FACTORS THAT INFLUENCE THE IODINE CONTENT OF MILK AND MEAT: A REVIEW

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SUMMARY

Recently reported values for the iodine content of milk are higher than those reported prior to 1970. Several reports indicate that milk iodine content from some farms would supply more iodine than recommended for adults by the National Research Council if an individual was to consume a liter or even a half liter of milk. Published meat iodine values are few in number but are relatively low as compared with milk values. Supplementary feed iodine increases milk iodine and is apparently the cause of many of the high milk iodine values. Iodine teat dips and sanitizers also contribute to increased milk iodine values, but do not cause large increases unless they are not used properly. The effect of supplementary iodine on meat iodine content is not clearly established, however, serum iodine content and radioiodine studies would indicate that lactating animals would have a higher iodine content of milk than for muscle tissue.

(Key Words: Milk Iodine, Muscle Iodine, Teat Dips, Iodine Sanitizers, Supplementary Iodine.)

INTRODUCTION

Surveys (Fisher and Carr, 1974; Talbot et al., 1974, 1976) in the U.S. of food iodine content and evaluations of the effects of iodine intake suggest that iodine deficiency is not as likely to occur today as it did several decades ago. In fact, it has been suggested that iodine toxicity is more likely to occur than iodine deficiency. The increased iodine content of food is due to greater usage of iodine in food processing, an increase in the iodine content of farm animal rations, and increased use of iodine as antibacterial agents both on and off the farm.

The Food and Nutrition Board (1970) of the National Research Council has stated that iodine intake between 50 and 1,000 μg/day are estimated to be safe for adults; intakes between 100 and 300 μg/day are desirable. If we accept these levels, it would seem that those of us concerned with producing human food should know what factors influence the iodine content of food products.

IODINE CONTENT OF MILK AND MEAT

Dunsmore and Luckhurst (1975), in reviewing the world literature on the iodine content of milk and milk products, reported very few values over 100 μg/liter or kilogram (on fresh basis) prior to about 1970. A few higher values were reported but were still below 165 micrograms. Fisher and Carr (1974) in their review prepared for Division of Nutrition, Bureau of Foods, Food and Drug Administration, noted the increase in milk iodine content in reports starting about 1970. Connolly (1971) reported values of 113 to 346 μg/liter on farms in Tasmania where sanitizing agents containing iodine had been used. Hemken et al. (1972) reported milk iodine values from 13 Illinois farms averaged 425 μg/liter and samples from eight Maryland farms averaged 457 μg, with a range in farm values of 63 to 1,610 μg/liter. Iwarsson and Ekman (1973) have shown that bulk herd milk ranged from 55 to 353 μg/liter on farms in Sweden where teat dipping was practiced. Dunsmore (1976), in a more extensive survey of Australian milk, reported average values of 570 μg/liter (range of 370 to 1,070) for factory raw bulk samples and an average value of 706 μg/liter (range of 320 to 1,170) for the iodine concentration of bottled pasteurized milk. A small survey of milk purchased from stores in Lexington, Kentucky in

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3Department of Animal Sciences
1976 gave an average value of 317 μg/liter (range 150 to 620) (R. W. Hemken, unpublished data). In a Michigan study (Convey et al., 1977) herds fed an average of 16 mg vs 164 mg of iodine per head per day were compared. Milk iodine was 2,200 μg/liter for the high level of feeding as compared with 370 μg/liter for the low level of iodine feeding. All recent published values support the contention that milk and milk products are currently, on the average, a very high source of iodine for humans. However, the amount reported is quite variable.

Values for the iodine content of meat are not so numerous as milk values. Fisher and Carr (1974) in their review of iodine content of foods quote several studies in which the average iodine content (μg/kg) of meat was 50, 260, 1.6 for three different studies. These values are highly variable and may reflect differences in iodine intake and could be due to differences in analytical procedures. Iodine values for meats were from one-half to one-tenth the amount found in seafoods, a normally rich source of iodine. Even if the high value of 260 μg/kg is used to estimate daily iodine intake, it is not likely that an individual will approach the upper safe limit of 1,000 μg of iodine intake as prescribed by the Food and Nutrition Board.

A study from the Wisconsin Alumni Research Foundation (1973) reported iodine values (μg/kg) for McDonalds Corporation as follows: egg McMuffin 220, hamburger 490, cheeseburger 430, filet of fish 840, french fries 200, chocolate shake 470, vanilla shake 470, and strawberry shake 490. A comparison of these products which contains a large amount of meat and dairy products suggests that an iodine deficiency is not likely to occur if one eats a diet primarily of this type of food. Some finished food products also contain iodized salt which would likely increase the iodine content of the finished product.

**EFFECT OF RATION IODINE**

Iodine content of milk and meat products consumed can be increased by a number of different sources. Natural feed sources have been shown to vary considerably in iodine level and will differ greatly by areas of the country and world. Data (Hemken et al., 1972) comparing farms in northern Illinois with farms in Maryland indicated a higher iodine content for crops in Maryland. There were also marked differences between crops with corn silage having a lower iodine content per unit of dry matter than alfalfa. Alderman and Jones (1967) have shown that heavier applications of fertilizer reduce the average iodine content of pasture grasses. It is assumed that most natural feed sources will not produce meat or milk with even adequate levels of iodine to provide a desirable intake of iodine for humans.

Feed sources of iodine are supplied for several reasons. Some iodine is added to almost all rations to prevent goiter in the newborn animals and other iodine deficiency signs. In addition, organic iodine is added to many rations to prevent foot rot. Some dairymen also add organic iodine to attempt to improve reproductive efficiency and perhaps correct other problems (Weldy, 1978). The efficacy of organic iodine to correct reproduction and other problems does not appear to be well documented by controlled research but appears to be based more on field observations. Certainly, some added iodine will improve reproductive efficiency (McDonald et al., 1961; Moberg, 1961) if an iodine deficiency is present, however, the upper level needed to maximize reproductive performance is apparently not clearly established.

Milk iodine and plasma iodine levels are related to the amount of iodine consumed. Miller and Swanson (1973) have fed ethylenediaminedihydiiodide (EDDI) in amounts up to 1,000 mg per cow daily. The 1,000 mg of EDDI contains about 800 mg of iodine. Blood serum and milk concentrations of iodine increased with each additional increment of the supplement, indicating that the animal system did not have a limit in the absorption or transfer of iodine to milk. However, the increase of EDDI from 500 to 1,000 mg/day did not increase either milk iodine or serum by the amount caused by the added increment of 200 to 500 mg of EDDI. Other studies (Connally, 1971; Convey et al., 1977; Hemken et al., 1972; Fish et al., 1977) also show increased milk iodine with added increments of iodine.

The study of Miller and Swanson (1973) included one group which received iodine in the form of potassium iodide (KI). The group receiving KI had higher serum but lower milk iodine levels than the group receiving the same amount of iodine in the form of EDDI. This demonstrates different metabolism rates or pathways for these two forms and would indicate different limits for different forms of iodine if a limit on milk iodine were to be set. Additional research seems to be needed in order to classify various other sources of iodine from either organic or inorganic forms.

Based on available studies, it is not clear how meat iodine is related to iodine intake. The radioiodine iodine concentration in extrathyroidal tissues after six or eight daily doses is only .006 to .04% as much radioiodine per unit weight as
iodine contained by the thyroid gland (Miller and Swanson, 1973). When either EDDI or KI was the source of radioiodine, muscle tissue contained only .29 to .26% of the daily dose/kg. This compares with 1.46 and 1.31% of daily dose/liter in the plasma at a comparable time. Depending on the amount of blood removed from the tissues at slaughter, the blood plasma iodine concentration would influence the meat content.

A study of concentration and nature of skeletal muscle iodine in mice would suggest that short term studies with radioiodine may not clearly indicate muscle iodine concentration. This possibility is also suggested in the review of iodine metabolism by Miller et al. (1975). Cottino et al. (1972) report that muscle tissue pools may adjust very slowly to a change in available iodine. Their data suggest two muscle iodine pools: one consisting of hormones and iodides with a fast exchange rate with blood, and the other with a slow exchange rate requiring more than 3 months to reach equilibrium. If data for mice can be applied to meat producing animals, it would suggest that not only level but length of iodine administration would be important. It would also suggest that short withdrawal periods may not be so beneficial as blood serum iodine values would indicate.

**USE OF TEAT DIPS**

Milk iodine increases may be due to factors other than increased dietary levels. The relative amounts of iodine entering milk from other sources can vary considerably from farm to farm and even after leaving the farm.

Reports of increased milk iodine due to teat dips come from a number of countries. The research techniques to determine the increased iodine caused by teat dips varies from farm surveys to controlled studies in research herds. Joerin and Bowering (1972) reported milk iodine content of 10 to 700 \( \mu g \)/liter on New Zealand farms using teat dips compared with 30 to 110 \( \mu g \)/liter on farms not using iodophor teat dips. A similar study in Tasmania by Connally (1971) gave values of 113 to 346 \( \mu g \)/liter for farms using iodophor dips compared with 13 to 23 \( \mu g \) for farms not using iodophors. In both of these studies, no control of other sources of iodine was maintained.

Studies by Iwarsson and Ekman (1973) used pre-experimental periods as control periods with Swedish farm herds. They concluded the average increase on 17 farms to be 174 \( \mu g \)/liter with a range of 55 to 353 \( \mu g \)/liter when teat dips containing iodophors were used. The teat dip contained 16 g of iodine per liter. Pre-milking hygiene on most of the farms was described as the use of a dry udder towel or cloth. Several studies (Dunsmore, 1976; Iwarsson and Edman, 1974; Uusi-Rauva et al., 1974) have estimated the increase in milk iodine when using 5 g of iodine per liter in the teat dip. The increases ranged from 35 to 390 \( \mu g \)/liter of milk.

Studies of milk iodine concentration as influenced by the iodine concentration of the teat dip definitely demonstrate a relationship. Iwarsson and Ekman (1974) report a reduction of milk iodine concentration when changing from 16 to 8 g of iodine per liter of teat dip. Dunsmore et al. (1977) tested teat dips with iodine concentrations ranging from .2 to 5.0 g of iodine per liter. Significant reduction in milk iodine occurred with reduced iodine concentrations in the teat dips. Data are currently not available, however, on the efficacy of iodophor teat dips with concentrations lower than 5.0 g iodine/liter.

Many of the iodophor teat dips sold in the U.S. are formulated with 1% iodine rather than .5%. While the cost to test the efficacy of all new formulations would be considerable, it seems that research is needed to establish the minimum amount of iodine required to be effective under field conditions for the various types of formulas.

The mode of entrance of the iodine from teat dips has been assumed to be primarily from surface contamination. Several studies, however, have demonstrated that sizeable amounts of iodine can be absorbed through the skin and then rescreted in the milk. Conrad and Hemken (1978) reported increased milk iodine values from both halves of the udder even though teat dip was used only on one side. This observation is supported by the study of Uusi-Rauva et al. (1974) who found that labeled iodine penetrated the skin and connective tissue of the teat.

The use of udder preparations prior to milking to reduce the transfer of iodine to milk has been very effective in several trials and not very effective in others (Conrad and Hemken, 1978; Dunsmore et al., 1977). Cattle walking through pasture, teat dip formulation mixtures, and the thoroughness with which the cattle are washed could probably all affect the results. Dunsmore et al. (1977) have demonstrated the influence of teat dip formulation.

**IODINE UDDER WASH AND SANITIZERS**

Iodophors are used as a premilking sanitizer on some farms to clean the udder. They are also used as sanitizers on some farms with the teat cups dipped into solutions between milking individual cows and other equipment sanitized after milking.
Cantor and Most (1976) reported milk iodine content was not increased through the use of a premilking udder wash. More recent reports by Dunsmore and Nuzum (1977) and Hemken et al. (1978) have shown increases of about 35 µg/liter when containing 3-iodine udder wash was used. Evidently, the amount of material applied to the udder and the effort to remove the wash affect the amount of increase noted in milk iodine.

The reported increases due to udder wash are lower than most of the increases related to teat dips. However, there is some question as to the effectiveness of sanitizers applied to the udder to provide an effective bactericidal effect on the teat (Neave, 1971). If they are not effective in reducing the bacterial count of milk or in reducing the incidence of mastitis, their use should not be recommended.

Dunsmore and Luckhurst (1975) have reviewed and studied the amount of iodine entering the Australian milk supply following removal of the milk from the cow. They suggest that with bad management, the amount can be up to 740 µg/liter. The sources would include cleaning of the milking machine, refrigerated farm vat, road transport tanker, raw milk tanks, pasteurized milk vats, and bottle filler sealing rubbers. It is doubtful that this much iodine is added to milk as it is processed and bottled in the U.S.

MISCELLANEOUS SOURCES

Other iodine sources can include such items as salves or ointments. Dunsmore and Nuzum (1977) have shown that iodine-bearing udder salve increased milk iodine by 53.6 µg/liter. A herd which uses such a salve would probably only find large increases following periods when some other stress is causing teat damage. The use of tincture of iodine (Conrad and Hemken, 1978) on other parts of the cow will cause increases in milk iodine. It is unlikely that the use of iodine for treatment of occasional injuries would lead to a significant or measurable level of iodine in the milk supply.

SURVEY OF MILK IODINE CONTENT

Samples of milk from 114 dairy farms were obtained by utilizing samples taken by the truck driver at the time milk was picked up (R. W. Hemken, unpublished data). Analysis of these samples gave an average iodine content of 764.2 µg/liter with a range of 40 to 8,420 µg/liter (table 1). Five of the farms with high iodine content were visited and supplemental iodine intake was estimated together with observations on the use of teat dips and other iodine sanitizers. The high values (2,676, 1,227, 2,421 and 4,840) on four of the farms were apparently the result of high levels of organic iodine. The fifth farm was dipping the teat cups between milkings in an iodophor solution.

The results of this survey plus the results of Convey et al. (1977) and Bruhn and Franke (1978) support the idea that iodine added to rations is a definite contribution to the very high levels observed on some farms. The high content of iodine in the milk on one farm, when an iodine sanitizer was used between milkings, should create an awareness that sources of iodine other than feed can create problems for some operators.

PRESENT STATUS

Published values indicate that the iodine content of meat is variable but meat is not a source of excess dietary iodine. While this could be interpreted as indicating that no changes are needed in the feeding and management of meat producing animals, some caution is needed because of the paucity of controlled, long-term experiments with high levels of dietary iodine supplementation. If a muscle iodine pool exists which takes three or more months to reach equilibrium as suggested by Cottino et al. (1972) studies with various forms and levels of iodine would be needed to determine the extent of iodine storage.

<table>
<thead>
<tr>
<th>Range in iodine content</th>
<th>No. of farms</th>
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<tbody>
<tr>
<td>µg/liter</td>
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<tr>
<td>40-199</td>
<td>15</td>
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<td>200-399</td>
<td>40</td>
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<td>2000-2999</td>
<td>4</td>
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<tr>
<td>3000-3999</td>
<td>3</td>
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<tr>
<td>&lt; 4000</td>
<td>2</td>
</tr>
<tr>
<td>Mean 764 µg/liter</td>
<td>114</td>
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</tbody>
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*If three farms are removed because of possible iodine contamination at sampling time, the mean value is 646 µg/liter.
The amount of iodine in milk has increased in recent years and the amount reported in a liter of milk for some samples exceeds the safe limit as set by Food and Nutrition Board (1970). In the U.S., iodine added to the ration seems to be a main source for farms with very high concentrations of iodine. Iodine teat dips and iodine sanitizers also increase the amount of milk iodine. The research completed to date, however, would not indicate increases of more than 100 to 200 μg/liter from udder applications.

LITERATURE CITED


