators.

Additionally, from the nutritional point of view, micro-elements play a decisive role in forming of milk structural proteins and affect the quality and food value of milk products. Moreover, zinc, iron and copper compete for a relevant role in the improvement of the antioxidant system.

Zinc is a co-factor in many enzymes, can prevent cell damage and plays a central role in the immune system (WHO/FAO, 1996). In the present study, camel's milk had an average zinc level of 0.33mg/100 ml which is higher than zinc content in cow and human milk (0.38 and 0.165 mg/100 ml, respectively) as reported by Soliman (2005). Previous study reported similar results to the current study (Shamsia, 2009) however, Aludatt *et al.* (2010) reported higher results.

Iron is a vital component of blood hemoglobin required for oxygen transportation, enzyme systems, red blood cells formation and functions, and brain functions (WHO/FAO, 1996). Iron level in the present study varied from 0.12 to 0.46 mg/100 ml. These findings are close to Soliman (2005) and Shamsia (2009) while, Haddadin *et al.* (2008) have reported higher values.

Iron content in breast milk reported by many authors was lower than our results for camel milk. Soliman (2005) reported an average iron of 0.053 mg/100 g. Cai *et al.* (2015) reported range from 0.013 to 0.046 mg/100ml of iron content in breast milk. The high content of iron in camel's milk comparing to breast milk suggests that it might be a better alternative to human milk under circumstances where iron supplementation required. It could be beneficial for people with health problems due to anemia or malnourishment (Aludatt *et al.*, 2010). This suggestion supported by the fact that most of the iron in camel's milk located in the low molecular weight fraction that is easily accessible for intestinal absorption and may facilitate the bioavailability of this element (Al-Awadi and Srikumar, 2001).

Copper is important in red blood cells and connective tissue formation and acts as a catalyst contributes to central nervous system function (WHO/FAO, 1996). Our data revealed that camel's milk had an average of Cu level higher than Cu content in cow milk (Soliman, 2005). These results comply with Soliman (2005) and Shamsia (2009).

From aforementioned data (Table 3), the obtained results could reveal that serving size cup of camel's milk (250 ml) intake can meet the daily requirement for human from GE, vitamin C, Zn, Cu and Fe with 10.5, 23.3, 7.8, 38.9 and 7.5 %, respectively compared with recommended dietary allowances (DRIs, 2001).

The potential relationship between different milk components was determined in Table 4. Correlation data in the present study revealed diversity in the correlation between TAC and other variables of camel's milk. Ascorbic acid represented the highest positive correlation with TAC ($P<0.005$) while there was significant ($P<0.05$) negative correlation with fat. There was a lack of correlations with Fe, Cu and lactose. These results indicated that AA may be the major contributor to TAC in camel's milk. The variation in the correlation between TAC and other variables could be due to the fact that the antioxidant systems act synergistically and molecules with antioxidant characteristics in food have a wide range of functions and different modes of action. While, different TAC assays imposes chemical limitations (Fraga *et al.*, 2014). Also, the correlation can be influenced by extraction procedures, assay methods and solvents (Shan *et al.*, 2005; Wojdylo *et al.*, 2007; Sariburun *et al.*, 2010). These results could explain the potential antioxidant effect of camel's milk in immune compromised patient.

Conclusion

The present study demonstrated that camel's milk complies with the requirements of functional food provides a wide range of important nutrients, energy in addition to its potential candidates for the role of useful and natural antioxidant supplements in the human diet.

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