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Iodine Determination in Raw Cow's Milk in Iran

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ABSTRACT: Iodine is an essential trace element in the human diet. The following work presents the latest information concerned with iodine determination in raw milk, in Iran. Iodine content of milk was determined by Sandell-Kolthoff method where the samples were taken from Holstein dairy cows, in Shahrkord, the central part of Iran. Thirty six samples were taken from transportation tanks in semi industrial farms (group 1) and 66 samples were taken from 66 cows in an industrial dairy farm (group 2). The mean iodine content of group 1 was 148.02 ± 85.36 μg/L, where the minimum and maximum iodine concentrations were 20 μg/L and 289 μg/L, respectively. In group 2 the mean iodine content was 314.27 ± 32.72 μg/L, where the minimum and maximum concentration were 227 μg/L and 378 μg/L, respectively. Milk iodine concentration in group 1 is significantly different from the amounts obtained in group 2 ($P \leq 0.05$). Mean iodine value of all the samples was 225.59 ± 9792 μg/L. Mean iodine concentration did not changed in rainy and dry seasons. This study indicated that cow's milk might be an important source to provide the body with the required iodine.

Keywords: *Iodine, Iran, Milk.*

Introduction

Iodine plays an important role in human nutrition and it is well known as an essential trace element for the growth, development and human essential functions. Iodine deficiency results in nutritional disorders concerned with thyroid gland disease and fetus congenital anomalies. On the other hand, adverse reactions have been also associated with excessive iodine intake as the increase of thyroid volume. Therefore, one needs a controlled daily uptake of iodine to ensure the optimum concentration and as, a consequence, many food products are enriched with iodine (WHO, 2007). According to the World Health Organization, the optimal daily intake of iodine is 150-300 μg for adults, and less than 100 μg per day is thought to be insufficient; Need for children is lower and is proportional to the age, while pregnant and breastfeeding women have higher iodine needs. Medical risks are not associated with higher iodine requirement (Hejtmankova *et al*., 2006; Hetzel, 1983). The recommended daily intake of dietary iodine has recently been revised according to the age, sex and other factors (Isaac-Olive *et al*., 2008; Soriguer *et al.,* 2011). The effects of iodine deficiency on growth and development are now denoted by the term iodine deficiency disorder (IDD). Iodine deficiency at critical stages during pregnancy and early childhood results in impaired development of the brain and consequently mental function. IDD is among the easiest and least expensive of all disorders to prevent according to WHO. Cretinism, an IDD resulting from iodine deficiency during prenatal development, is detected by a reduced intellectual capacity and physiological impairment. Goiter, an IDD where the thyroid gland enlarges, is in

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response to the need to capture the limited amount of Iodine circulating in the blood more efficiently and is generally reversed with increased iodine intake. IDD effects are seen at all stages of development, and particularly in the fetus, the neonate and the infant, i.e., in periods of rapid growth. Levels less than 50% of the normal are associated with goiter (Cressey, 2003). Iran has been recognized as an area of iodine deficiency. The importance of milk in the supply of iodine for Iran is unknown. Among other reasons, this is because the amount of iodine is not stated on packs of milk. IDD was seen in Europe prior to the 20th century, but with more varied diets and salt fortification it has been brought under the control in most countries, but it is still present in some countries such as Bulgaria, Germany, Greece, Italy, Poland, Rumania, Spain, Turkey and Iran (Lamberg, 1993; Marcia, 2010). A mild to severe degree of iodine deficiency has been detected in Iran. Due to the large proportion of iodide present in dairy products, they have been found to contribute a significant amount of iodine to human diets. A study in Canada indicated that dairy products contribute 64.5% of an individual's total iodine intake, when iodized salt was not included. In another study, in New Zealand total diet surveys estimated that approximately 40% of the iodine intake for a young male was contributed by dairy products, while for a young child the contribution was approximately two thirds (Fischer and Giroux, 1993; Pearce *et al.,* 2004).

The iodine content of raw cow's milk is the cumulative result of animal diet, supplementation and the use of iodine as an antiseptic in the dairy industry. Ethylenediamine dihydroiodide (EDDI) is an organic form of iodine that was used in livestock supplements such as free choice mineral blocks prior to 1985. EDDI is readily absorbed and its effect on iodine levels in milk has concerned the Food and Drug Administration (FDA). In September 1986 the use of EDDI was banned in mineral supplementation, however, inorganic iodine is still used for supplementation. EDDI is now used for the prevention and treatment of livestock maladies, such as foot rot and lumpy jaw. Together these prophylactic and supplemental additions of iodine to livestock feeds (including those used with dairy cows) and the use of iodoform in disinfectants and sanitizing solutions utilized in milk collection and processing have significantly contributed to the concentration of iodine in raw cow's milk (Li *et al.,* 2006; Marcia *et al.,* 2010).

Iodine concentration in food has been measured by several methods. Sandell-Kolthoff method based on spectrophotometric method has been still used, after it was first proposed by Sandell-Kolthoff (Divrikli *et al.*, 2000; Mason *et al.,* 1995; Sandell and Kolthoff, 1934). The determinations of iodine concentrations in milk in other countries have indicated that iodine content of dairy products varies according to the season, geographical origin of the milk, natural iodine content of the feed, drinking water given to the cows, vitamin and minerals feed added to enrich the diets, veterinary drugs and milking machine disinfectants and food processing applications(Baumann, 1990; Pennington, 1990; Lee *et al.,* 1994; Larsen *et al.,* 1999; Brzoska *et al.,* 2005; Herzig and Suchy, 1996; Bobek, 1998). The aim of the present study was to determine the iodine concentration in raw cow's milk samples collected from central part of Iran (Shahrekord).

Materials and Methods

Thirty six samples were taken from milk transportation tanks in semi industrial farms (group 1) and sixty six samples were taken from cow's in an industrial dairy farm (group 2) that had past the lactation peak and diets were formulated according to NRC (NRC,

2001) recommendations, in Shahrekord, the central part of Iran. The samples were taken manually after washing of quarters and halves, respectively, without the use of iodine disinfectant. The samples were frozen in standard sampling bottles on the day of sampling and kept at -15 °C for 4 to 6 weeks until required for analysis. In total, 102 raw cow's milk samples were examined. All the chemicals used were of analytical grade obtained from Sigma-Aldrich Co. (Sigma-Aldrich Chemie GmbH, Munich, Germany). Deionized glass double-distilled water was used for the preparation of the reagents. Iodine in milk was determined on the basis of alkaline ashing by the spectrophotometric method according to Sandell-Kolthoff (Bednar *et al*., 1964). The principle behind the determination is the reduction of Ce^{4+} to Ce^{3+}, in the presence of As^{3+} due to the catalytic effect of iodine. Dry mineralization takes place in the alkaline environment at 600°C. Standard iodine solutions (2, 5, 10, 20, 30, and 40 mg/dL) were prepared using serial dilution of 1,000 mg/mL stock solution. Stock solution was prepared by dissolving 1.6860 g potassium iodate in 1,000mL deionized double distilled water. The above described method was used to determine the total iodine (inorganically and organically bound iodine to proteins). Iodine content was also expressed per 1 kg dry matter of milk on the basis of conversion according to the actual dry matter of milk. The results were summarised, expressed in percentage, means (x), standard deviations (SD), median, minimum, and maximum values; in sum and on corresponding farms. Statistical evaluation of the differences was done by one-way ANOVA analysis with subsequent non-paired Student's *t*-test (MS Office Excel, 2007).

Results and Discussion

The iodine concentration in raw cow's milk samples collected from transportation tanks in semi industrial farms (group 1) and industrial dairy farm (group 2) was 225.59 ± 97.92 µg/L, with the minimum and maximum concentrations , of 20 and 378 µg/L, respectively. The iodine concentrations in dairy cows milk (groups 1, 2) are presented in Tables1, 2. The range of iodine concentrations in group 1 from the semi industrial farms was much smaller than the group 2 related the industrial dairy farm. The lowest milk iodine concentration was found in group 1 (148.02 µg/L) and the highest in group 2 (314.27µg/L). Mean iodine concentration was not changed during the rainy and dry seasons. Iodine is an essential part of the structure of thyroid hormones. Thyroid hormones play an important role in the development of brain function. Iodine deficiency causes serious delays in neurological development. Various kinds of milks (cows, Sheep, goats and formula) are the exclusive source of iodine intake in milk-fed children, therefore milk iodine concentration is an index to the infant iodine intake. Historically, iodine has been a difficult element to measure accurately at trace levels in biological and food samples for a number of reasons, namely sample preparation, analyte volatility leading to losses and contamination at trace levels in the laboratory (Delange, 1994; Brzska *et al.,* 2005). Cows' milk iodine content depends on many factors, mainly the supply of dietary iodine in cow diets. Iodine is ingested in basal feed such as pasture forage, silage, hay, and feed mixtures. It is also ingested in drinking water and inhaled from the air. Cows' milk iodine content depends on the awareness of cow breeders, the economic conditions of farm, and the amount of iodine- treated feed additives given to cows. Iodine in milk may also originate from iodophor preparations used to disinfect udders and milking machines (Falkenberg *et al.,* 2002; EFSA, 2005; Travnick *et al.,* 2001; Travnick *et al.,* 2001).

We were expecting different iodine

concentrations in the groups examined due to the fact the region is an iodine deficient area. There is a significant difference between the milk of this groups ($P \leq 0.05$). The high iodine content of milk from the Industrial Farm (group2) might be due to the fact that the milk arrives from the Industrial Farm and the feeding consists of mixtures enriched with minerals, including iodine, and might also use vitamin and mineral mixtures and salt licks. The opposite situation exists in Semi Industrial Farms (group 1) that are dominated by small milk producers who keep several to dozens of cows and generally use no iodine-supplemented feed mixtures. Few producers use mineral and vitamin mixtures and salt licks. In these regions, the iodine supply of animals might be improved by application of efficient feeding methods involving the enrichment of the diets with components absent in the feeds that are found in feed mixtures and mineral feeds, including salt licks. The mean iodine concentration in all the samples of milk was 225.59 ± 97.92 μg/L during the studied period, with the values ranging from 20 to 378 μg/L (Table l). The wide range of iodine concentrations is connected with differences in iodine saturation of dairy cows and it is the result of multiple factors. Mean iodine concentrations in the milk from group 2 were higher than those reported in the literature: 150 μg/L (Lee *et al.,* 1994), 205 μg/L (Fiedlerova, 1998) while group 1 had lower values. Several studies have shown that the dietary iodine concentration has varied greatly over the years. In the USA, the concentration of iodine in milk fell from 1975 to 1982, and remained relatively stable from 1982 to 1990 with concentrations around 230μg/L (Pennington, 1990). However, an area of Boston has been reported to have mean concentrations of 454 μg/ L (Pearce, 2004). In Australia, the iodine concentration in milk fell from 593μg/L in 1975 to 195μg/L in 2004 (Li, 2006). The authors of this study suggest that, since no active iodine prophylaxis policy exists in Australia (with iodized salt), the reduced amount of iodine in milk is likely to be one of the explanations for the re-emergence of iodine deficiency in Sydney and perhaps elsewhere in Australia. In the Czech Republic, the iodine concentration in cow's milk rose from means of less than 50μg/L in 1982 to over 300μg/L in 2005, with 16% of the samples above 500 μg/L (Hejtmankova *et al.,* 2006). In Czech Republic, among all the 457 samples of bovine milk, iodine content less ahan 50 μg/L was recorded in 114 samples (24.94%)and 294 samples (64.33%) ranged between 50 to 200 μg/L, 19 samples (4.16%) ranged from 200 to 500 μg/L, 17 samples (3.72%) showed the concentration of 500 to 1 000 μg/L, and 13 samples (2.85%) indicated the iodine concentrations over 1 000 μg/L (Paulíkova *et al.,* 2008). Travnicek *et al.,* (2006) presented iodine concentrations in raw bovine milk in the Czech Republic in 2005. In 169 tank samples from 14 areas of South-western Bohemia they found the average concentration of 442.5 ± 185.6μg/L and in five regions they recorded a milk iodine content higher than 500μg/L. Milk iodine concentrations are also influenced by goitrogens present in the diet. Trinacty *et al.,* (2001) determined 594.8 ± 178.1μg/L of iodine in the milk of dairy cows and with the same supply of iodine and simultaneous feeding of rapeseed meal (270 g/kg/ food) the iodine content in milk decreased to 209.4 ± 145.3 μg/L. Similarly, Hermansen *et al.,* (1995) reported a decrease in the milk iodine content in dairy cows fed over 4.4 kg rapeseed per day. Concerning dairy cow saturation with iodine, Mee and Rogers (1996) suggested the following milk iodine concentrations, very low (below 25 μg/L), low (25–38 μg/L), marginal (39–50 μg/L), normal (51–300 μg/L), and high (over 300 μg/L). According to Anke *et al.,* (1998) milk iodine concentration of 50μg/L is considered to be normal. In Peru, the iodine concentration in cattle milk varies from 24 µg/L in the region of Cajamarca to 170 µg/L in Lima (Cardenas Quintana *et al.,* 2003). Studies on the iodine concentration of milk have also been undertaken in other countries over recent years. The general conclusion in all these studies is that the iodine composition in milk varies greatly from one sample to another. The causes of variations are known and are common in all the studies. The differences in iodine administration in veterinary practices might also explain part of the variation (Girelli *et al.,* 2004; Soriguer *et al.,* 2011). Several authors reported higher milk iodine concentrations during the winter feeding period (Dahl *et al.,* 2003; Travnicek *et al.,* 2006; Paulikova *et al.,* 2008; Soriguer *et al.,* 2011). Seasonal differences are explained by the lower iodine content in summer food rations. Iodine content increases due to water loss during plant biomass preservation. Hay and ensiled fodders have higher iodine content than green matter (Herzig and Suchy, 1996; Bobek, 1998). However, loss of iodine might occur during drying and storing of foods (Kroupova *et al.*, 2001). Opposite findings were reported by Azuolas and Caple (1984), who reported the highest milk iodine concentrations in late summer and decreasing during autumn and reaching to the lowest in spring. Similarly, Graham (1991) reported higher thyroid iodine content in summer and autumn. Seasonal differences in the milk iodine content might be related also to environmental temperature. Unak *et al.,* 2004 reported that iodine concentration in milk is very variable from season to season and iodine concentration might change up to eight times, since the animals have been fed dry grains and some supplements (EDDI) have been added for the winter season. Variations in the concentration throughout the milk supply might be due to dairy farmers in different areas utilizing different supplementation and feed and their soils might contain different amounts of trace elements. However, we could not find seasonal changes in the milk of the Shahre-kord region of Iran. Based on the acquired data, it might be concluded that the iodine content in the environment, especially in dairy cows' diet, has a crucial effect on milk iodine content. The presence of goitrogenic substances in feed for dairy cows is also an important factor.

Conclusion

The results of this study confirmed that milk is an important source of iodine. It would be necessary to standardize the concentration of iodine in the milk and submit it to legal regulation. A concentration of 200-300 mg of iodine per liter of milk would be recommended as an optimum level.

Table1. Milk iodine concentrations in dairy cows (µg/L) from various farms in the center of Iran

Milk Iodine concentrations (µg/L)	*n*	Mean	*SD*	Min.	Max.
Semi Industrial Farms (group 1)	36	148.02	85.36	20	289
Industrial Farm (group2)	66	314.27	32.72	227	378

Table 2. Milk iodine concentrations in dairy cows (µg/L) from various farms in the center of Iran

Milk Iodine concentrations (µg/L)	20-100	100-200	200-300	300-400
Semi Industrial Farms (group 1)	12(33.3%)	11(30.6%)	13(36.1%)	0(0%)
Industrial Farm (group2)	0(0%)	0(0%)	20(30.3)	46(69.7%)

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