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Assessment of Cadmium Intake from the Consumption of Traditional food in Fort Resolution, Northwest Territories

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ABSTRACT

The aim of this study was to investigate the cadmium (Cd) exposure level from traditional food in Fort Resolution, Northwest Territories. We used dietary recalls and traditional food use frequency to obtain information on traditional food consumption, and analyzed Cd concentrations in traditional food. We also estimated total Cd intake via market and traditional food, and cigarette smoking. Traditional food accounted for only 10 % of the diet in the community in terms of energy intake. The range of Cd concentrations measured was 0 to 1869 μg/100g wet weight, with the lowest found in cranberry, and the highest in moose kidney. Cd concentrations in traditional food groups were comparable with those of Canadian market food. Cd concentration in the liver and kidney of caribou and moose exceeded the action level (1 μg/g) established by *Agriculture Canada*, but the frequencies of consumption of these foods were relatively low. Cd intakes from traditional food ranged from 0.01 to 1713 μg/day/person. Average Cd intakes from traditional food were estimated to be 10 % and 6 % of the Provisional Tolerable Weekly Intake (PTWI), 7 μg/kg body weight/person, for women and men, respectively. The major contributors to the total Cd intake on a population basis were moose liver for women, and flesh of moose and caribou for men. The average Cd inhaled from cigarette smoking was 21.1 ± 9.1 μg/day/person. Total Cd intakes from traditional food and smoking were estimated to be 24% and 20% of the PTWI for women and men, respectively. The total Cd intakes of smokers and nonsmokers were significantly different ($p < 0.001$). The total Cd intake via market and traditional food, and cigarette smoking was 246.4 μg/week which was lower than the PTWI, 500 μg/week. Another objective of this study was to investigate an effect of food preparation on Cd speciation in food. We hypothesized that food preparation had an effect on Cd speciation in food. Baking caribou kidney at 350 °C resulted in a significant decrease in the level of Cd bound to high molecular weight proteins ($p < 0.05$). Metallothionein level was significantly decreased, but it still contained about 40% of the Cd. The effect of cooking on the bioavailability of Cd in food remains to be confirmed.

RÉSUMÉ

Cette étude a pour objectif d'étudier le niveau d'exposition au cadmium (Cd) contenu dans les aliments traditionnels, à Fort Resolution dans les Territoires du Nord-Ouest. Nous avons utilisé des rappels alimentaires et des études de la fréquence de la consommation d'aliments traditionnels pour recueillir des données sur la consommation d'aliments traditionnels et analyser leurs concentrations de Cd. Nous avons également évalué les apports totaux en Cd provenant d'aliments traditionnels, d'aliments commerciaux et du tabac. L'alimentation traditionnelle représente 10 % seulement de l'alimentation de la communauté. L'éventail des concentrations de Cd varie entre 0 et 1 869 mg/g du poids frais, la plus faible concentration ayant été observée dans les canneberges et la concentration la plus élevée dans les reins d'orignaux. Les concentrations de Cd dans les groupes d'aliments traditionnels ont été comparées à celles des aliments disponibles sur le marché canadien. Les concentrations de Cd dans les foies et reins de caribou et d'orignal dépassent le seuil d'alerte (100 mg/g) fixé par Agriculture Canada, quoique la fréquence de consommation de ces aliments reste relativement faible. Les apports en Cd provenant d'aliments traditionnels varient entre 0,01 et 1 713 mg/jour/personne. Les apports moyens en Cd provenant d'aliments traditionnels équivalent respectivement à 10 % et 6 % de la dose hebdomadaire provisoire acceptable (DHPA), soit 7 mg/kg BW/personne pour les hommes et pour les femmes. Pour les femmes, c'est le foie d'orignal qui fournit la dose la plus importante de Cd et pour les hommes c'est la chaire d'orignal et de caribou. La quantité moyenne de Cd inhalé (cigarettes) s'établit à 21,1 ± 9,1 mg/jour/personne. Les apports totaux en cadmium provenant des aliments traditionnels et du tabac équivalent respectivement à 24 % et 20 % de la dose hebdomadaire provisoire acceptable pour les hommes et pour les femmes. Les apports totaux en cadmium des fumeurs et des non fumeurs diffèrent de manière significative ($p < 0,001$). Les apports totaux en cadmium provenant des aliments traditionnels et commercialisés et du tabac équivalent à 246,4 mg/semaine, ce qui est inférieur à la DHPA (500 mg/semaine). L'autre objectif de cette étude était de définir l'effet de la préparation alimentaire sur la spéciation du cadmium dans l'alimentation. Nous sommes partis de l'hypothèse que la préparation des aliments avait un effet sur la spéciation du cadmium. Lorsque l'on fait cuire le rein de caribou à 350 °C, on observe une diminution significative de la quantité de cadmium dans les protéines à fort poids moléculaire ($p < 0,05$). Les concentrations métallothionéines ont diminué de façon marquée même si elles contenaient encore 40 % de cadmium. L'effet de la cuisson sur la biodisponibilité du cadmium dans l'alimentation doit néanmoins être encore confirmé.

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ABBREVIATIONS

AAS	Atomic Absorption Spectrophotometer
Ag	Silver
BW	Body weight
Ca	Calcium
CaBP	Calcium binding protein
Cd	Cadmium
$CdCl_2$	Cadmium chloride
Cd-Cysteine	Cadmium bound to cysteine
Cd-GSH	Cadmium bound to glutathionein
Cd-MT	Cadmium bound to metallothionein
CdO	Cadmium oxide
Cu	Copper
FPLC	Fast Protein Liquid Chromatography
GI tract	Gastrointestinal tract
Hg	Mercury
HPLC	High Performance Liquid Chromotography
MT	Metallothionein
Ni	Nickel
NTD	Nitrilotriacetic acid
PCBs	Polychlorinated biphenyl
PTWI	Provisional Tolerable Weekly Intake
Zn	Zinc
Zn-MT	Zinc bound to metallothionein

CHAPTER 1: INTRODUCTION

Cadmium (Cd) has been recognized as one of the major toxic pollutants in the arctic ecosystem (Barrie et al. 1992; Thomas et al. 1992). Together with other toxic metals and organic compunds, Cd is transported to the Canadian Arctic and subarctic areas from industrially active mid-latitudinal areas through ocean and air currents (Lockhart et al. 1992). Cd contamination is a consequence not only of long-range transport but also of natural processes and local discharges to the environment (Government of Canada 1991). The Canadian Arctic is richly endowed with mineral resources: before 1986, 68 mines had been developed and abandoned (Thomas et al. 1992). To date, 10^{11} kg of tailings have been produced at mine sites in the Arctic and discharged into lakes and the ocean (Caine and Brown 1987; Government of Canada 1991).

High levels of Cd have been found in fresh water fish (Lockhart et al. 1992), marine animals, and land animals (Muir et al. 1992; Thomas et al. 1992) from the Arctic. Fish and games are important food resources to the Canadian Arctic Indigenous Peoples (Kuhnlein et al. 1994; Kuhnlein and Soueida 1992). Concerns about the adverse health effect of Cd on Indigenous Peoples have been raised since elevated Cd levels in some traditional food items were reported (Archibald and Kosatsky 1991; Barrie et al. 1992; Gamberg and Scheuhammer 1994).

Fort Resolution in the Northwest Territories (60°10'N, 113°40'W, population 445, 1988) is located on the southshore of Great Slave Lake (Figure 1). Because of the proximity of Fort Resolution to an abandoned lead/zinc mine (Pine Point), the Indigenous People in Fort Resolution are concerned about the levels of Cd in their traditional food and health effects related to the consumption of Cd comtaminated food. This research was requested by the community to assess the risk of Cd exposure from consuming traditional food.

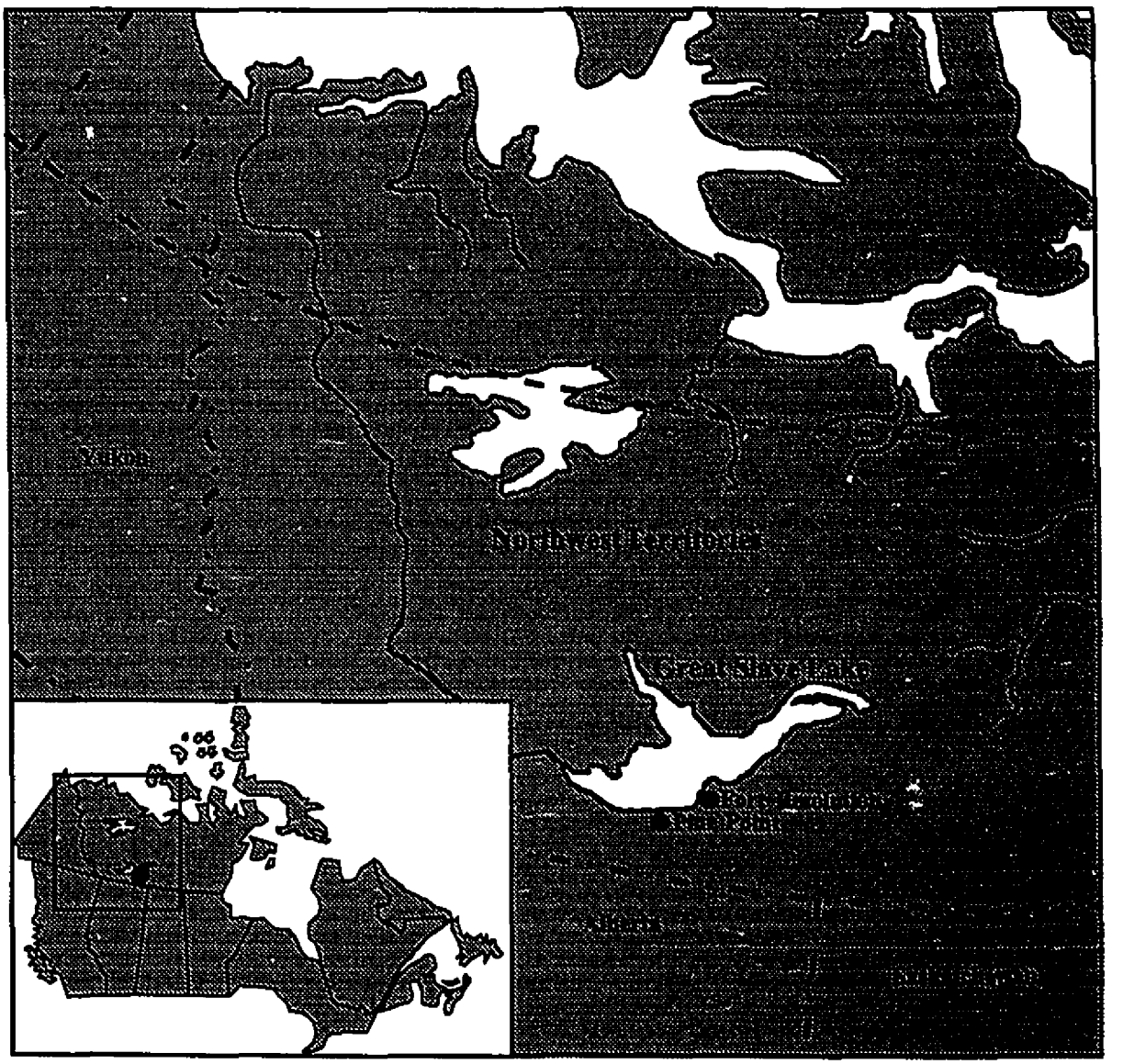


Figure 1. Location of Fort Resolution

To ascertain whether the Indigenous People in the community are at risk, it is necessary to estimate the actual dietary intake of Cd from traditional food consumption. In this study, dietary survey and analysis of Cd in traditional food were conducted for the estimation of Cd exposure level.

Another purpose of this study was to investigate the effect of food preparation on Cd speciation in food. Toxicokinetics of ingested Cd are known to be different depending on chemical forms of Cd (Cherian et al. 1979; Maitani et al. 1984; Ohta and Cherian 1995).

1.1. Rationale

This study was undertaken to assess the the risk of Cd exposure level from traditional food in Fort Resolution, Northwest Territories. The presence of chemical contaminants in Canadian northern ecosystem has been reported to threaten traditional food systems of the Indigenous People (Barrie et al. 1992; Lockhart et al. 1992; Muir et al. 1992; Thomas et al. 1992). Cd accumulates in the food chain and is one of the contaminants of particular concerns. The abandoned lead/zinc mine, Pine Pont, is located near Fort Resloution. It is well known that foodstuffs produced in the vicinity of point sources show elevated Cd levels (Environment Canada 1994). The Indigenous People in the community are concerned about the safety of their traditional food and adverse health effects of Cd. Thus, this study was requested by the community.

1.2. Hypotheses

We hypothesize that the exposure level of Cd from traditional food in the community is within the guideline level specified by Provisional Tolerable Weekly Intake (PTWI). Another hypothesis is that the total exposure level of Cd from smoking, market food and traditional food, is within the PTWI.

For the Cd speciation, we hypothesize that food preparation has an effect on Cd species in the food.

CHAPTER 2: LITERATURE REVIEW

2.1. Cd in our environment

Cd (atomic number 48; relative atomic mass 112.40) is a metal that belongs, together with zinc and mercury, to group IIb in the Periodic Table. Cd is widely distributed throughout the environment. Cd can be detected in all environmental media including freshwater, soil, sediment, and seawater (Environment Canada 1994). The major Cd-bearing minerals are zinc sulphides, sphalerite, and wurtzite (Nriagu 1980).

Increased anthropogenic activities such as mining and industrisal uses of Cd have caused environmental Cd contamination, and it has drawn public awareness during the last few decades (Elinder 1985). Commercially, Cd is produced as a by-product of zinc refining (Robards and Worsfold 1991). Since the 1940s, Cd has been used for industrial purposes such as for Ni/Cd-batteries, pigments, stabilizers for PVC, and alloys (Lymburner 1974). Cd is easily volatilised at the operating temperatures in common industrial processes.

Anthropogenic activities add about 3 to 10 times more Cd into the atmosphere than natural sources (Niragu 1980; Yeats and Bewers 1987). Cd occurs naturally as a result of volcanic emmisions, and Cd is distributed and transported by rain and wind. Waste incineration and combustion of coal and oil are other sources of Cd released into the atmosphere. Cd sludge and soil waste account for most of the Cd waste (Environment Canada 1994). Increased use of sludge-based fertilizers and phosphate fertilizers has caused Cd contamination of agricultural soil (Sherlock 1984).

In Canada, Cd was identified from the Canadian Environmental Protection Act as one of the priority substances to be studied because it may be harmful to the environment and to human health (Environment Canada 1994).

2.2. Toxic effects of Cd on human health

Adverse health effects from chronic and acute Cd exposures have been reported in experimental animals and human populations (WHO 1992). There have been a few studies on toxic effects of oral Cd exposure in animal models where normal dietary intakes of human were simulated (Groten et al. 1990; Groten et al. 1991a). Toxic effects of Cd discussed here mainly focus on reports from human populations.

2.2.1. Acute Cd toxicity

Acute Cd toxicity mostly occurs among industrial workers through the inhalation of high doses of cadmium oxide (CdO) and cadmium fumes (Friberg et al. 1973). Symptoms are manifested as severe respiratory toxicity with dyspnea, cough, edema, and even pulmonary fibrosis or permanently impaired lung function (Heath et al. 1968; Townshend 1968; Cherian and Goyer 1989). Ingestion of high doses of Cd through contaminated hands is another exposure route of acute Cd intoxication in the working environment (Robards and Worsfold 1991). Only a few cases of acute Cd intoxication via ingestion have been reported in the general population. In Sweden, children were intoxicated by fruit juice from a vending machine where a Cd-plated reservoir was used (Nordberg et al. 1973). From 1940 to 1950, acid food prepared in Cd-plated utensils caused acute Cd intoxications (Lufkin et al. 1944). Symptoms of acute ingested Cd toxicity included nausea, vomitting, and abdominal pain, but the recovery was fast because of the low amount of absorbed Cd due to vomitting.

2.2.2. Chronic Cd toxicity

Chronic Cd toxicity is usually caused by long term exposure to low levels of environmental Cd, and the symptoms are sometimes expressed even after the cessation of Cd exposure (WHO 1992). The major target organ of chronic Cd toxicity is the kidneys. Renal tubular damage is the best identified health effect of chronic Cd exposure (WHO Task Group1977). Renal tubular dysfunction is characterized by proteinuria rich in low

molecular weight proteins. Proteinuria as a sign of chronic Cd toxicity was first reported in workers exposed to CdO dust (Friberg 1948).

Cases of renal damage from chronic Cd exposure have been documented. In the general population, consumption of Cd contaminated food caused nephrotoxicity. The most well known incidence of Cd poisoning was reported in Japan. The syndrome is termed as "Itai-Itai disease" which causes bone fracture as a secondary effect of renal failure. The Cd source was rice grown in irrigated water contaminated by Cd from the effluents of mining operations (Nogawa et al. 1989; Nriagu 1990). In England, contaminated vegetables and fruits produced from gardens in a zinc-mining town, Shipham, caused renal damage among the inhabitants who consumed these contaminated foods (Inskip et al. 1982).

Pulmonary emphysema is caused by chronic inhalation of Cd. Cases of toxic effects of Cd on the lung are usually reported from industrial workers who are exposed to airborn Cd (Davison 1988).

Bone disorders are another manifestation of chronic Cd toxicity. Several cases of bone effects were reported from industrial workers exposed to Cd (Nicand et al. 1942; Friberg 1950; Potts 1960). Osteomalacia was diagnosed together with renal tubular dysfunction among Itai-Itai disease patients reported in Japan (Kono 1956; Yamagata and Shigematsu 1970). Since Itai-Itai disease was mostly shown in multiparous and menoposal women, nutritional status such as levels of vitamin D and Calcium (Ca) has been thought to be involved in Cd induced bone effects (Cherian and Goyer 1989). Bone disorder was believed to be secondary to renal failure rather than a direct effect of Cd on bone because required levels of Cd for bone disorder were higher than those for renal damage (Cherian and Goyer 1989). However, there is evidence showing that Cd accumulates directly in bone even when the kidneys function normally, indicating that the toxic effect may be primary to the bone rather than solely secondary to renal failure (Krishnan 1989; Whelton et al. 1994).

Carcinogenecity of Cd in human has been suggested with limited evidence, whereas in animal studies Cd carcinogenecity is well documented (Snow 1992). Even though epidemiological studies have reported increased mortality from cancer of factory workers

exposed to Cd by inhalation (Friberg 1950; Kipling and Waterhouse 1967; Lemen et al. 1976), available epidemiological data are insufficient because studies are usually based on small numbers and Cd exposure is usually found with the presence of other carcinogens (Ryan et al. 1982). However, it has been generally accepted that Cd may be associated with cancer of the lung and prostate in human (Piscator 1981; Waalkes and Oberdorster 1990). Cd has been classified as a possible human carcinogen (IARC 1987).

There are other reported chronic Cd toxicities such as hypertension, cardiovascular effects, and atherosclerosis. Nevertheless, whether chronic Cd exposure causes these toxicities directly is still uncertain (Cherian and Goyer 1989).

2.3. Cd in food and Cd intake

Food is the main Cd source in the general population, with minor contributions of Cd intake from ambient air and water (WHO 1992). Contamination of agricultural soil from excessive application of sewage sludge and phosphatic fertilizer has been recognized as a potential problem of the transfer of Cd to the human food chain (Ryan 1982). Elevated concentrations of Cd have been reported in tissues of animals which were fed sewage sludge-amended diets (Boyer et al. 1981) and corn leaves grown in soil treated with sludge (Miller and Boswell 1981). Cd levels in garden crops planted on sludge amended soil have been reported to be higher than those from untreated soil (Furr et al. 1976).

Cd levels in foodstuffs are relatively low except for a few specific food items (Chmielnicka and Cherian 1986). Root crops and leafy vegetables usually show higher Cd levels because they are more responsive to soil Cd (Street 1977). Shellfish, and animal organs such as liver and kidney are the foods with the highest Cd contents (Sherlock 1984). Table 1 shows typical Cd levels in foodstuffs. Cd levels in food depend on areas where the food is produced. Elevated levels of Cd have been found in cereals, fruits, and leafy vegetables grown in Cd-contaminated soils (Sherlock 1984; Krishnan et al. 1990; Moreiras 1992). In Flin Flon, Manitoba, a town near a metal smelter, garden vegetables were produced with considerably high Cd concentrations. The

Table 1.

Typical Cd Concentrations in Food[a]

Food	Cd (mg/kg)	Food	Cd (mg/kg)
Cabbage	0.01 (0.04)*	Meat, beef	0.02
Lettuce	0.06 (0.18)*	Beef kidney	0.6
Potatoes	0.03 (0.14)*	Beef liver	0.15
Tomatoes	0.02	Meat, pork	0.02
Carrots	0.05 (0.15)*	Pork kidney	0.26
Spinach	0.08 (0.63)*	Pork liver	0.09
Apples	0.01	Chicken liver	0.09
Plums	0.01 (0.02)*	Freshwater fish	0.1
Whole rice	0.08	Lobster parts	3.4
Wheat grain	0.04 (0.07)*	Crab(brown meat)	4.3
Whole wheat	0.09	Mussels and oysters	0.56
Wheat flour	0.2	Salt cod	2.51
Eggs	0.03	Salmon	0.2
Milk	0.02	Ground fish cod	0.11

[a] modified from Chmielnicka and Cherian, 1986

* Contaminated area

soil also showed a high Cd content in that area (Eva 1991). Several factors affect Cd uptake of plants from soil including Cd content in the soil, pH of the soil and presence of other metals (Bruwaene et al. 1984). Cd levels in Canadian market food have been monitored for over 20 years (Meranger and Smith 1972; Kirkpatrick and Coffin 1977; Conacher et al. 1989; Dabeka and McKenzie 1992). The levels were similar to those from other countries (Chmielnicka and Cherian 1986; Schumacher et al. 1994).

Daily intake of Cd via food can be estimated by two different approaches (Kjellstrom 1979). One is measuring excreted Cd in feces and the other is measuring Cd in food. The latter combined with dietary survey is more commonly used for epidemiological studies to calculate daily intake of Cd. Various countries have estimated daily Cd intakes (Table 2). Levels of daily Cd intake are affected by dietary habits and Cd concentrations in individual foodstuffs consumed.

Direct comparisons of estimated values of daily Cd intake need consideration because study methods used for the estimation, study approaches, and preparation of food for Cd analysis even with the same method vary from country to country (Galal-Gorchev 1991; Chmielnicka and Cherian 1986). Over the past decades, Canadian Cd daily intakes have been investigated by different approaches and their results varied from 14.5 to 82 μg/day/person (Meranger and Smith 1972; Kirkpatric and Coffin 1977; Conacher et al. 1989; Dabeka and McKenzie 1992).

Cd contents in food, frequency of food consumption, and dietary habits are important factors which can affect dietary Cd intake levels. Several countries including Canada, the USA, and Denmark reported cereals, potatoes, and vegetables as the major contributors to daily Cd intakes (Galal-Gorchev 1991). In Spain, vegetable consumption accounted for 55% of the total daily Cd intake (Moreiras and Guadrado 1992). Cereals and their products in Greece constituted 30% of the total daily Cd intake (Tsoumbaris and Tsoukali-Papadopoulou 1994). This study also showed that Cd contents in food were not always positively related with the contribution to the daily Cd intake implying that food frequency was also a major factor affecting the level of Cd intake. A study conducted in the USA for a period of 45 years has reported that changes in food consumption patterns caused the total dietary Cd intake to remain constant or decline

Table 2.

Daily Cd Intakes in Various Countries

Country	Cd intake (μg/day)	References
Australia	20~50	Australian Government 1977, Webb 1975
Belgium	15~45	Buchet et al.1983, Fouassin and Fondu 1980
Canada	15~80	Conacher et al. 1989, Dabeka and Mckenzie 1992 Kirkpatrick and Coffin 1977
China	43	Chen et al. 1993
Czechoslovakia	60	US EPA 1979
Denmark	39	Tjell et al. 1983
Finland	8.3	Loekari et al. 1988
France	20~30	Chmielnicka and Cherian 1986
Germany	17~57	Chmielnicka and Cherian 1986, Robards and Worford 1991
Italy	32	Coni et al. 1992
Japan[a]	19~800	Chmielnicka and Cherian 1986, Robards and Worford 1991
UK	10~30	Bernard and Lawerys 1984
Netherland	32	Chmielnicka and Cherian 1986
New Zealand	2.5~27	Chsolm et al. 1987, Staessen et al. 1988
Poland	20	Forstner 1984
Sweden	10~20	Kido et al. 1988
USA	13~92	Chmielnicka and Cherian 1986, Robards and Worford 1991

[a] Polluted and unpolluted areas.

slightly in spite of increased Cd levels in food for the period of time (Travis and Etnier 1982).

Levels of dietary Cd intake in certain groups of people with special eating habits can be much increased by consuming particular food items. A study in Italy has shown that consumption of seafoods just once a week can increase the Cd intake by up to 375 μg/week from 222 μg/week, suggesting a possible health risk for people who consume these foods frequently (Coni et al. 1992). Assessment of dietary Cd intake among Indigenous People in James Bay Cree, Quebec also demonstrated an increase in Cd intake from 385 μg/week up to 685 μg/week due to consumption of particular food items (Archibald and Kosatsky 1991).

In addition to food, cigarette smoking is another important souce of Cd intake because of the Cd accumulated in tobacco leaves. It is well known that cigarette smokers show higher body burdens of Cd than non-smokers (Lewis et al. 1972; Archibald and Kosatsky 1991; Coni et al. 1992). Inhaled Cd through the respiratory system can be absorbed more efficiently than ingested Cd. Respiratory absorption of Cd is about 20 to 60% (Cherian and Goyer 1989). Since one cigarette contains approximately 1 to 2 μg of Cd (Elinder 1985), about 0.2 to 1.2μg of Cd can be absorbed per one cigarette. Smokers who smoke one or two packs a day will be exposed to the Cd levels which may cause health risks. Cigarette smoking was found to be a major source of Cd intake in Inuit in Northern Quebec (Benedetti et al. 1994)

2.4. Cd metabolism

Less than 10% of ingested Cd can be absorbed by the GI tract in humans, and the major route of excretion is the feces (Friberg 1971). Cd absorption is affected by several factors such as nutritional status, forms of ingested Cd, and degree of bioavailability of Cd in food (Fox 1983; Cherian & Goyer 1989). Age (Kjellstrom 1979) and gender (Flanagan et al. 1978) also affect Cd absorption. The mechanism of Cd absorption in the GI tract is not clearly understood. Absorbed Cd is accumulated mainly in the liver and kidneys with different preferential sites of deposition depending on chemical forms of Cd

(Chmielnicka & Cherian 1986). The liver and kidneys together account for more than half of the Cd body burden (Nordberg et al. 1985). Cd is excreted very slowly with a long biological half-life of 10 to 30 years (Robards 1991).

Cd metabolism also appears to be affected by routes of Cd exposure, resulting in different tissue distributions (Lehman and Klaassen 1986; Scheuhammer 1988). Accumulation of Cd is more responsive to orally administered Cd than to intravenously administered Cd. When Cd is given orally, the concentration of Cd in tissues increases more than the increase in dosage, whereas intravenously administered Cd shows a proportional increase in tissue Cd concentration with increase in dosage (Lehman and Klaassen 1986). The ratio of Cd accumulation (kidney/liver) differs depending on the route of Cd exposure. The ratio (kidney/liver) is higher after oral administration than parenteral administration (Engstron and Nordberg 1979; Cahill et al. 1983; Bhattacharyya et al. 1986). Jonah & Bhattacharyya (1989) have reported that the ratio of Cd accumulation (kidney/liver) from the two routes are the same at the early stage of Cd absorption, but the ratio from only oral Cd increases later while that from parenteral administration remains constant.

2.4.1. Interaction with nutrients

Interactions between Cd and essential minerals have been reported both in human and animal studies. Cd is known to alter the metabolism and functions of essential minerals by competing for ligands in biological systems (Julshamn et al. 1977; Petering et al. 1979; Whanger 1979; Schafer and Forth 1984). Thus, many of Cd induced toxicity are thought to be derived from secondary deficiency of these minerals (Bremner 1974).

Results from animal studies have shown that uptake of Cd from the intestinal mucosa and transport of Cd to other organs are increased in iron-deficiency (Hamilton and Valberg 1974; Flanagan et al 1978; Fox 1979). In humans, low iron stores can enhance Cd absorption by as much as 20% (Nordberg et al. 1985b). Detailed mechanism of the development of Cd induced anemia is not well known, but binding of Cd to mucosal transferrin is thought to interrupt iron metabolism, which results in anemia

(Samarawickrama 1979; Aisen 1980). A recent study from mice has shown that even low doses of Cd cause a dose-dependent elevation of transferrin concentration in plasma and a decrease in the saturation of transferrin with iron (Kozlowska 1993).

However, supplementation of iron can exert a protective effect against Cd toxicity accompanied by reduction of Cd accumulation in organs (Fox et al. 1980; Cousins et al. 1991). The protective effect of iron on Cd toxicity has been attributed to decreased uptake of Cd through gastrointestinal tract due to competition between these two metals for the binding sites of mucosal transferrin (Schafer and Forth 1984; Fox et al. 1971; Groten 1991).

Zn deficiency can also increase Cd absorption (Foulkes 1985; Hoadley and Cousins 1985), and supplementation of Zn can decrease Cd absorption and Cd toxicity (Jacobs et al. 1978; Jaeger 1990). Competition between these two metals for binding sites of metallothionein (MT) in intestines has been regarded as one explanation for the antagonistic effect of these two metals (Hempe and Cousins 1991).

Copper (Cu), calcium (Ca), and selenium (Se) are other trace minerals which are known to affect Cd absorption and retention (Chmienicka and Cherian 1988; Whanger 1992). Since the binding affinity of Cd to the calcium binding protein (CaBP) is almost as high as calcium and the activity of CaBP is increased in case of Ca deficiency, diets with low Ca can increase body retention of Cd (Hamilton and Smith 1978; Nordberg 1985). Cd absorption has been shown to be decreased by high Ca containing diet (Nordberg et al. 1985b).

Cousins et al. (1991) reported that the effect of essential minerals on the interruption of Cd metabolism is most significant when iron is combined with these minerals. Interactions of Cd with other nutrients such as protein (Itokawa et al. 1973; Uthe and Chou 1980) and dietary fiber (Spiller and Amen 1975; Kiyozumi et al. 1982) have been also reported to affect Cd absorption.

2.4.2. Cd Speciation

Speciation can be defined as "the range of physico-chemical forms of an element which together make up its total concentration in a sample" (Florence 1982). The importance of metal speciation in environmental and biological systems has been discussed, including concerns about human health in terms of the mobilization and transportation of heavy metals and their complexes to the food chain (Quintus 1995).

Forms of Cd present in nature can be classified as free hydrated Cd ion and complexed labile and non-labile Cd species (Robards and Worsford 1991). The complexing agents can be both organic such as nitrilotriacetic acid (NTD), extracellular components and dietary fiber, and inorganic such as chloride. The principal Cd species in seawater are various chloride complexes, while the ionic form is predominant in soft water. In river, Cd is present either in free hydrated form or cadmium carbonate depending on water pH. In animal tissues, most of the Cd is complexed to a binding form of Cd-MT (Kagi et al. 1980), and in plants and vegetables, most of Cd are known to be bound to MT-like proteins (Kaneta et al. 1983;Wagner 1984).

Because of the different toxicokinetics of ingested Cd depending on its chemical form, specially more pronounced toxic effect of biologically bound Cd (Weigel et al. 1987), and heat stability of Cd-MT(Cherian 1974), identifying Cd species in food may be helpful in investigating a way of decreasing exposure levels of Cd toxicity by screening special foods or preparation methods. (Cherian et al. 1978; Cherian 1979; Maitana et al. 1984).

2.4.3. Risk assessment

In evaluating health risks from Cd exposure, the most critical organ is the kidney. Since the cortex is the site where the first adverse effect occurs, the Cd concentration in the cortex is of importance. The critical renal Cd concentration in the human is 200 mg/kg wet tissue which is a starting point for renal effects (Friberg et al. 1971). Levels of Cd in human kidney cortex in Canada have been reported to range from 40 to 232 mg/kg dried tissue which are higher than values reported from other countries (Meranger et al. 1981). The general population in Canada are considered to be exposed to Cd levels which have been associated with mild effects on the kidney (Environment Canada 1994).

The level of total Cd intake over a lifetime which may cause toxic effects has been calculated as 2000 mg (Sugita 1988; Nogawara 1989). Levels of daily Cd intake required for a non-smokers at age 50 to reach the critical Cd concentration in the renal cortex, 200 mg/kg tissue, has been estimated to range from 104 to 486 μg, depending on assumptions (WHO 1992). These assumptions include gastrointestinal absorption rate (either 5 or 10 %), half time in the kidney cortex (either 17 or 30 years), one- third or one-quarter of the body burden of Cd in the kidney, and constant Cd levels in the food for the last 50 years.

The Joint FAO/WHO Expert Committee on Food Additives (JECFA) has established the Provisonal Tolerable Weekly Intake (PTWI) for Cd as 7 μg/kg BW (1989). Unlike the case of food additives and pesticides where the Acceptable Daily Intake (ADI) limits are established based on the known certainty that a lifetime exposure will not result in any adverse health effect, heavy metal contaminants are expressed as PTWI (WHO 1985). The term "provisional" expresses the tentative nature of the evaluation of the contaminants, and the term "tolerable", signifying permissibility rather than acceptibility, is used when the intake of the contaminants is unavoidable with otherwise nutritious food. The provisional tolerable intake is also expressed on a weekly basis rather than daily basis because of the nature of the contaminants which accumulate in the body.

The PTWI of Cd, 7 μg/kg BW, was estimated from the assumption of Cd accumulation of over a period of 50 years at an exposure rate equivalent to 1μg/ kg BW. The PTWI is applicable to adults, children, and infants for all food types. JECFA (1989) also estimated the dietary Cd intake to be usually 1-4 μg/kg BW/week, and recognized a relatively small safety margin between exposure in the normal diet and exposure that produced deleterious effects. Thus, it was suggested that the level of Cd intake should be monitored continuously.

2.5. Metallothionein (MT)

2.5.1. Characteristics of MT

MT is a low molecular weight protein (6000-7000 Da) which was first isolated from equine renal cortex (Margoshes & Vallee 1957; Kagi and Vallee 1960). MT is characterized by its high metal content and high cysteine content (up to 30%). MT shows a unique amino acid sequence with a characteristic distribution of cysteinyl residues, Cys-X-Cys, in the absence of aromatic amino acids and histidine residues (Kagi et al. 1979). Cysteine residues in MT are involved in binding seven divalent metal ions through mercaptide bonds.

MT can be divided into three classes based on structural characteristics (Kojima 1991). Class I MTs are polypeptides with locations closely related to those in equine renal MT, and all vertebrate forms are included in this class. Class II MTs include polypeptides with locations of cysteine only distantly related to mammalian forms such as yeast MT. Class III MTs refer to atypical nontranslationally synthesized metal-thiolate polypeptides containing Ɣ-glutamylcysteinyl units (Robinson and Jackson 1986).

MT occurs throughout the animal kingdom, and is also found in higher plants, eukaryotic microorganisms, and some prokaryotes (Kagi and Schaffer 1988). MT has multi-isoforms which differ slightly in their amino acid sequences. Most vertebrate tissues contain MT I and MT II as two major isoforms (Kagi 1979), whereas MT III is specific to the brain (Uchida et al. 1991) and MT IV is specific to skin (Quaife et al. 1994). In animals, MT is most abundant in the liver, kidneys, pancreas, and intestines (Kagi and Schaffer 1988).

The tertiary structure of MT is characterized by two domains: α- domain and β-domain (Neilson and Winge 1984; Neilson et al. 1985). A total of twenty cysteine residues in these domains render MT an ability to bind heavy metal ions such as Cd, Hg, Zn, and Cu with different binding affinities. The α-domain extends from amino acid residue 31 to 61 within the carboxyl-terminal end of the molecule, and the amino terminal β- domain extends from 1 to 30. The α-domain has 11 cysteine residues which can bind four atoms of Zn or Cd, or five to six atoms of Cu. The β-domain contains 9 cysteine residues which can bind three atoms of Zn or Cd, or six atoms of Cu. Zn and Cd preferentially fill the α-domain first, whereas Cu fills the β-domain first. The number and position of cysteines

that participate in the binding of metals are invariant between MT I and MT II (Winge et al. 1984).

MT synthesis in the nucleus and cytoplasm can be induced by administration of metals such as Cd and Zn at the transcriptional level (Bremner 1987). Other factors which stimulate biosynthesis of MT include hormones, cytotoxic agents, and pathophysiological conditions associated with physical or chemical conditions (Cherian and Chan 1993).

Degradation and the half-lives of MT are closely related to the type of metals bound to MT (Cousins 1983). Half-lives of MT are 1-4 days depending on the types of metals bound. Metals bound to MT appear to protect MT from proteolysis because the order of sensitivity toward degradation is apo-MT >> Zn-MT > Cd-MT (Meulenaar et al. 1985). The degradation rate of Zn-MT and Cd-MT has been shown to be approximately 1/5000 that of apo-MT (Cuoudhuri et al. 1992). In vivo, half-life of Cd-MT is three to four times longer than that of Zn-MT. The degradation of MT seems to occur concomitantly with the release of metals or right after the release of metals bound, and the turnover of metals bound to MT is associated with the degradation of MT (Dunn et al. 1987).

2.5.2. Biological functions of MT

Resistance against metal toxicity has been regarded as the major role of MT due to its metal-binding properties. Protective effects of MT are demonstrated by reduced metal toxicity after the induction of MT by Zn or low doses of Cd (Goering et al. 1984a; 1984b).

MT has been suggested to serve as a Zn and Cu storage protein because MT is isolated as a major Zn- and Cu-binding protein in many tissues such as liver, kidneys, pancreas, and intestines (Kagi and Kojima 1987). The positive relationship between contents of Zn and Cu and MT concentrations in tissues has been demonstrated in animal studies with various results depending on the species of animals and the type of tissue studied (Templeton and Cherian 1991; Cherian and Chan 1993).

Homeostatic controls of MT in Zn and Cu metabolism have been also studied in the gastrointestinal absorption level. Absorption of Zn is inversely related to the

concentration of intestinal MT (Menard et al. 1981; Cousins 1985; Hoadley et al. 1988). In case of Zn-deficiency, the amount of MT present in the intestinal mucosa is little with increased transfer of Zn to the plasma. Contrarily, in Zn-loaded state, more Zn is incorporated into increased intestinal MT and the transport to the plasma is reduced. Cousins et al. (1992) have suggested that binding competition between saturable cystein-rich intestinal protein and MT for intracellular Zn is responsible for the inhibitory effect of MT on Zn absorption. However, the role of MT in regulating absorption of Zn and Cu is based on results from studies using physiologically irrelevant levels. Whether intestinal MT is important in controlling absorption of nutritionally relevant levels of Zn and Cu needs further investigation (Bremner 1991).

2.5.3. Cd and MT

Chemical form of Cd in food is one of the factors affecting Cd absorption and metabolism (Chmielnicka and Cherian 1986). Cherian (1979) showed that different biocomplexes of orally administered Cd are distributed in tissues in different manners. Cd-MT was mainly distributed to the kidneys whereas cadmium chloride ($CdCl_2$), Cd-Cysteine, and Cd bound to glutathionein (Cd-GSH) were distributed mainly in the liver. Other sudies also showed that Cd-MT was preferentially transported to the kidneys and $CdCl_2$ to the liver when given orally (Tanaka et al. 1975; Min et al. 1991; Ohta et al. 1991). In addition, much less Cd is thought to be absorbed from Cd-MT than from $CdCl_2$ (Sugawara et al. 1988; Sugawara and Sugawara 1991).

Cd absorption in GI tract is thought to be undertaken through two steps: (1) uptake of Cd from the lumen into mucosa involving non-specific binding to the membrane, and (2) transport of Cd from mucosa into blood by an internalization process (Sahagian et al. 1967; Foulkes 1985; Foulkes 1988). The second step is slower than the first step which is thought to regulate the absorption of Cd (Kello et al. 1979; McGivern and Mason 1979). However, the mechanism of Cd absorption through the gastrointestinal (GI) tract is still not fully understood.

MT is believed to play a role in regulating Cd absorption (Richards and Cousins 1975; Sqibb et al. 1976; Foulkes and McMullen 1986). Foulkes and McMullen (1986) have reported that endogenous mucosal MT appears to be a major determinant of mucosal Cd retention. Min et al. (1991) supported the idea of the regulatory role of MT in Cd absorption by showing that mucosal MT preinduced by Zn or Cd traps Cd in intestinal mucosa and reduces Cd transport to organs. Furthermore, different roles of endogenous and exogenous MT in Cd absorption have been demonstrated (Ohta et al. 1989; Ohta and Cherian 1991). It is suggested in these studies that the exogenous MT can decrease the Cd uptake from lumen to mucosa (step 1), wheras the endogenous MT can decrease the release of Cd from the intestinal mucosa into the bloodstream (step 2).

Depending on forms of Cd, different mechanisms of Cd absorption have been suggested. Cd-MT is probably internalized in an intact form into intestinal cells and further passes through the basolateral membrane, still remained intact (Lehman and Klaassen 1986; Ohta et al. 1989; Sugawara and Sugawara 1991). For $CdCl_2$, dissociated Cd ions are internalized into the cells, and Cd absorption is regulated by Cd induced MT (Foulkes and McMullen 1986; Sugawara and Sugawara 1987). One study also reported that Cd may enter the portal circulation via a paracellular route when the dose of $CdCl_2$ is very high (Goon and Klaassen 1989).

2.5.4. MT and Cd Toxicity

Cd induced MT shows a paradoxical role in Cd toxicity (Nordberg et al. 1975). Intracellularly induced MT decreases Cd toxicity by sequestering Cd ions and forming Cd-MT (Cherian 1980; Goering and Klaassen 1984b). Pretreatment of low doses of Cd prevents acute Cd toxicity in animal studies (Cherian and Nordberg 1983; Goering and Klaassen 1984a; 1984c). Extracellular Cd-MT, however, has been shown to be more toxic than inorganic Cd (Nordberg et al. 1975; Sendelbach et al. 1989; Chan et al. 1992). The concentration of Cd in the kidneys which can cause nephrotoxicity is much lower after an injection of Cd-MT than $CdCl_2$ (Goyer et al. 1989).

Cd salts and Cd-MT have different target organs for toxicity. Injected Cd-MT shows nephrotoxicity after preferential distribution to the kidneys (Squibb et al. 1984; Sendelbach et al. 1989), wheras $CdCl_2$ shows hepatotoxicity after selective accumulation in the liver (Sendelbach and Klaassen 1988; Sendelbach et al. 1989). Target organ of Cd toxicity is also affected by whether the exposure to Cd is acute or chronic. Acute exposure to inorganic Cd produces only hepatotoxicity, but the target organ changes to the kidneys with chronic Cd exposure (Friberg et al. 1974; Goering and Klaassen 1984a; 1984c).

The reasons why the target organ changes from the liver to the kidneys and Cd-MT is more nephrotoxic is still unclear. Dudley et al. (1985) suggested that nephrotoxicity due to Cd-MT is caused by Cd-MT released from the liver. It has been reported that kidney synthesizes less MT than liver in response to both $CdCl_2$ and Cd-MT with the least induction of Cd-MT in the kidney (Sendelbach and Klaassen 1988). The theory of kidney damage caused by Cd-MT released from liver was supported by Chan et al. (1993) with a study of liver transplantation. It was found from this study that Cd can be released from the liver, exist in the form of Cd-MT in blood stream, and accumulate in the kidney.

2.6. Traditional foods

Traditional foods which are also known as indigenous foods are those "foods from the environment which became included into the cultural food use patterns of a group of Indigenous People" (Kuhnlein and Turner 1991). Patterns of food uses among Indigenous Peoples in Canada have gone through changes since contacts with Europeans. Declines in the use of traditional foods by Indigenous Peoples with the introduction of market food due to several factors such as political, demographic, and economic elements, have resulted in deteriorated diet quality (Kuhnlein 1992). Increased consumption of nutritionally inferior market food, usually highly processed food with lowest costs, has been noted as a warning for possible health risks and nutritional deficiencies (Kuhnlein 1989b; Kinloch et al. 1992; Johns et al. 1994).

Traditional food systems for Indigenous Peoples in Canada show diverse patterns reflected by different physical environments (Kuhnlein and Turner 1991). Generally, plants, greens, sea mammals, land animals, and birds which were available in surrounding environments were the sources of precontact diets. In the west coast of British Columbia, various kinds of roots, plant greens, wild berries, shrubs, and fish and seafoods are still important food items (Lepofsky et al. 1985; Kuhnlein 1989a; Kuhnlein 1990; Kuhnlein 1992). In the Canadian arctic and subarctic, varieties of species of sea mammals, land animals and birds are predominantly used (Kuhnlein and Soueida 1992; Kuhnlein et al. 1994). The species most frequently used by the Sahtu Dene-Metis of the Northwest Territories in the western Canadian arctic include the caribou, moose, beaver and black scoter (Kuhnlein et al. 1994). For the Inuit food of Baffin Island inside the Arctic circle, ringed seals, narwhal, arctic char, and tundra greens as well as caribou are the most frequently used food items (Kuhnlein and Soueida 1992; Chan et al 1995).

2.6.1. Contamination of traditional foods

The presence of contaminants in the arctic ecosystem has been recognized as a threat to the arctic food chain (Lockhart et al. 1992; Muir et al. 1992; Thomas et al. 1992). Potentially toxic organic compounds, metals, acids, and radionuclides are known to be the major pollutants in the Canadian arctic and subarctic areas. Chlorinated organic compounds (eg. PCBs), organic pesticides (eg. toxaphene), polycyclic aromatic hydrocarbons, and metals (eg. mercury, cadmium, lead and arsenic) are the contaminants of most concern (Muir et al. 1988; Zedeck 1980; Barrie 1992; Thomas et al. 1992).

Pathways and sources of the arctic contaminants are discussed in detail by Barrie et al. (1992). Many mines have been developed and abandoned in the Canadian North because of its rich mineral resources, which is known to contribute to the metal contamination in the soils and waters of arctic area (Lockhart et al. 1992; Thomas et al. 1992). Industrial activities in mid-latitudinal areas are also important contributors to the arctic contamination of metal and organic compounds. These toxic substances are transported to the arctic by air and ocean currents.

Significantly higher levels of toxic metals have been reported in lower trophic levels (Macdonald et al. 1986), and in marine mammals such as ringed seals and narwhals from the arctic (Wagemann et al. 1983; Hansen et al. 1990; Wageman et al. 1994).

Safety of traditional foods is of particular concern among Indigenous Peoples. They still consume traditional foods available in their natural environment and some of the traditional foods have exceptional nutrient attribute to them (Wong 1985; Wein 1994).

Dietary mercury intake for Arctic residents from contaminated fish and wildlife animals has been discussed as an important issue (Berkes 1980; Kershaw et al. 1980; Wheatley and Wheatley 1981). Chan et al. (1995) have reported that, in Baffin island, mercury intake from traditional food exceed the guideline in all age groups. Organic mercury levels in blood of Inuit residents have been shown to exceed the 'risk' level of 100 ng/g because of consumption of contaminated traditional foods (Kinloch et al. 1992).

There is no systematic study on levels of Cd in traditional food. Cd levels in marine mammals, fish, and caribou have been reported (Wong 1985; Gamberg and Scheuhammer 1994; Chan et al 1995). Cd intake from consuming organs of arctic wildlife such as caribou, moose, muskoxen has been considered as a health risk to Indigenous Peoples who rely on these animals as food resources (Archibald & Kosatsky 1991; Gamberg & Scheuhammer 1994).

2.6.2. Benefits of traditional foods

Traditional foods are good sources of many nutrients and contribute to the nutritional balance of diets of Indigenous Peoples. Wild plants, wildberries, and greens utilized by Indigenous Peoples are good sources of carbohydrate, vitamins, and essential minerals (Kuhnlein 1989; Kuhnlein 1990; Kuhnlein and Soueida 1992). Various kinds of sea mammals and land animals contain many essential nutrients including energy, protein, fat, retinol, and minerals (Appavoo et al. 1991; Kuhnlein and Soueida 1992; Morrison and Kuhnlein 1993; Kuhnlein et al. 1994). Although imported market foods have been displacing traditional foods to a great extent, Indigenous Peoples still rely on their

traditional foods for energy, protein, and micronutrients, compensating for the poor quality of market foods they consume (Kinloch et al 1992).

Some of the green plants, wild berries, and root foods consumed by Indigenous Peoples have almost the same as or even higher nutrient values than those from market foods (Kuhnlein 1989; Kuhnlein 1990; Kuhnlein and Turner 1991; Wein 1994). Many traditional meats such as moose and caribou have higher nutrient densities for protein, iron, and riboflavin than commercial meats (Wein 1994). Lipid compositions of the traditional Dene foods have shown that traditional foods can make an important contribution to a decrease of fat intake per unit energy and to maintain beneficial ratio of P:S and omega-3 to omega-6 fatty acids for cardiovascular health (Appavoo et al. 1991). Studies conducted in Broughton Island showed that significantly higher levels of omega-3 fatty acid were found in the blood and breast milk of the residents consuming sea mammal fatty tissues rich in omega-3 fatty acids (Innis et al. 1988; Innis and Kuhnlein 1988). The fat tissue of fish (ooligan) are richer in vitamin A and E than lard, corn oil, or margarine (Kuhnlein et al. 1982).

There are also cultural, social, and economic benefits in the traditional food system (Kinloch et al. 1992; Wein 1994). Activities of hunting and fishing promote social ties, individual spirit, and physical strength. In addition, imported market foods are very expensive and quality of diets becomes deteriorated when market foods are substituted for traditional foods.

2.6.3. Risk and benefit assessments

Assessment of risks from consuming contaminated traditional foods is a complicated issue. There are nutritional, economic, social, and cultural benefits in traditional food system, and there are health risks associated with the diet transition to imported market food (Kuhnlein 1989c; Kinloch et al. 1992). In an attempt to avoid contaminated traditional food by mercury, the residents in Sugluk, Northern Quebec, switched to store food. However, they could not afford to buy substitute foods equal in nutritional value to that of the traditional food they replaced (Wheatley & Wheatley 1981). In an isolated

community, economic hardship was even encountered because of the expenditure on market food. There have been recommendations for the use of traditional foods regardless of the presence of contaminants, considering the benefits of traditional foods (Kuhnlein 1989c; Archibald & Kosatsky 1991; Kinloch et al. 1992). A risk evaluation of Cd intake from traditional food in the Cree has concluded that consumption of caribou and moose should not necessarily be avoided (Archibald & Kosatsky 1991). A similar conclusion was made from the risk assessment of diet mercury intake in Sugluk, Northern Quebec, where high blood mercury levels were big concerns (Wheatley & Wheatley 1981).

CHAPTER 3: ASSESSMENT OF DIETARY CADMIUM INTAKE FROM TRADITIONAL FOOD IN FORT RESOLUTION

3.1. Introduction

For risk assessments of dietary intake of contaminants, it is necessary to obtain valid information on food consumption and contaminant levels in the food consumed. Based on this information, in case of heavy metals, dietary intakes of the contaminants are estimated, and it is determined whether the estimates exceed Provisonal Tolerable Weekly Intake (PTWI) to assess potential health problems (WHO 1985).

There are several methods for obtaining food consumption data in estimating heavy metal intake: total diet or market basket studies, selective studies of individual foodstuffs, and duplicate portion studies (WHO 1985). The choice of the most appropriate method depends on several factors; whether the object to be studied is individuals or populations, the size of a given population, whether a given population is a risk group, and available resources (WHO 1985; Kumpulainen 1991; Pennington 1991). Comparative evaluations of the methods above have been well discussed by Pennington (1991).

The major Cd sources in a general population are food and cigarette smoking (Chmielnicka and Cherian 1986). In the present study, surveys on diet and smoking habits were undertaken together with Cd analysis in traditional food in 1994, in order to estimate the Cd exposure level through traditional food and smoking. The estimated Cd intakes were compared with PTWI for risk assessment.

Findings in patterns of traditional food use, Cd concentrations in traditional food, and estimates of Cd intake from traditional food followed by smoking habits and estimate of Cd intake from cigarette smoking are presented in this chapter.

3.1.1. Community profile

Fort Resolution (61° 10'N, 113° 40'W) is located on the peninsula of Resolution Bay on the south side of Great Slave Lake, Northwest Territories. The total population in Fort Resolution is estimated as 475 (53% of males and 47% of females) (1988, Government of NWT). Indigenous Peoples comprise 87% of the population in the community (42% of Dene and 47% of Metis) (1987). The native language, Chipewyan, and English are the spoken languages in this area.

Topographically, the area is on lake sands and silts in swampy coast, and is thickely forested. Fort Resolution is rich in mineral resources, specially lead, zinc, and silver. The mean high and low temperatures in January are -22.4°C and -32.9°C, and, in July, 20.7°C and 10.5°C. The average annual precipitation of rainfall is 16.2 cm and snowfall 174.0 cm.

Major ecomomic activities include logging/sawmill, trapping, hunting, and domestic fishing. Trapping still provides a significant proportion of the residents' livelihood. The total number of trappers are estimated as 114 people (1987-1988). Private household average income is $25,741 (1985). Food prices are 3 % higher than in Yellownife (1987).

The main water source for the community is Great Slave Lake, and most houses have 1137 litre storage tanks. There is a small pit area for sewage disposal 2.7 km away from the community. The community has a health centre with a medical staff of seven people.

3.2. Materials and Methods

3.2.1. Dietary survey

During the study period in 1994, 50 people of age over 20 were randomly selected for the survey in each of late winter and fall. The total number of selected participants was 100. This represented 10 % of the population in Fort Resolution.

The survey consisted of four parts: 24-hour dietary recalls, traditional food use frequency, smoking habit questionnaires, and sociocultural questionnaires. The survey was carried out by a trained local research assistant both in English and Chipewyan during

late winter (February-April) and fall (September-November). Questionnaires used in this study are presented in Appendix 1. Three women who were pregnant or breast feeding were excluded. Hence, the total number of participants in this study was reduced to a total of 97 people.

Respondents recorded the kinds and amounts of both traditional and market food they consumed on the previous day in dietary recall questionnaires. Only traditional food recorded to be consumed was used for the purpose of this study. The traditional food use frequency questionnaire already developed specifically to Dene-Metis food was used. About 60 species of animals, fish, birds, their specific parts, and plants were listed in the questionnaire. Respondents were asked whether or not each species had been consumed for the last three months in the food use frequency questionnaire. If yes, the questionnaire asked how often specific parts of the species had been consumed: never, <1/week, 1-2/week, 3-5/week, 6-7/week. Thus, the food use frequency reflected food use patterns during summer and winter.

The periods for the maximum and the minimun use of traditional food had been identified as fall and late winter, respectively. These two seasons, therefore, were chosen for the dietary recall interviews for quantitative estimation on recent intake of traditional food. To obtain more representative consumption pattern of usual intake of traditional food, the food frequency questionnaire was used for summer and winter.

3.2.2. Traditional food sample collection

In order to estimate daily Cd intake from traditional food, it is necessary to know Cd concentrations in the food items actually consumed. Commonly consumed traditional food was sampled for Cd analysis three times during the study period. Individual food items were hunted or collected independently. Prepared food items were purchased from households in the community when available. No specific precaution was taken into account to avoid Cd contamination during food preparation proccesses in order to reflect the 'on the table' levels of Cd in food.

Collected traditional food items included not only those mentioned in the dietary recalls but also other food resources available in the community. Collected food samples were shipped frozen to the laboratory (CINE, Macdonald Campus, McGill University) and immediately stored at -80°C until analysed for Cd.

3.2.3. Cd analysis

Chemicals and glassware

Nitric acid (ultrapure grade) was purchased from J. T. Baker (Baxter, Missassagua, ON), and standard Cd solution was purchased from ACP chemicals (St. Leonard, QC). Cd standard solution with the same acid concentration as samples was prepared daily with 40% nitric acid diluted with deionized water. All glassware was soaked in 20% hydrochloric acid for at least one day prior to use.

Cd analysis

Two aliquots of about 1.0 g of samples were weighed and dried to constant weights in a vacuum oven at 60°C with a pressure of 30 Pa for 24 hours. Dried samples were digested with nitric acid. First, 2ml of nitric acid was added and the samples were left overnight at room temperature. The samples were then heated at 60°C for 12 hours. Another 2 ml of nitric acid was added, and the samples were heated at 80 °C for 24 hours. Completely digested samples were made up to 10 ml with deionized water.

Cd concentrations in the digested food samples were determined by using a Hitachi Z-8200 Atomic Absorption Spectrophotometer with Zeeman Background Correction with external reference standards. Either flame or graphite furnace mode was used. Optimal analytical parameters and temperature program were selected as suggested by the manufacturer (Hitachi 1987; Hitachi 1992). The instrumental detection limit was three times the standard deviation of the blank. Detection limits for the flame and the graphite furnace modes were 0.01 ppm, and 0.01 ppb, respectively. Concentrations below the detection limits were regarded as zero.

Quality control assurance

Accuracy and precision of the analytical method were tested with standard reference materials from the National Institute of Standard & Technology (oyster tissue SRM 1566a, Apple leaves SRM 1515 and Bovine liver SRM 1577b). Standard reference materials were always included in the digestion and Cd analysis with every batch of sample. Analysis results of standard reference materials were within 1 S.D. of the certified values. Two replicates of blank samples were included in each analytical batch to monitor contamination. Deionized water was used throughout the analyses.

3.2.4. Statististical analysis

The distribution of Cd intakes did not conform to the normal distribution when tested with Shapiro-Wilk test. The lack of fit to the normal distribution was not substantially altered by log transformation of the data. Therefore, nonparametric statistic was conducted for the significance test by using the Wilcoxon rank sum test or the Kruskal-Wallis test. Average daily servings of traditional food were normally distributed, and the differences in season and gender were tested by the Student's *t*-test. Statistical analyses were performed with SAS/STAT (Version 6, SAS Institute Inc., Cary, North Carolina).

3.3. Results

3.3.1. Use of traditional food

Of the 97 dietary recalls collected, 61 dietary recalls contained traditional food. A demographic distribution of participants in the present study is shown by gender and age in Table 3A. Men accounted for 56 % of the participants in the study. In Table 3B, distribution of gender and age of dietary recalls which contained traditional food are

Table 3A.

Age and Gender Distribution of Participants in the study

Age\Gender	Women	Men	Total (% [a])
20-39	19	26	45 (46.4)
40-60	13	13	26 (26.8)
> 60	11	15	26 (26.8)
Total (% [a])	43 (44.3)	54 (55.7)	97

[a] Values in the brackets are percentage of the total number of the participants.

Table 3B.

Age and Gender Distribution of Participants with Dietary Recalls Containing Traditional Food

Age\Gender	Women	Men	Total (%[a])
20-39	8	11	19 (31.1)
40-60	10	9	19 (31.1)
> 60	10	13	23 (37.7)
Total (%[a])	28 (45.9)	33 (54.1)	61

[a] Values in the brackets are percentage of traditional food consumers.

shown. Men accounted for 54 % of the traditional food consumers in the study. Proportions of traditional food consumers of older people (31.1 % for 40-60 yrs., and 37.7 % for over 60 yrs.) were greater than the corresponding proprtions of the age groups of participants in the study (26.8 % for both 40-60 yrs. and over 60 yrs.).

A total of 33 kinds of traditional food species were reported to be used in the community from the traditional food use frequency interview. Frequencies of use of these traditional food items are presented in Table 4 in descending order of frequency. The number of total mentions (N) for each food item was the sum of mentions of "yes" to the question whether the food was used by respondents for the last three months, regardless of how many times the food was consumed weekly. Percentage (%) shows the proportion of total mentions of each food item to the total number of respondents of traditional food use frequency (N=97).

Moose is the most frequently consumed traditional food in the community. A total of 92 out of 97 participants, or an equivalent of about 95% of the participants, mentioned consuming moose. In addition to moose, barrenland caribou and whitefish are the food mentioned by more than 80% of the participants in summer and late winter. The food mentioned by more than 50 % of the participants include ptarmigan, jackfish, rabbit, loche, trout, and Canada goose in descending order of total mentions. Food least frequently used are some species of wildberries, wild rhubarbs, black currents, bear, and spruce hen. Frequencies of use of specific parts of animals and fish are presented in Appendix 2 by season.

Table 5 lists traditional food mentioned in dietary recalls collected. Only 16 kinds of traditional food were mentioned in the dietary recalls. Duck fat and black scoter flesh marked with asterisks (*) were not available during the periods of food sample collection for Cd anaysis.

Average amounts of daily intake of traditional food (g/day/person) were estimated for the whole community on a population basis from dietary recall. The result is presented in Table 6. Total weights of each types of food mentioned in dietary recalls were divided by the total number of participants in the study (N=97). Barrenland caribou flesh, whitefish flesh, and moose flesh were the most important food in the community.

Table 4.

List of Traditional Food Mentioned by All Participants in Descending Order of Frequency (Traditional Food Use Frequency) (N=97)

Food	Frequency	
	N[a]	%
Moose	92	94.8
Barrenland Caribou	87	89.7
Whitefish	85	87.6
Ptarmigan	69	71.1
Jackfish	64	66.0
Rabbit	62	63.9
Loche	58	59.8
Trout	51	52.6
Canada goose	46	47.4
Mallard	42	43.3
Longnose sucker	38	39.2
Prairie chicken	37	38.1
Muskrat	36	37.1
Saskatoon berry[b]	29	30.9
Inconnu	24	24.7
Cranberry	22	23.4
Canvasback	17	17.5
Beaver	13	13.4
Pintail	13	13.4
Swan	10	87.0
Wild raspberry	7	7.4
Woodland Caribou	6	6.2
Purple gooseberry	6	6.2
Snow goose	5	5.2
Spruce hen	3	3.1
Green gooseberry	3	3.1
Bear	2	2.1
High blueberry	1	1.0
Blackberry	1	1.0
Wild strawberry	1	1.0
Black currents	1	1.0
Wild onion	1	1.0
Wild rhubarb	1	1.0

[a] Number of respondents who answer that they consume each food item

[b] Total number of respondents=94 (missing frequency=3)

Table 5.

List of Traditional Food Mentioned in Dietary Recalls[a] (N=61)

Food	Part	Preparation
Whitefish	Flesh	Baked
Loche	Flesh	Baked
Moose	Flesh	Baked
Moose	Liver	Baked
Caribou	Flesh	Dried and Baked
Rabbit	Flesh	Boiled
Muskrat	Flesh	Cooked
Black scoter*	Flesh	Baked
Caribou	Bone marrow	Cooked
Moose	Flesh	Dried and Smoked
Moose	Nose	Cooked
Moose*	Fat	Cooked
Bison	Flesh	Cooked
Moose	Ribs	Cooked
Duck	Fat	Cooked

* Food items which were not included in Cd analysis and calculation of daily Cd intake

[a] Both seasons, late winter and fall, are included.

Table 6.

Average Daily Intake of Traditional Food

Food	Part	Preparation	Estimated Daily Intake[a] (g/day/person)
Barrenland caribou	Flesh	Baked	71.5
Moose	Flesh	Baked	44.4
Whitefish	Flesh	Baked	33.1
Muskrat	Flesh	Cooked	13.7
Black scoter	Flesh	Baked	5.9
Rabbit	Flesh	Boiled	5.8
Bison	Flesh	Baked	5.2
Loche	Flesh	Baked	4.6
Moose	Flesh	Dried and Smoked	4.1
Caribou	Bone marrow	Cooked	2.6
Moose	Ribs	Cooked	2.3
Duck	Fat	Cooked	2.3
Moose	Liver	Baked	1.7
Woodland caribou	Flesh	Dried	1.1
Moose	Fat	Cooked	0.6
Moose	Nose	Cooked	0.6

[a] Values were generated by total weight (g) of each food ÷ the number of total participants in the study (N=97).

Average amounts of daily intake of traditional food by gender are shown in Table 7. These values were obtained by dividing the total weights of each food by the number of dietary recalls of each gender group in the study. For example, the average amount of daily intake for barrenland caribou flesh for women was estimated as 59 g/day/person by dividing the total weight (2546 g) by the number of dietary recalls collected from women (N=43). Amounts of daily intake of some food tended to differ by gender. Average daily intakes of barrenland caribou flesh and moose flesh for men were greater than for women. In contrast, whitefish flesh was consumed more by women than men.

Daily servings of traditional food (g/day) are presented in Table 8. The largest daily serving (450 g/day) was calculated from baked loche flesh. The smallest daily serving was 44 g/day from dried and smoked moose flesh. Daily servings were calculated by dividing the total weights of each food recorded to be consumed in dietary recalls by the number of people who consumed the food. An average daily serving of traditional food was 233.2 g/day with a standard error of 13.5 g/day.

Average daily servings of traditional food were calculated by gender and season. The average was 342.6 g/day with a standard error of 23.5 g/day for men (N=33), and 287.3 g/day with a standard error of 22.5 g/day for women (N=28). The result of the statistical test showed no difference of average daily servings between gender groups. By season, the average for late winter was 283.0 g/day with a standard error of 21.9 g/day (N=37), and 370.0 g/day with a standard error of 22.8 g/day for fall (N=24). Average daily servings of late winter and fall were significantly different ($p < 0.05$).

Table 9 shows the frequency of consumption of traditional food by season. The frequency, shown as day/week/person, was estimated from dietary recalls. The frequency of consumption for each traditional food was calculated as the number of dietary recalls containing each food item divided by the total number of dietary recalls in each season multiplied by 7. Since dietary recalls do not differ greatly from day to day on a population basis even if one individual may show very different eating patterns from one day to the next day, it can be assumed that dietary recalls overall represent a daily eating pattern in a given week. Barrenland caribou flesh was the item consumed most frequently in both late winter and fall with a frequency of consumption of 2 days/week/person.

Table 7.

Estimated Daily Intakes of Traditional Food by Gender[a]

Women

Food	Part	Preparation	Average Daily Intake [b] (g/day/person)
Barrenland caribou	Flesh	Baked	59.2
Whitefish	Flesh	Baked	41.9
Moose	Flesh	Baked	40.1
Muskrat	Flesh	Cooked	19.2
Bison	Flesh	Boiled	6.6
Rabbit	Flesh	Boiled	5.2
Duck	Fat	Cooked	5.2
Moose	Liver	Baked	3.9
Moose	Flesh	Dried and Smoked	2.9
Moose	Fat	Cooked	1.4
Woodland caribou	Flesh	Dried	1.2
Black scoter	Flesh	Baked	0.3

Men

Food	Part	Preparation	Average Daily Intake [c] (g/day/person)
Barrenland Carribou	Flesh	Baked	81.3
Moose	Flesh	Baked	47.9
Whitefish	Flesh	Baked	26.0
Black Scoter	Flesh	Baked	10.4
Muskrat	Flesh	Cooked	9.3
Loche	Flesh	Baked	8.3
Rabbit	Flesh	Boiled	6.3
Moose	Flesh	Dried and Smoked	5.0
Caribou	Bone marrow	Cooked	4.6
Bison	Flesh	Cooked	4.2
Moose	Ribs	Cooked	4.2
Moose	Nose	Cooked	1.0
Woodland caribou	Flesh	Dried	1.0

[a] Based on dietary recalls in spring and fall.

[b] Calculated by total weight of each food item consumed ÷ number of women in the study (N=43).

[c] Calculated by total weight of each food item consumed ÷ number of men in the study (N=54).

Table 8.

Estimated Daily Servings for Traditional Food

Food			N[a]	Daily serving[b] (g/day)
Barrenland caribou	Flesh	Baked	28	247.7 ± 15.1
Moose	Flesh	Baked	16	269.4 ± 31.2
Whitefish	Flesh	Baked	11	291.5 ± 37.8
Muskrat	Flesh	Cooked	3	441.7 ± 36.3
Black scoter	Flesh	Baked	3	191.3 ± 80.1
Rabbit	Flesh	Boiled	2	281.5 ± 56.2
Bison	Flesh	Baked	2	254.0 ± 28.8
Loche	Flesh	Baked	1	450.0 ± 0.0
Moose	Flesh	Dried and Smoked	9	43.8 ± 7.8
Caribou	Bone marrow	Cooked	1	250.0 ± 0.0
Moose	Ribs	Cooked	1	225.0 ± 0.0
Duck	Fat	Cooked	1	225.0 ± 0.0
Moose	Liver	Baked	1	169.0 ± 0.0
Woodland caribou	Flesh	Dried	2	53.0 ± 0.0
Moose	Fat	Cooked	1	60.0 ± 0.0
Moose	Nose	Cooked	1	56.0 ± 0.0
Total traditional food			83	233.2 ± 13.5

[a] Number of consumers of the food

[b] Average daily serving ± SEM

Table 9.

Frequency of Consumption of Traditional Food [a]

Food			Frequency of Consumption (Day/Week/Person)		
			Late winter[b]	Fall[b]	Both seasons[c]
Barrenland caribou	Flesh	Baked	2.3	1.7	2.02
Moose	Flesh	Baked	1.4	0.9	1.15
Whitefish	Flesh	Baked	0.4	1.2	0.79
Moose	Flesh	Dried and Smoked	0.8	0.5	0.65
Muskrat	Flesh	Cooked	0.3	0.2	0.22
Black scoter	Flesh	Baked	0.1	0.3	0.22
Rabbit	Flesh	Boiled	0.3	0.0	0.14
Bison	Flesh	Baked	0.1	0.2	0.14
Woodland caribou	Flesh	Dried	0.3	0.0	0.14
Loche	Flesh	Baked	0.0	0.2	0.07
Caribou	Bone marrow	Cooked	0.1	0.0	0.07
Moose	Ribs	Cooked	0.1	0.0	0.07
Duck	Fat	Cooked	0.1	0.0	0.07
Moose	Liver	Baked	0.1	0.0	0.07
Moose	Fat	Cooked	0.1	0.0	0.07
Moose	Nose	Cooked	0.1	0.0	0.07

[a] Based on dietary recalls

[b] Calculated by (number of dietary recalls containing each food item ÷ total number of dietary recalls in each season x 7)

[c] Calculated by (number of dietary recalls containing each food item ÷ total number of dietary recalls in the study x 7)

Food items with second highest frequency of consumption in late winter and fall were baked moose flesh and whitefish flesh, respectively.

More varieties of traditional food were consumed in late winter than in fall. In late winter, there was only one food item with zero frequency of consumption. In fall, food with zero frequency of consumption included rabbit flesh, caribou bone marrow, moose ribs, fats from moose and duck, moose liver and moose nose. In general, traditional food was consumed more frequently in late winter than in fall.

3.3.2. Cd concentrations in traditional food

Cd concentration was measured in a total of 100 traditional food items. The result is shown in Table 10. Food was catagorized in four major food groups; meat, fruits and vegetables, organs, and fish. Cd concentrations were expressed as μg/100g wet weight. The result of Cd analysis for individual food items is presented in Appendix 3.

Cd concentrations measured in food species ranged from 0 to 1869 μg/100g wet weight with an overall mean of 136 ± 630 μg/100 g wet weight and a median of 2.0 μg/100 g wet weight. The lowest Cd concentration was measured from cranberry jam and mooseberry, and the highest was measured from moose kidney.

The meat group consists of raw and cooked flesh of land animals such as moose, caribou, rabbit, bear, muskrat, buffalo, beaver, and of birds species such as ptarmigan and mallard. The highest Cd concentrarion in the meat group was measured in smoked and fried moose with 15.8 μg/100 g wet weight. The lowest Cd concentration was measured in boiled ptarmigan with 0.6 μg/100 g wet weight.

In the fruits and vegetables group, cranberry and mooseberry either in raw or in jam, rhubarb and garden potatoes were included. Cd concentrations in these food items were generally lower than those from other food groups. Cd concentrations in the fruits and vegetables ranged from 0 to 1.7 μg/100 g wet weight. The highest Cd concentration was measured in garden potatoes.

Cd concentrations in animal organs ranged from 0.3 μg/100 g wet weight to 1869 μg/100 g wet weight. The lowest was found in raw internal fat of moose, and the highest

Table 10.

Cd Concentrations in Traditional Food from Fort Resolution (µg/100g wet weight)

Food			Preparation	N[a]	Cd (µg/100g wet weight)
Meat					
Moose	*Alces alces*		dried and smoked	2	4.4 ± 0.1
			raw	4	2.5 ± 1.5
			fried	1	1.4
			boiled	2	1.9 ± 2.3
			smoked	2	4.5 ± 5.0
			smoked and fried	1	15.8
Caribou	*Rangifer tarandus*		raw	5	1.7 ± 1.5
Rabbit	*Lepus americanus*		raw	1	1.9
Bear	*Ursus americanus*		raw	3	1.1 ± 0.6
			smoked	1	1.0
Muskrat	*Ondatra zibethious*		raw	1	3.9
Buffalo	*Bison bison*		raw	1	1.0
Beaver	*Castor candadenis*		raw	2	9.1 ± 9.9
			smoked and boiled	1	2.1
Ptarmigan	*Lagopus mutus*		raw	2	1.4 ± 0.7
			fried	1	1.9
			boiled	1	0.6
Mallard duck	*Anas platyrhynchos*		boiled	1	4.6
Fruits and Vegetables					
Cranberry	*Oxycoccus spp.*		raw	4	0.2 ± 0.2
			jam	1	0
Mooseberry	*Viburnum edule*		raw	1	0
Rhubarb	*Rheum rhaponticum*		raw	2	0.2 ± 0.1
Berry			raw	2	1.3 ± 0.4
Garden potato			raw	3	1.7 ± 0.8
Organ					
Moose	*Alces alces*	liver	raw	2	703 ± 379
			boiled	1	121
		kidney	raw	3	1869 ± 276
			boiled	1	787
		heart	raw	4	6.2 ± 4.6
			boiled	3	4.6 ± 5.6
		entrails	raw	2	16.9 ± 3.3
			boiled	2	17.3 ± 11.0
		tongue	raw	1	14.3
		internal fat	raw	1	0.3
Caribou	*Rangifer tarandus*	marrow	raw	3	1.9 ± 0.4
		heart	raw	3	1.2 ± 0.5
		kidney	raw	3	126 ± 74.9
		liver	raw	2	161 ± 146
		intestine	raw	3	2.6 ± 2.1
Fish					
Whitefish	*Coregonus Clupeaformis*	flesh	raw	5	1.4 ± 0.9
Jackfish	*Esox lucius*	flesh	raw	5	9.3 ± 18.0
			fried	1	10.9
		intestine	raw	4	13.7 ± 10.9
		egg	raw	1	0.6
Sucker	*Catostomus catostomus*	flesh	raw	5	1.9 ± 2.3
			smoked	1	16
Trout	*Savelinus namaycush*	flesh	raw	1	1.6
Loche	*Lota lota*	flesh	raw	2	0.2 ± 0.1

[a]Number of independently harvested samples

was found in raw kidney of moose. Other organ samples from which Cd levels were measured include the liver, heart, intestine, bone marrow and tongue from moose and caribou. Cd concentrations in livers and kidneys were much higher than those from the rest of the food items in the organ group. Mean Cd concentrations in raw livers and kidneys from moose were 703 ± 379 and 1869 ± 276 μg/100 g wet weight, respectively. Mean Cd concentrations measured in raw livers and kidneys from caribou were 161± 146 and 126 ± 75 μg/100 g wet weight, respectively. Cd concentrations in hearts were less than 10 μg/100 g wet weight.

The fish group consists of fresh water fish including whitefish, jackfish, sucker, trout, and loche. Cd was measured in flesh, eggs, and intestine of the fish samples. Smoked sucker flesh showed the highest Cd concentration with 16 μg/100 g wet weight in the group. The lowest Cd concentration was found in the flesh of loche with 0.2 μg/100 g wet weight.

The mean, median, and range of Cd concentrations in each food group are presented in Table 11. The organ group showed the highest mean Cd concentration with 255 μg/ 100 g wet weight, and the fruits and vegetables group showed the lowest mean with 0.6 μg/100 wet weight. The mean Cd concentration of the meat group, 42 μg/100 g wet weight, was higher than that of the fish group, 6 μg/100 g wet weight, but the medians of two groups were the same with 2 μg/100 g wet weight.

The mean, median, and range of Cd concentrations in traditional food groups were also compared with those from Canadian market food in Table 11. The higest mean Cd concentration in Canadian market food groups was found in the organ group, 271 μg/ 100 g wet weight, which was similar to the mean of the same group in traditional food, 255 μg/100 g wet weight. The range of Cd values in the organ group of Canadian market food, 1 - 18500 μg/100 g wet weight, was wider than that of traditional food, 0.3 - 1869 μg/ 100 g wet weight. The lowest mean Cd concentration in Canadian market food was shown from the meat group as 0.9 μg/ 100 wet weight which was lower than that from traditional food. The fish group in Canadian market food showed a mean of 11 μg/100g

Table 11.

Mean Cd Concentrations (µg/100g wet wt.) in Traditional and Canadian Market Food

Food	Traditional Food from Fort Resolution				Canadian Market Food[a]			
	N[b]	mean	median	range	N[b]	mean	median	range
Meat	32	42	2	0.6~16	18	0.9	0.4	0.1~7
Organ	34	255	17	0.3~1869	12	271	17	1~18500
Fish	25	6	2	0.2~16	5	11	0.5	0.1~8
Fruits and Vegetables	13	0.6	0.2	0~2	37	2	1	0.1~12

[a]Dabeka & McKenzie 1992

[b]Number of independently harvested samples

wet weight, and the fruits and vegetables group showed a mean of 2 μg/100g wet weight. Both means of fish and fruits and vegetables were similar to those of traditional food.

3.3.3. Estimation of daily Cd intake from traditional food

To calculate daily Cd intakes from traditional food, information on the types and amounts of traditional food consumed on a given day is necessary in addition to the information on Cd concentrations in the food. Results of dietary recall interviews were used to obtain such information. Out of the total of 97 participants in the interview of dietary recalls, only 61 people recorded to consume traditional food. In general, participants who recorded to eat traditional food did not consume a wide variety of traditional food.

Traditional food mentioned in dietary recalls, as shown in Table 5, were mainly freshwater fish and games. Two food samples, duck fat, and black scoter flesh were not included in Cd analysis because they were not available during the time of sample collection. Cd intakes from consumption of these food were not included in the estimation of Cd intake. However, the dietary recalls where the duck fat and black scoter flesh were recorded to be consumed were included in the calculation and analysis of Cd intake because those dietary recalls contained more than one kind of traditional food. Duck fat and black scoter flesh were consumed by only two people. Therefore, it can be assumed that these food items do not contribute significantly to the average Cd intake on a population basis. In addition, Cd levels in fat are usually negligible.

Daily Cd intakes (μg/day/person) from traditional food for 61 individuals were calculated by multiplying Cd concentrations (μg/g) of consumed food by weight (g) of the food, and adding up Cd intakes from all traditional food items consumed on that day. For the daily Cd intake of one person who consumed food with Cd concentration below the instrumental detection limit, 0.01 μg/day/person was used for the calculation of geometric mean.

The overall arithmetic mean of estimated daily Cd intakes from traditional food was 37.0 µg/day/person with a standard deviation of 218.3 µg/day/person and a median of 9 µg/day/person. The range of daily Cd intakes from traditional food was from 0.01 to 1713 µg/day/person. The highest daily Cd intake from traditional food was reported from a sixty-year-old woman who consumed baked moose liver.

Figure 2A shows how the traditional food consumers are distributed over the various ranges of Cd intake. The range of Cd intakes, 0.01 to 6 µg /day/person accounted for 28% of the consumers, while 46% had Cd intakes of 6 to 12 µg/day/person. Of the remaining 26%, only 1% accounted for the Cd intake over 1500 µg/day/person and rest of the remainder had Cd intakes of 12 to 15 ug/day/person. The overall geometric mean of daily Cd intakes from traditional food was 7.2 µg/day/person with a 95% confidence interval of 5.8 - 8.6 µg/day/person. Figure 2B shows the distribution of Cd intakes from traditional food for all participants.

Table 12 presents means and medians of daily Cd intake from traditional food. The means are expressed both in arithmetic and geometric means as µg/day/person. There were no statistically significant effects of gender, age, and season on daily Cd intake from traditional food.

In order to identify which traditional food contributed most to the total Cd intake on a population basis during the study period, the proportion of Cd intake from each food was calculated. The result is shown as percentage (%) of contribution to the total Cd intake in Table 13A and 13B by gender. The contribution (%) of each traditional food to the total intake of traditional food is also presented in Table 13A and 13B. Individual Cd intakes for each type of food were added up and a proportion of the added value to the total sum of Cd intakes from traditional food for each gender was taken as the contribution (%) of each type of food to the total intake of Cd from traditional food. The same procedure was used to calculate the contribution of each traditional food to the total intake of traditional food. The amount of each traditional food consumed was added up, and the proportion of this value to the total weight of traditional food consumed was calculated in each gender.

Figure 2A.

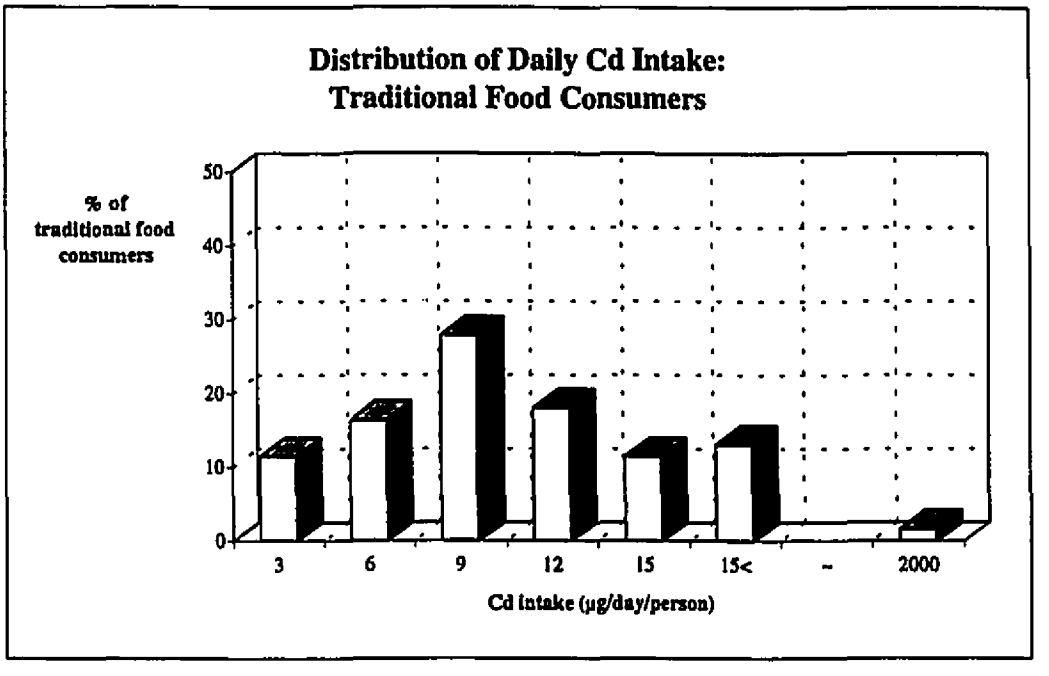

Distribution of Daily Cd Intake:
Traditional Food Consumers
% of traditional food consumers
50
40
30
20
10
0
3
6
9
12
15
15<
-
2000
Cd intake (μg/day/person)

Figure 2B.

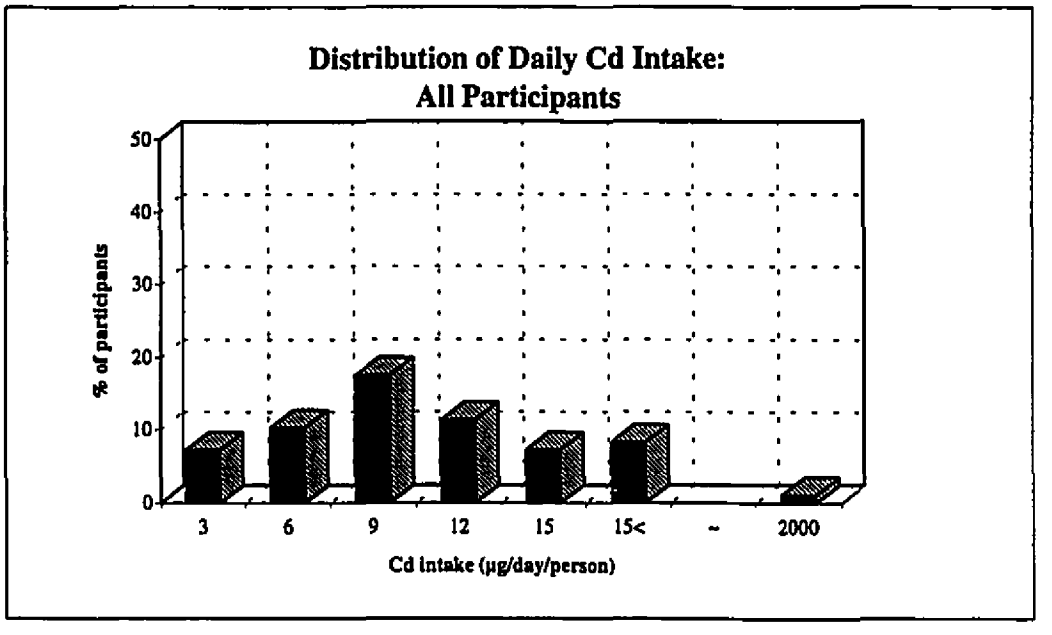

Distribution of Daily Cd Intake:
All Participants
% of participants
50
40
30
20
10
0
3
6
9
12
15
15<
~
2000
Cd intake (μg/day/person)

Table 12.

Mean and Median of Daily Cd Intake (μg/day/person) from Traditional Food

Season	Gender	Age	N	Arithmetic[a]	Geometric[b]	Median
Late winter	Female	20-39	5	9.3 ± 5.0	8.3 (5.3-13.2)	9.0
		40-60	7	6.3 ± 4.2	4.7(2.4-9.2)	4.6
		>60	6	292.0 ± 696.3	18.4 (3.1-110.5)	8.2
	Male	20-39	5	13.0 ± 8.7	10.9 (6.2-19.4)	12.7
		40-60	6	8.7 ±6.4	5.8 (2.2-15.7)	7.3
		>60	8	9.1 ± 5.0	8.0 (5.5-11.7)	7.5
Fall	Female	20-39	3	6.8 ± 2.3	6.5 (4.4-9.6)	6.8
		40-60	3	5.1 ± 4.9	2.9 (0.5-16.4)	4.5
		>60	4	15.3 ± 4.4	14.7 (10.6-20.5)	16.5
	Male	20-39	6	9.0 ± 4.2	7.5 (4.0-14.1)	10.5
		40-60	3	9.8 ± 6.5	7.4 (2.3-23.9)	13.5
		>60	5	9.0 ± 6.2	2.7(0.2-41.4)	9.0

[a] Arithmetic mean ± SD

[b] Geometric mean (95 % confidence interval)

Table 13A.

Proportionate Distribution of Cd Intake from Traditional Food By Women[a]

Food		Contribution (%) to total intake	
	Part (Prep.)	Traditional food[b]	Cd
Caribou	Flesh (baked)	31.6	3.9
Whitefish	Flesh (baked)	22.4	1.9
Moose	Flesh (baked)	21.4	3.0
Muskrat	Flesh (cooked)	10.3	1.7
Bison	Flesh (cooked)	3.5	0.1
Rabbit	Flesh (boiled)	2.8	0.2
Moose	Liver (baked)	2.1	88.4
Moose	Flesh (dried and smoked)	1.6	0.2
Caribou	Flesh (dried)	0.7	0.0
Total		96.4[c]	99.4

[a] Data from a total of 28 dietary recalls containing traditional food are pooled together and the relative contribution of each food item is expressed as the percentage of the total intake. Women are age of over 20 years.

[b] Traditional food is by weight.

[c] Totals do not add up to 100% because food items which were not included in the Cd analysis are not shown in this table.

Table 13B.

Proportionate Distribution of Cd Intake from Traditional Food By Men[a]

Food		Contribution (%) to total intake	
	Part (Prep.)	Traditional food[b]	Cd
Caribou	Flesh (baked)	38.8	41.4
Moose	Flesh (baked)	22.9	31.8
Whitefish	Flesh (baked)	12.4	8.7
Muskrat	Flesh (cooked)	4.4	6.3
Loche	Flesh (baked)	4.0	0.0
Rabbit	Flesh (boiled)	3.0	2.1
Moose	Flesh (dried and smoked)	2.4	3.6
Caribou	Bone marrow (cooked)	2.2	1.6
Bison	Flesh (cooked)	2.0	0.7
Moose	Ribs (cooked)	2.0	2.1
Moose	Nose (cooked)	2.2	0.7
Caribou	Flesh (dried)	0.5	0.2
Total		96.8[c]	99.2

[a] Data from a total of 33 dietary recalls containing traditional food are pooled together and the relative contribution of each food item is expressed as the percentage of the total intake. Men are age of over 20 years.

[b] Traditional food is by weight.

[c] Totals do not add up to 100% because food items which were not included in the Cd analysis are not shown in this table.

As shown in Table 13A, most of the Cd intakes for women, 88.4%, came from the consumption of baked moose liver. The second contributor was baked caribou flesh with 3.9 %, followed by baked moose flesh (3.0 %) and baked whitefish (1.9 %). Regarding the contribution of each food to the total intake of traditional food, the rank of contribution was not the same as in the contribution to the total Cd intake. Baked caribou flesh and baked whitefish flesh accounted for 31.6 % and 22.4 % of the total intake of traditional food, respectively. Consumption of baked moose flesh accounted for 21.4 % of traditional food consumption, and raw muskrat flesh, 10.3 %. Baked moose liver, the major contributor to the total Cd intake, accounted for only 2.1 % of the total intake of traditional food, which reflects that the greater contribution of moose liver to total Cd intake was due to the high Cd concentration in moose liver.

The result for men is shown in Table 13B. Major contributors to the total Cd intake for men were baked caribou flesh (41.4 %), baked moose flesh (31.8 %), and baked whitefish flesh (8.7 %). These three traditional food items also accounted for most of the traditional food consumption in the same order as in the contribution to the total Cd intake from traditional food. That is, baked caribou flesh, whitefish flesh and moose flesh had a contribution of 38.8 %, 22.9 % and 12.4 %, respectively.

Since the contribution of moose liver accounted for most of the total Cd intake in women due to the high Cd concentration in the moose liver, the proportionate contributions of traditional food items were recalculated without the moose liver. Major contributors to the total Cd intake were baked caribou flesh (33.8 %), baked moose flesh (30.5 %), and baked whitefish (15.9 %). The rank order was the same as in men.

The totals summed from the contributions to the traditional food intakes in Table 13A and 13B did not add up to 100 % because the samples in which Cd concentrations were not analyzed were not included. The totals from the contributions of each food to the total Cd intakes did not add up to 100% due to the rounding errors.

Table 14 shows estimated average weekly Cd intakes from traditional food for women and men. The estimated averages weekly Cd intakes were 0.7 μg/kg BW/week for women, and 0.4 μg/kg BW/week for men. The average weekly Cd intakes were calculated as:

Table 14.

Comparison of Average Weekly Cd Intakes from Traditional Food with the Provisional Tolerable Weekly Intake (PTWI)(µg/kg body weight/week)

Group	N	Calculated Cd intake [a]
Women >20 years	43	0.7
Men > 20 years	54	0.4
PTWI[b]		7.0

[a] Geometric mean of daily intake x 7 x probability of consuming traditional food on any given day÷body weight (50 kg for women, 65 kg for men).
The probability of consuming traditional food was calculated as the proportion of dietary recalls which mentioned traditional food to all dietary recalls in each gender group (28/43, and 33/54 for women, and men, respectively).
[b] From WHO, 1989

$$\frac{\text{(the geometric mean of daily Cd intakes)} \times 7 \times \text{(the probability of consuming traditional food on any given day)}}{\text{body weight.}}$$

The probability of consuming traditional food on any given day was calculated as a proportion of dietary recalls containing traditional food of the total number of dietary recalls in each gender group. The probability for women was 28/43, and 33/54 for men. Body weights were assumed to be 50 kg for women and 65 kg for men.

The calculated values of weekly Cd intakes from traditional food were compared with the Provisional Tolerable Weekly Intake (PTWI) established by WHO in Table 14. The average weekly Cd intakes from traditional food for both men and women were much lower than than PTWI, 7.0 μg/kg BW/week.

3.3.4. Risk of Cd exposure from traditional food

Frequencies of consumption of food items with the highest Cd concentrations are presented in Table 15. The frequency of consumption shown in the table was obtained from traditional food use frequency interviews. Selected food items with the highest Cd concentrations were livers and kidneys from moose and caribou. The average Cd concentration in moose kidneys was about seven times higher than that in caribou kidneys (703 μg/100 g wet weight, and 161 μg/100 g wet weight, respectively). Moose livers had an average Cd concentration approximately fifteen times higher than caribou kidneys (1869, and 126 μg/ 100 g wet weight, respectively).

Frequencies of consumption of liver were higher than those of kidney for both moose and caribou. By season, these animal organs were consumed more frequently in the summer than in the winter during the study period. Organs of barrenland caribou were consumed more frequently than those from woodland caribou in both seasons.

In Table 16, estimated Cd doses from particular food items are presented. Values were calculated by multiplying daily servings of each food by Cd concentrations. Cd doses shown in the table estimate how much Cd can be consumed on the average by daily

Table 15.

Frequency of Consumption of Traditional Food with Highest Cd Concentrations

Food and Frequency	Season				Cd concentrations[c] (µg/100g wet wt.)
	Winter (n[a]=51)		Summer (n[a]=46)		
	N[b]	%[e]	N[b]	%[e]	
Woodland Caribou liver					161[d]
None	51	100	45	97.8	
< 1/ week	0	0	1	2.2	
Barrenland Caribou liver					
None	42	82.4	36	78.3	
< 1/ week	9	17.6	10	21.7	
Woodland Caribou kidney					126[d]
None	51	100	45	97.8	
< 1/ week	0	0	1	2.2	
Barrenland Caribou kidney					
None	44	86.3	35	76.1	
< 1/ week	7	13.7	11	23.9	
Moose liver					703
None	41	80.4	40	87.0	
< 1/ week	10	19.6	6	13.0	
Moose kidney					1869
None	49	96.1	40	87.0	
< 1/ week	2	3.9	6	13.0	

[a] Number of traditional food use frequency in each season.

[b] Number of response either to None or to <1/ week.

[c] Cd levels measured in raw samples.

[d] Average of Cd concentration measured in both species.

[e] Percentage of participants.

Table 16.

Estimated Cd Doses from Traditional Food (µg/day)[a]

Food	Part	Preparation	N	Cd Dose*
Moose	Liver	Baked	1	1713.3 ± 0.0
Muskrat	Flesh	Cooked	3	17.7 ± 1.6
Moose	Flesh	Baked	18	10.1 ± 1.2
Caribou	Flesh	Baked	28	7.4 ± 0.5
Whitefish	Flesh	Baked	11	5.8 ± 0.8
Rabbit	Flesh	Boiled	2	5.6 ± 1.1
Caribou	Bone marrow	Cooked	1	5.0 ± 0.0
Bison	Flesh		2	2.5 ± 0.3
Moose	Flesh	Dried and smoked	9	1.8 ± 0.3
Caribou	Flesh	Dried	2	0.6 ± 0.0
Loche	Flesh	Baked	1	0.0 ± 0.0
Total traditional food			78	28.9 ± 21.9

[a] Ranked by Cd doses

* Values calculated as daily serving size of each food multiplied by Cd concentration of that food.
Cd dose ± SEM

servings of each traditional food. The largest amount of Cd, 1713 μg, can be consumed from moose liver. The Cd intake level from a daily serving of moose liver is three times higher than the limit of PTWI, 500 μg/person/week, without body weight consideration (WHO 1972). The average Cd dose for total traditional food consumed was 28.9 μg with a standard error of 21.9 μg.

Since Cd is mainly accumulated in the kidneys and the liver of animals and higher doses of Cd can be consumed by these organs, mean frequencies of consumption of animal organs were calculated from the traditional food use frequency interviews. The result is shown in Table 17 together with the percentage of people who responded to consume the animal organs. In general, animal organs were not consumed very frequently with mean frequencies of less than 0.1 day/week. Mean frequencies of consumption of animal organs by season and gender are presented in Appendix 4.

Weekly Cd intakes from animal organs can be estimated from the results of Cd doses and mean frequencies of consumption of animal organs. The weekly Cd intake from moose liver was estimated to be 56.5 μg/week. The estimate was calculated as: Cd dose from moose liver (1713.3 μg/day) × mean frequency of consumption of moose liver (0.033 days/week).

3.3.5. Smoking

Since cigarette smoking is another important source of daily Cd intake in addition to food, smoking habits of residents in the community were also surveyed. A total of 88 participants filled the smoking questionnaires completely.

82% of the participants were smokers. Of these smokers, 58.3% were women and the rest of the smokers, 41.7%, were men. Smokers smoked on the average of 14 ± 6 cigarettes/day/person. On the average, smokers had been smoking for 19 ± 13 years. In order to estimate the amount of Cd intake from smoking, 1.5 μg of Cd was assumed to be inhaled from one cigarette. The average Cd inhaled from cigarette smoking was 21.1 ± 9.1 μg/day/person for the smokers. The 95th percentile of Cd intakes from smoking was

Table 17.

Mean Frequency of Consumption of Animal Organs (Days/ week) *

Food		N[c]	%[d]	Mean Frequency[b] (N[a] = 97)
Woodland caribou	Liver	1	1.0	0.002 ± 0.020
	Kidney	1	1.0	0.002 ± 0.020
Barrenland caribou	Liver	19	19.6	0.039 ± 0.080
	Kidney	18	18.6	0.037 ± 0.078
Moose	Liver	16	16.5	0.033 ± 0.075
	Kidney	18	18.6	0.016 ± 0.055
Rabbit	Liver	21	21.5	0.043 ± 0.083
Muskrat	Liver	2	2.1	0.004 ± 0.029
Ptarmigan	Liver	10	10.3	0.021 ± 0.061
	Kidney	14	14.4	0.029 ± 0.071
Pintail	Liver	1	1.0	0.002 ± 0.020
	Kidney	1	1.0	0.002 ± 0.020
Mallard	Liver	4	4.1	0.008 ± 0.040
	Kidney	2	2.1	0.004 ± 0.029
Canada goose	Liver	6	6.2	0.012 ± 0.048
	Kidney	7	7.2	0.014 ± 0.052
Prairie chicken	Liver	2	2.1	0.004 ± 0.029
	Kidney	3	3.1	0.029 ± 0.071
Spruce hen	Liver	1	1.0	0.002 ± 0.020
	Kidney	0	0.0	0.006 ± 0.035

* For the whole population

[a] Number of participants in the food frequency questionaires

[b] Mean ± S.D.

[c] Number of respondents who consumed the food

[d] Percentage of respondents who consumed the food

37.5 μg/day/person. There was no sifnificant difference in smoking habit between men and women.

3.3.6. Total Cd intake from smoking and traditional food

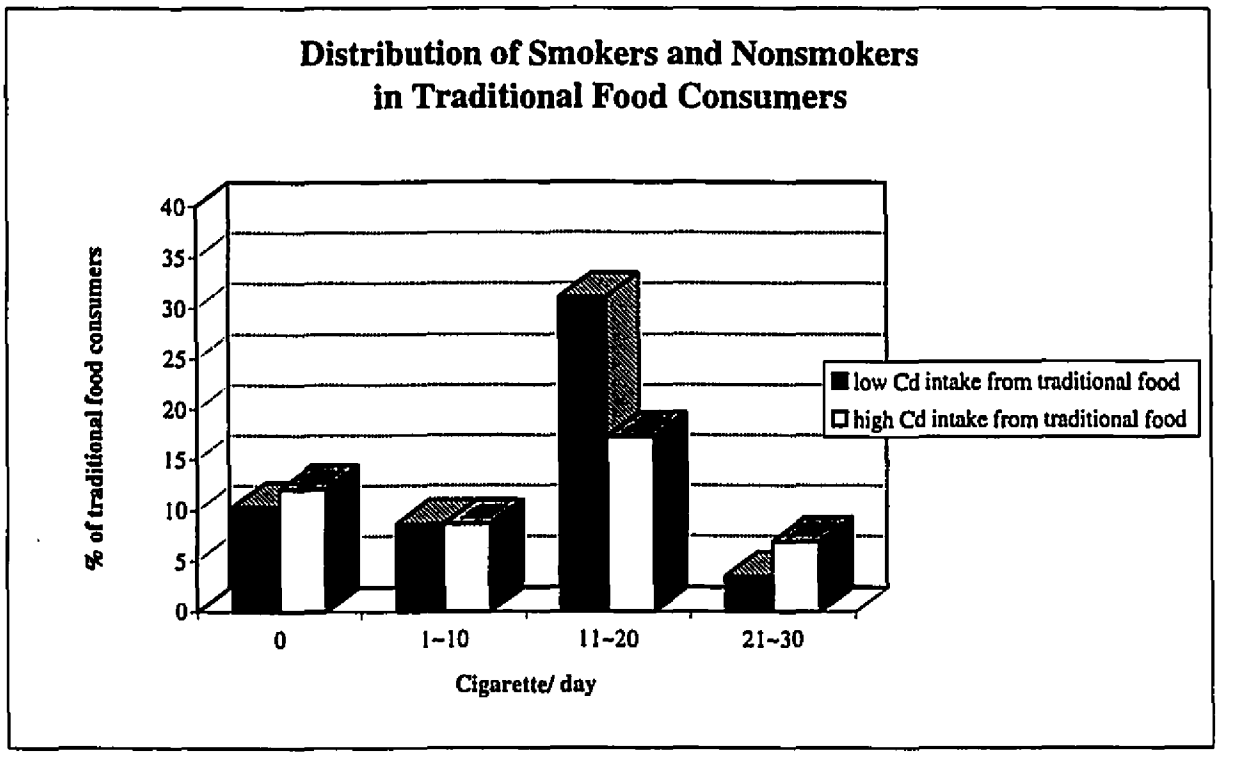
Total Cd intakes from both traditional food and smoking were estimated. The number of participants who reported to consume any traditional food in dietary recalls and completed smoking questionnaires at the same time was 58. Of these 58 people, 27 were women and 31 were men. Table 18 shows the distribution by gender and age.

Results showed that 78% of traditional food consumers were smokers. 42% of them were women. The 95th percentile of total Cd intake from both traditional food and smoking was 57.1 μg/day/person. Total daily Cd intakes for smokers from traditional food and smoking ranged from 16.6 μg/day/person to 83.3 μg/day/person with a median of 25.5 μg/day/person. For non-smokers, their total Cd intakes ranged from 4.6 μg/day/person to 1713.3 μg/day/person with a median of 10 μg/day/person.

Figure 3 displays how many cigarettes were smoked daily by traditional food consumers who were exposed to low and high levels of Cd from traditional food. Traditional food consumers were grouped into either a low Cd intake group or a high Cd intake group, depending on whether their Cd intakes from traditional food were greater or less than 9 μg/day/person, the median Cd intake from traditional food. More than half of the traditional food consumers were in the range of smoking 11 - 30 cigarettes/day, and nonsmokers accounted for 22% of the traditional food consumers. Heavy smokers (21-30 cigarettes/day) accounted for only 10% of the traditional food consumers.

In Table 19, arithmetic and geometric means of total daily Cd intakes from traditional food and smoking for smokers and non-smokers are presented. The geometric mean of the total daily Cd intakes for smokers was 30.5 μg/day/person with a 95 % confidence interval of 27.2 - 34.1 μg/day/person. The geometric mean for non-smokers was 13.9 μg/day/person with a 95 % confidence interval of 6.1- 35.5 μg/day/person. Smoking had

Figure 3.



Low Cd intake from traditional food indicates <9 μg/day/person
High Cd intake from traditional food indicates 9< μg/day/person

Table 18.

Age and Gender Distribution of Smoking Questionnaire Combined with Dietary Recalls Containing Traditional Food

Age\Gender	Women	Men	Total
20-40	7	10	17
40-60	10	8	18
>60	10	13	23
Total	27	31	58

Table 19.

Mean and Median of Total Daily Cd Intakes (μg/day/person) of Smokers and Nonsmokers[a]

	N[b]	Arithmetic[c]	Geometric[d]	Median
Nonsmokers	13	141.1 ± 472.4	13.9 (6.1-35.5)	9.3
Smokers	45	32.9 ± 14.2	30.5 (27.2-34.1)	29.3

[a] Total daily Cd intake was calculated from both consumption of traditional food and smoking.
Total daily Cd intakes of smokers and nonsmokers were significantly different at $p < 0.001$

[b] The final number of participants whose smoking questionnaires and dietary recalls (with traditional foods) are matched.

[c] Arithmetic mean ± S.D.

[d] Geometric mean (95% confidence interval)

a statistically significant effect on the total daily Cd intake ($p < 0.001$). It should be noted from Table 19 that the arithmetic mean of non-smokers resulted in a higher value than that of smokers due to one extreme value of Cd intake from moose liver among non-smokers.

Means and medians of total daily Cd intakes from traditional food and smoking are presented in Table 20. Season, age, and gender did not show any effects on total daily Cd intakes from traditional food and smoking.

Average weekly total Cd intakes from traditional food and smoking were calculated, and compared with the PTWI. The result is presented in Table 21. The average weekly total Cd intakes estimated for women and men were 1.7 and 1.4 μg/kg BW/week, respectively, which were lower than the PTWI, 7.0 μg/kg BW/week. The average weekly total Cd intake was calculated as:

$$\frac{\text{(geometric mean of total daily Cd intake from traditional food and smoking)} \times 7 \times \text{(probability of consuming traditional food on any given day)} \times \text{probability of smoking}}{\text{body weight}}$$

The probability of smoking was obtained from the proportion of smokers to all participants in the smoking habit interview (81/97). Assumptions for body weights and the probability of consuming traditional food are the same as in a similar calculation of Cd intake from only traditional food in the previous section.

3.3.7. Estimation of weekly Cd intake from smoking and market and traditional food

Weekly Cd intakes from smoking, and market and traditional food were estimated. The result is presented in Table 22. The estimate of total weekly Cd intake was 246.4 μg/week which was within the limit of PTWI, 500 μg/week (WHO 1972). The major Cd source for the total weekly Cd intake was cigarettee smoking (123.3 μg/week). Weekly

Table 20.

Mean and Median of Total Daily Cd Intake (μg/day/person) from Smoking and Traditional Food

Season	Gender	Age	N	Arithmetic[a]	Geometric[b]	Median
Late winter	Women	20-39	4	26.7 ± 11.7	25.2 (17.4-36.5)	21.6
		40-60	7	29.6 ± 17.3	23.8 (13.0-43.7)	25.5
		>60	6	298.3 ± 693.3	30.1 (5.9-154.5)	16.5
	Men	20-39	4	33.3 ± 17.1	30.4 (19.0-48.8)	28.0
		40-60	6	41.2 ± 15.4	38.6 (29.0-53.3)	14.1
		>60	8	31.0 ± 23.7	24.5 (14.5-41.2)	26.1
Fall	Women	20-39	3	17.3 ± 9.2	15.0 (6.8-33.1)	21.0
		40-60	3	27.6 ± 4.8	27.3 (22.4-33.2)	27.0
		>60	4	20.9 ± 12.0	18.4 (10.3-32.9)	18.8
	Men	20-39	6	23.0 ± 9.4	21.3 (15.0-30.2)	22.3
		40-60	2	41.2 ± 13.8	40.1 (25.0-64.2)	41.2
		>60	5	28.8 ± 0.3	23.7 (11.9-47.0)	31.5

[a] Arithmetic mean ± S.D.

[b] Geometric mean (95% confidence interval)

Table 21.

Comparison of Average Weekly Cd intake from Smoking and Traditional Food with the Provisional Tolerable Weekly Intake (PTWI) (µg/kg body weight/week)

Group	N	Calculated Cd Intake [a]
Women >20 years	43	1.8
Men >20 years	54	1.5
PTWI [b]		7.0

[a] Geometric mean of total daily Cd intake from smoking and traditional food x 7 x probability of consuming traditional food on any given day x probability of smoking/ body weight (50 kg for women, 65 kg for men).
The probability of consuming traditional food was calculated as the proportion of dietary recalls which mentioned traditional food to all dietary recalls in each gender group (28/43, and 33/54 for women, and men, respectively).
The probability of smoking was calculated as the proportion of smokers to all participants in the Smoking Questionnaire (81/97).
[b] From WHO, 1989

Table 22.

Estimated Weekly Total Cd Intake from Traditional and Market Food and Smoking

Source of Cd intake	Estimated Cd intake (µg/week)
Traditional food	31.7[a]
Market food	91.4[b]
Smoking	123.3[c]
Total	246.4
PTWI[d]	500

[a] Overall geometric mean of daily Cd intake from traditional food (7.2) x 7 x probability of consuming traditional food on a given day (61/97). The probability of consuming traditional food was calculated as the proportion of dietary recalls which mentioned traditional food to the total number of dietary recalls collected.

[b] Recalculated from the average daily intake of Canadians, 14.5 µg/day, (Dabeka and McKenzie,1992). Market food accounted for 90 % of the diet in Fort Resolution. The value was calculated as 14.5 µg/ day x 7 x 0.9.

[c] Arithmetic mean of Cd inhaled from cigarette smoking daily (21.1) x 7 x probability of smoking cigarettes (81/97).

[d] Provisional Tolerable Weekly Intake from WHO (1972).

Cd intakes from traditional food and market food were estimated as 31.7 µg/week and 91.4 µg/week, respectively.

The estimate for market food was recalulated from the average Cd intake of Canadians (14.5 µg/day, Dabeka and McKenzie, 1992), based on the assumptions that: 1) the dietary pattern of market food in Fort Resolution would be the same as that of average Canadians; 2) Cd levels in the market food available in Fort Resolution are the same as those in average Canadian market food. The average Cd intake of Canadians was multiplied by 7 for the estimation of weekly intake, and 90 % of this estimate was taken as the Cd intake from market food. It was shown from our analysis that market food accounted for 90% of the diet in the community in terms of energy intake.

3.4. Discussion and conclusion

Traditional food used in the community of Fort Resolution consisted of about 30 species of land animals and freshwater fish, and some wildberries and plants. Types of traditional food used in the community appeared to be affected by the surrounding natural environment. The types of traditional food used were comparable to those reported from other areas such as the Pacific coasts, Baffin Island, and the remoted areas in the Yukon (Kuhnlein 1984; Kuhnlein 1992; Chan et al. 1995; Wein 1995).

About 63% of the population consumed traditional food on a daily basis, but traditional food accounted for only 10 % of the diet in the community in terms of energy intake. The average weight of traditional food consumed per person per day was less than those reported from other native communities where similar studies were conducted (Kuhnlein 1989; Kuhnlein 1991). Most of the traditional food consumers recorded to consume only one kind of traditional food item in their dietary recalls. There is a possibility that the use of traditional food was influenced by the availability of natural food resources, particularly during the study period. Neverthless, it is more likely that the dietary pattern in the community has been affected by urbanization and westernization.

Traditional food was consumed more in fall than in late winter when average daily servings of traditional food were compared. Contrary to a study result reported by Wong

(1985), results of the present study showed that animal organs appeared to be consumed more frequently by men than by women.

Cd concentrations measured in traditional food from Fort Resolution were similar to those of other studies. Cd concentrations in flesh of all fish species in the present study agreed with Cd values reported from Great Slave Lake and from various lakes in the Canadian arctic (Wong 1985; Lockhart et al. 1993). Cd levels in livers and kidneys of moose and caribou in this study were also within the range of Cd levels measured in livers and kidneys of moose and caribou from Ontario, Northwest territories, and Yukon (Glooschenko et al. 1988; Gamberg and Scheuhammer 1994). From these results, it can be implied that mine tailings discharged from a point source near the community have not affected the Cd concentrations of wildlife in Fort Resolution. Considering that Cd concentrations in leafy vegetables are indicators of Cd contamination of soils (WHO 1992), it can be implied from the low Cd concentrations measured in vegetables and berries that the soil in Fort Resolution is not contaminated by Cd.

There were large intragroup variations of mean Cd concentrations of some food samples such as animal organs and fish as shown in Table 10. The reason for the variations may be explained by the fact that Cd levels can be influenced by age and size of the species, and also by sampling times and location (Lockhart et al. 1993; Gamberg and Scheuhammer 1994). These factors were not considered in this study.

Cd concentrations measured in livers and kidneys of moose and caribou in the present study were higher than those of some animals reported from the studies monitoring heavy metals in organs of Canadian slaughtered animals (Salisbury et al. 1991; Korsrud et al. 1985). All of the livers and kidneys of land animals in our study exceeded the action level of Cd, 1 μg/g wet tissue, established by Agri-Food Safety Division of Agriculture Canada. If excessive amounts of Cd are found in food, further investigation is conducted and the food may be removed from stores. Whether the action level can be applied to traditional food is not fully justified because the action level was established conservatively based on consumption patterns of average Canadians (Wong 1985). Unlike the case of mercury where Federal Guidelines in fish is established, a similar guideline for Cd in fish does not exist (Lockhart et al. 1993).

Comparisons of Cd levels between traditional food and Canadian market food need caution because the food categories in traditional and Canadian market food are composed of different food items. For example, the meat group of traditional food include mainly wildlife whereas that of Canadian market food include slaughtered animals and coldcuts. Average Cd concentrations of the Canadian market food groups were similar to those of corresponding food groups in traditional food.

Similar consideration can be applied to a comparison of Cd levels between traditional food groups from different geographical areas. Ranges of Cd levels for organ and fish groups from this study are comparable with those from Baffin Inuit Food, but Cd levels of meat and vegetable groups tend to be lower in this study (Chan et al. 1995). Baffin Inuit Food mainly consists of marine mammals, caribou, fish, and greens from the sea.

Average Cd intakes from traditional food were estimated to be only 10% and 6% of the PTWI (7 µg/kg BW/person) for women and men, respectively, on a population basis. The exposure level of Cd, however, can be elevated depending on eating habits as shown in a similar study for mercury exposure from traditional food in Sugluk (Wheatley and Wheatley 1981). For example, the daily Cd dose of moose liver was estimated as 1713 µg/day/person from our study, which implied a possibility of exceeding the PTWI, 500 µg/person/week (WHO 1972) by consumption of a daily serving of animal organ. Levels of Cd exposure for those who eat animal organs more often will be higher than the levels estimated on a population basis. However, the result of food use frequency interviews indicated that animal organs were not commonly consumed in the community during the study period (less than 0.1 day/week). The weekly Cd intake from moose liver was estimated to be only 53 µg/week from the mean frequency of consumption and daily Cd dose.

The Cd exposure level estimated from traditional food in Fort Resolution is higher than that of average Canadians whose diets are mainly from market food. An average daily Cd intake for the general population of Canada was estimated as 0.2 µg/kg BW/person which coresponded to 3% of PTWI (Dabeka and McKenzie 1992). The results of the diet survey in the present study showed that market food accounted for 90 % of the diet in the community. Provided that the eating pattern and the Cd

concentrations of the market food consumed in Fort Resolution are similar to those of average Canadians, the total daily Cd intake via food in the community can be estimated as 13% and 8% of the PTWI for women and men, respectively.

Smoking is a health problem in Fort Resolution. 82% of adults were smokers and the average Cd intake from smoking was estimated to be higher than Cd intake from food. Levels of exposure to total Cd through smoking and consumption of traditional food reached 24 % and 20 % of PTWI (7 μg/kg BW/person) for women and men, respectively. Cd can be absorbed more efficiently by inhalation than through the GI tract (Nordberg et al. 1985). Levels of Cd exposure from both traditional food and smoking were significantly different between smokers and nonsmokers.

In conclusion, the level of total Cd exposure from traditional and market food, and smoking in Fort Resolution was estimated to be within the PTWI. Therefore, the potential health risk associated with Cd exposure via food and cigarette smoking is minimal in Fort Resolution.

CHAPTER 4: CADMIUM SPECIATION

4.1. Introduction

The dietary form of Cd is one of the major factors which affect the absorption and tissue distribution of ingested Cd (Maitani et al. 1984; Ohta et al. 1985; Bergland et al. 1995). Even though the exact mechanisms of Cd absorption in GI tract is not clearly known, several studies have suggested that Cd is absorbed through different mechanisms depending on the chemical form of Cd ingested (Sugawara and sugawara; Ohta et al. 1989; Ohta and Cherian 1995). For the tissue distribution of Cd, after the ingestion of $CdCl_2$, Cd is more likely to accumulate in the liver, and ingestion of Cd-MT results in an increased Cd accumulation in the kidneys (Cherian 1983; Maitani et al. 1984). The organ deposition ratio (kidney/liver) of Cd is also known to be different depending on the Cd species (Cherian 1979; Maitani et al. 1984; Groten et al. 1991a).

In long term exposure, the kidneys become the target organs of Cd toxicity (Friberg et al. 1974; Webb 1979). It has been shown that Cd-MT is more nephrotoxic than $CdCl_2$ (Nordberg et al. 1975; Groten et al. 1990), and that ingested Cd-MT reaches the kidneys in the form of Cd-MT (Cherian et al. 1976; Min et al. 1991).

The major source of Cd to human is food (Friberg et al. 1974). The importance of Cd speciation in food and in the food chain has been already recognized (Cherian et al. 1978; Cherian et al. 1979; Maitani et al. 1984; Quintus 1995). Cd is mainly present as bound to MT, a heat stable protein, in animal tissues, and metallothionein-like proteins in plants (Wagner and Trotter 1982; Stone and Overnell 1985; Webb 1986).

Speciation of Cd in food can be meaningful in investigating ways of decreasing Cd toxicities from consumption of specific food types. This study was undertaken to investigate the effect of food perparation on Cd speciation in food. We hypothesize that food preparation has an effect on Cd species in food.

4.2. Materials and methods

4.2.1. Food preparation

Each of ten Caribou kidneys were divided into two portions. One-half portion of each kidney was placed in acid washed crucibles and baked at 350°C for 30 minutes. About 2g of cooked and raw portions were measured in duplicate and dried in a vacuum oven for 24 hours to constant weights. Dry matter (%) of cooked and uncooked samples were calculated.

4.2.2. MT analysis

Chemicals

Analytical-grade glycine and sucrose were obtained from Fisher Scienfic Company (Toronto, Ont). Silver standard solution (1000 ppm) for atomic absorption spectrometry (Fisher, Toronto, Ont) was diluted in deionized water for 20 ppm silver solution.

MT analysis

Ag-hem method (Scheuhammer and Cherian 1986) was used for the analysis of MT. Approximately 0.5 g of raw and cooked caribou kidneys were homogenized with a polytron homogenizer (Brinkman instrument, Rexdale, Ont) in 2 ml of 0.25 M sucrose buffer. The homogenates were centrifuged at 13,000 rpm for 20 minutes at 4°C (Dupont, Sorval RC5C, Newtown, CONN), and the supernatant fractions were spun again in an Eppendorf centrifuge (Dupont, Sorval MC12C, Newtown, CONN) for 3 minutes. An aliquot of 0.2 ml of supernatant, 1.0 ml of 0.5 M glycine buffer (pH 8.5), 1.0 ml of silver solution (20 ppm), and 0.2 ml of hemolysate were mixed in a vortex and heated for at least 2 minutes in a water bath at 100 °C. Heated samples were cooled and then centrifuged at 3,000 rpm for 5 minutes to remove precipitated proteins. Addition of 2 ml of hemolysate and the same procedure of mixing, heating, and centrifuging were repeated twice. The

clear supernatant fractions were centrifuged in Eppendorf centrifuge for 2 minutes. Silver concentrations in the supernatants were measured with a Hitach Z-8200 AAS with Zeeman background correction in the graphite furnace mode. Amounts of MT in samples were calculated with the following equation:

MT (μg /g tissue) = Ag measured (ppm) × 3.54 × total volume per tube × sample dilution ÷ sample volume

where

3.54 μg MT= 1 ppm Ag, when MT was fully saturated with Ag

total volume per tube = 2.8 ml (1ml glycine buffer, 0.2 ml sample, 1ml Ag solution, 0.6 ml hemolysate)

sample dilution = (2ml sucrose buffer + sample weight (g)) ÷ sample weight (g)

sample volume = 0.2 ml.

4.2.3. Cd speciation

Sample preparation and Cd analysis

Approximately 1 g of each raw and baked kidneys were homogenized in 2 ml of 30 mM Tris-HCl (pH 8.6) (Fisher, Toronto, Ont) with a polytron homogenizer. Homogenized samples were centrifuged at 13,000 rpm at 4°C for 20 minutes. The supernatant fractions were spun in Eppendorf centrifuge for 3 minutes and kept frozen until analysis for total Cd and Cd speciation. Total Cd in the supernatants were measured with flame AAS. The procedures and quality assurance for the Cd analysis were the same as described in Chapter 3.

Fast Protein Liqiud Chromatography (FPLC)

The Superose 12HR 10/30 column (Pharmacia, Baie d' Urfé, Quebec) was calibrated with proteins of known relative molecular mass by using molecular markers. The column

was connected to an all stainless-steel HPLC system (Beckman, System Gold 126, Fullerton, CA).

Prepared frozen supernatants of kidney cytosol were thawed and filtered (0.45 μm) before injection to the FPLC system. Filtered supernatants (0.2 μl) were eluted from the pre-equilibrated Superose column with 10 mM Tris-HCl (pH 7.0) at a flow rate of 1 ml/min. The UV signals were monitored at 254 nm and 280 nm simultaneously with a diode-array detector (Beckman, System Gold 168 detector, Fullerton, CA). Eluted fractions were collected every minute with a fraction collector (Mandel Ltd., Gilson FC203B, Middletown, WI). Cd concentrations in the collected fractions were measured by graphite AAS.

Before every injection, the column was washed with two bed-volume (50 ml) of Tris buffer. Cd was measured in the collected fractions to make it sure that there was no Cd carried over between samples.

4.2.4. Statistical analysis

Paired *t*-test was used for comparions of total Cd concentrations, MT concentrations, and levels of Cd species (as % of total Cd) between raw and cooked samples. The comparisons were performed based on dry weights. $P < 0.05$ was considered to be significant. Microsoft Excel (Version 5, Microsoft, Redmont, WA) was used for the analysis.

4.3. Results

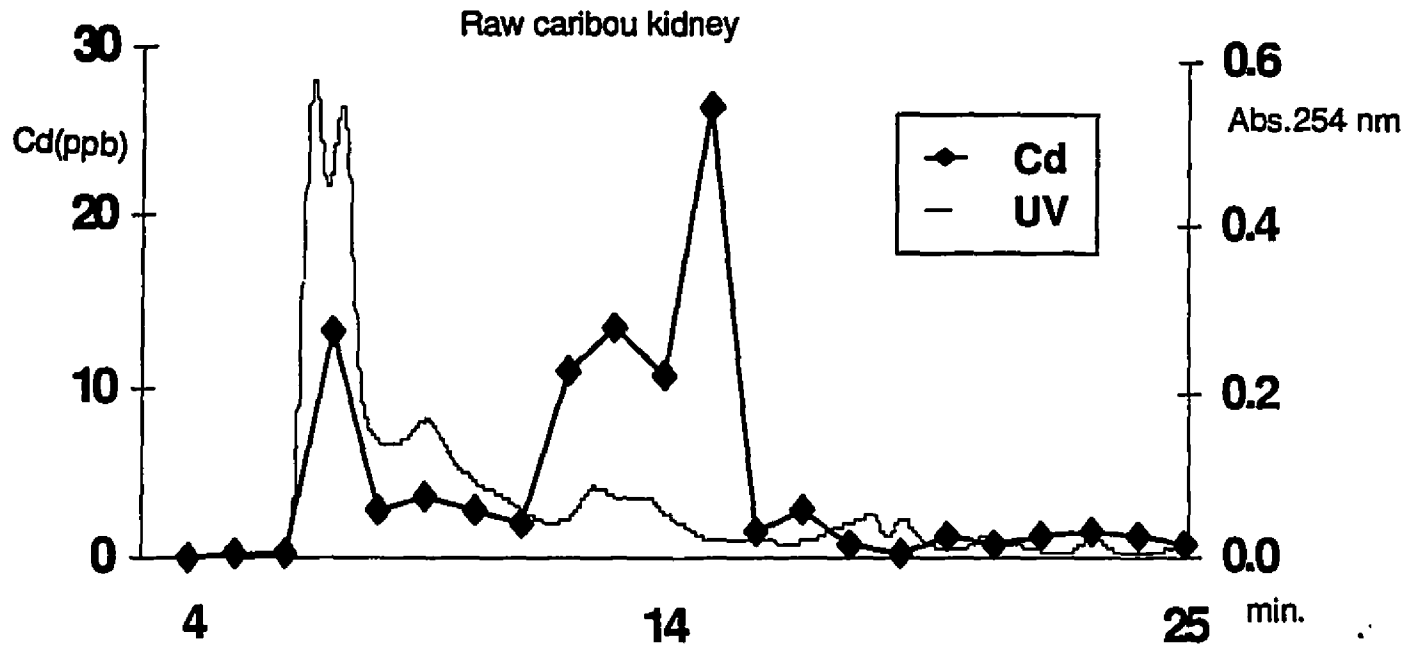
Cd concentrations and MT concentrations were determined in raw and cooked caribou kidneys. The result is shown in Table 23. There was no statistical significance in total Cd concentrations between raw and cooked samples. MT concentrations decreased significantly after cooking.

Elution profiles for the Cd speciation are presented in Figure 4 for raw and cooked samples. The solid line represents absorbance at 254 nm. MT with a molecular weight of

Table 23.

Comparison of Cd and MT in Raw and Cooked Caribou Kidneys

	n	Raw	Cooked	p
Water content (%)	10	78.6 ± 1.5	68.6 ± 4.5	< 0.001
Total Cd (µg/g wet wt.)	10	3.6 ± 2.1	12.3 ± 5.7	< 0.001
Total Cd (µg/g dry wt.)	10	15.6 ± 11.0	15.3 ± 7.8	n.s.
MT (µg/g wet wt.)	10	16.7 ± 16.9	16.4 ± 16.4	n.s.
MT (µg/g dry wt.)	10	56.4 ± 22.0	30.8 ± 31.0	< 0.05



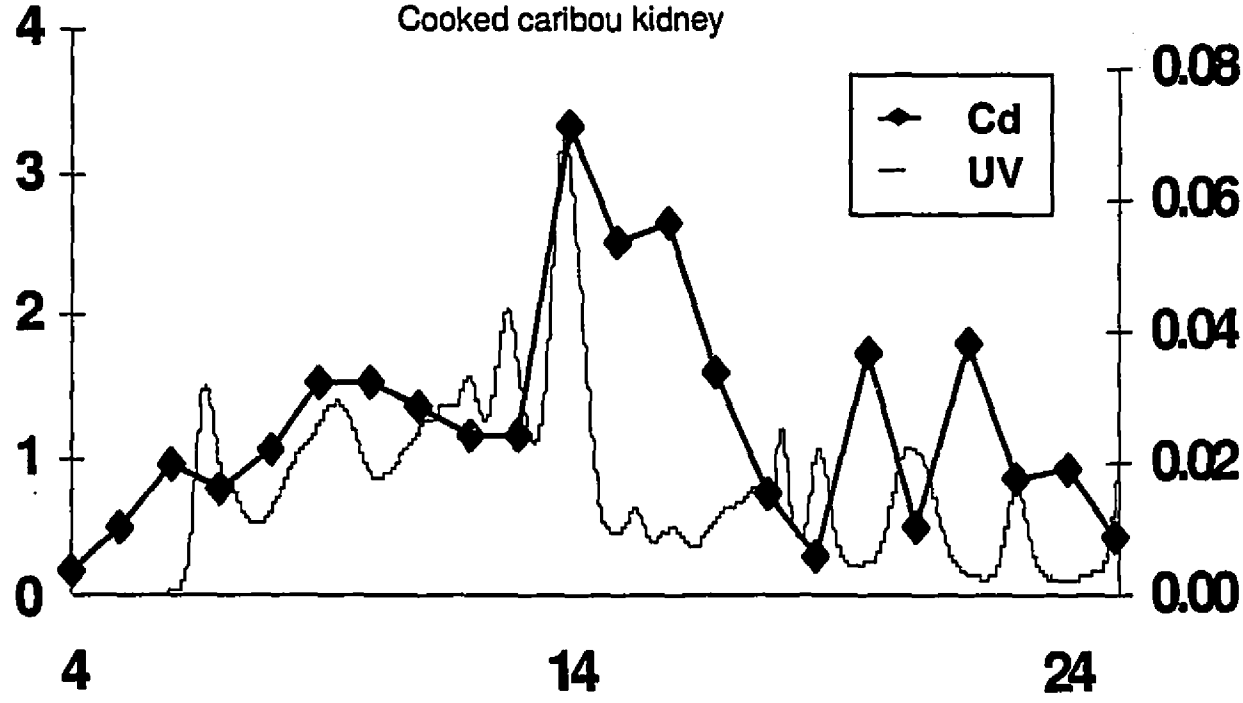


Figure 4. Cadmium distributions and elution profiles in raw and cooked kidney cytosol.

about 6000 was eluted at about 14 minutes. Cd concentrations measured in the fractions collected every minutes are also shown in Figure 4. These figures show how Cd is distributed in raw and cooked kidney cytosol. The majority of Cd in raw kidneys were measured in the fractions which contained high molecular weight proteins (HMWP, M_r = 50,000 - 500,000, fraction 6-13) and MT (M_r = 6000 - 8000, fraction 14-15). After food preparation, Cd concentrations in the fractions of HMWP were decreased as shown in Figure 4. It should be noted that the scale of Cd concentration in the elution profiles of raw and cooked samples are different.

An average of 78.1 % and 67.4% of Cd was recovered in raw and cooked samples, respectively (Table 24). In both raw and cooked samples, MT contained the highest proportion of Cd (about 40%).

Proportions of biologically bound Cd and free Cd to the total Cd in raw and cooked samples were calculated. In Table 24, levels of Cd bound to HMWP and MT, and levels of free Cd are presented as percentage (%) of the total Cd in raw and cooked samples. The level of Cd bound to HMWP was reduced significantly after cooking, but the level of free Cd did not change.

4.4. Discussion and conclusion

Total Cd concentrations in the caribou kidneys were not affected by heat treatment. The increase in the Cd concentration based on wet weight (9%) was probably a result of the loss of water content (10%) during cooking. However, the Cd concentration remained the same when expressed based on dry weight.

MT was shown to be stable after heating at 80°C for 2 to 5 minutes (Cherian, 1974). In this study, however, the MT level was significantly decreased after the samples were baked at 350 °C for 30 minutes. This result suggests that some MT may be oxidized or denatured in the process of cooking. The Ag-hem metal saturation method was used to measure MT concentration; the amount of Ag which replaced other metals (mainly Cd in this case) bound to MT was measured to estimate MT concentration. The decrease in

Table 24.

Comparison of Cd levels (% of total Cd) in Raw and Cooked Caribou Kidneys

	n	Raw	Cooked	p
Cd bound to HMWP	10	26.8 ± 9.3	15.3 ± 9.3	< 0.05
Cd bound to MT	10	39.4 ± 30.1	42.1 ± 23.1	n.s.
Free Cd	10	11.9 ± 10.8	10.0 ± 7.4	n.s.
Total (%)		78.1	67.4	

MT concentration suggests that the molecular structure of MT may have been altered and contained less metal ions.

The result of chromatography showed that the majority of the Cd in raw caribou kidney was bound to either HMWP or MT. However, most of the HMWP was denatured during the cooking process and the bound Cd was released to be free Cd. Even though MT concentration was decreased after cooking, most of the Cd (about 40%) was still bound to MT. Because of the difference in the recovery rates between raw and cooked samples after the elution from the column, the amount of recovered free Cd remained the same.

Results of our analyses of total Cd and MT, and Cd speciation imply that the total dietary Cd from animal kidneys remains the same after cooking, but the total amount of Cd bound to MT may be decreased.

The uptake of Cd is much lower for Cd-MT than for Cd salts (Sugawara et al. 1988; Sugawara and Sugawara 1991; Ohta and Cherian 1995), but biologically bound Cd-MT is known to be more toxic than free Cd , especially for the kidneys (Nordberg et al. 1975; Lagally et al. 1980; Weigel et al. 1987; Groten et al. 1990).

Cd ion and Cd-MT are thought to be absorbed through different absorption mechanisms, even though the exact mechanisms are not understood. Cd ion is believed to be absorbed through the GI tract and transported to the liver (Cherian et al. 1979; Ohta and Cherian 1995). For Cd-MT, it is suggested that the molecule is absorbed partially intact, and immediately transported to the kidneys (Groten et al. 1991; Ohta and Cherian 1991). The ionic Cd degraded from Cd-MT is thought to undergo the same uptake route as inorganic Cd (Groten et al. 1992). However, Crews et al. (1989) have shown that an MT-like protein in pig kidney could survive both cooking and simulated *in vitro* gastrointestinal digestion.

Mineral status also affect Cd uptake and tissue distribution of Cd. In states of essential mineral deficiency such as Zn, Fe, and Ca, Cd uptake is increased, but supplementation of these minerals can decrease Cd uptake in gastrointestinal level and tissue deposition of Cd (Nordberg et al. 1978; Chmielnicka and Cherian 1985; Groten et al. 1991b; Ohta and Cherian 1995). The protective effects of mineral supplementation against Cd uptake are not the same for Cd-MT and Cd salts. The total protection of mineral supplimentation for

Cd-MT has been shown to be lower than for $CdCl_2$ (Groten et al. 1992; Ohta and Cherian 1995). In addition, Groten et al. (1992) have shown that relatively more Cd is deposited in the kidneys with Cd-MT than with Cd salts when minerals are supplemented, suggesting that mineral supplementaion can not affect the absorption of the exogenous intact Cd-MT which would reach kidney unhampered.

In conclusion, the degree of Cd exposure from raw and cooked kidney is the same. The amount of Cd bound to MT may be slightly reduced, but the toxicological significance remains to be confirmed.

CHAPTER 5: GENERAL DISCUSSION AND CONCLUSION

The main purpose of this research was to investigate the degree of Cd exposure through the consumption of traditional food in Fort Resolution. Another purpose was to investigate whether or not cooking could affect Cd speciation in food. We also estimated Cd intakes from smoking and market food. The research was conducted in 1994 with surveys on traditional food consumption and smoking habits, and Cd analysis in traditional food. About 10 % of the population in Fort Resolution participated in the study.

The level of Cd exposure from traditional food was within the limit of PTWI on a population basis. Smoking elevated the Cd exposure level significantly, but the average total Cd intake from both smoking and traditional food consumption was still within the PTWI limit. In order to assess the total Cd exposure level via market and traditional food and smoking, Cd intake from market food was estimated from the average Cd intake of Canadians (Dabeka and Mckenzie 1992). The total exposure level via food and smoking in Fort Resolution was also below the PTWI.

The result on Cd intake from traditional food in the present study may represent the average yearly Cd exposure even though the survey with dietary recalls was conducted only for two seasons, late winter and fall. These two seasons represent the periods for the maximum and minimum traditional food use in a year. Nonetheless, the Cd intakes from traditional food in late winter and fall were not significantly different.

It has to be emphasized that the results of this study can not be applied to other northern communities. Both Cd concentrations in local food sources and dietary patterns may vary among communities.

The risk assessment in this study was conducted based on the estimation of intake level of an "average diet" in the community. Thus, the result is more pertinent to the risk assessment for public health. There may be groups or individuals who are at higher risk to Cd exposure, for example, due to "abnormally" high frequency of consumption of animal

organs. There was one sixty-year-old woman whose daily Cd intake from traditional food exceeded the limit of PTWI by consumption of 170g of baked moose liver.

The exposure level to Cd from consumption of animal organs was in the safe range on a population basis because of the very low mean frequencies of animal organ consumption. However, consumption of animal organs should be minimized if the consumers are heavy smokers or eat other animal organs from market food regularly.

With regards to the effect of food preparation on the level of Cd exposure, there is no evidence that the bioavailability of Cd in food could be altered significantly after cooking. Thus, cooking method may not be an important factor in determining risk of Cd exposure. It is more important to consider nutritional status, specially essential minerals, in the risk assessment of Cd intake and Cd toxicity.

Systematic monitoring and education programs about effects of Cd from consumption of specific traditional food items and from smoking on health should be initiated. In addition, surveys on Cd levels in animal organs such as livers and kidneys from moose and caribou should be continued on a regular basis. There is no need to avoid consuming traditional food considering that Cd exposure from traditional food is low and traditional food system provides nutritional, economical, and cultural benefits.

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Appendix 1: Dietary Recall, Traditional Food Use Frequency, and Smoking Habit Questionnaires.

Variance in Food Use in Dene/Métis Communities

I. FREQUENCY OF TRADITIONAL FOODS USE

Community _____ Household number _____ Respondent's gender ___
(number 1-28) (1=Female, 2=Male)

if gender=1 then ask (and circle) whether:
Pregnant: Yes No Lactating: Yes No

Respondent's ID # _____

Self-identification: Dene____ Métis___ Other___

Age-group: 20-40___ 41-60___ Over 60___

Interviewer's name _____ Date _____
(day/month/year)

Interviewer, please read to respondent:
This questionnaire concerns traditional foods: traditional foods are foods that are coming fi
the local land and environment (animals, fish, birds, wild plants...)
For last _____(season), that is for the months of _____
please, recall as exactly as you can, how many days a week, you personally ate the follow
foods:

McGill, Macdonald Campus
21,111 Lakeshore
Ste-Anne-de-Bellevue, Qc, H9X3V9

ID# _____

Eaten how many days a week[1]
[6-7 (7); 3-5 (5); 1-2 (2); <1 (1); Never (0)]

FISH

1. Whitefish: Yes No

Flesh
- cooked (fresh or frozen) _____
- smoked/dried _____

Organs/parts
- head _____
- eggs _____
- fish-pipe (esophagus) _____
- other part/organ (names)
  - _____ _____
  - _____ _____

2. Inconnu (coney): Yes No

Flesh
- cooked (fresh or frozen) _____
- smoked/dried _____

Organs/parts
- head _____
- eggs _____
- fish-pipe (esophagus) _____
- other part/organ (names)
  - _____ _____
  - _____ _____

3. Cisco (herring): Yes No

Flesh
- cooked (fresh or frozen) _____
- smoked/dried _____

Organs/parts
- head _____
- eggs _____
- fish-pipe (esophagus) _____
- other part/organ (names)
  - _____ _____
  - _____ _____

4. Trout: Yes No

Flesh
- cooked (fresh or frozen) _____
- smoked/dried _____

Organs/parts
- head _____
- eggs _____
- fish-pipe (esophagus) _____
- other part/organ (names)
  - _____ _____
  - _____ _____

5. Loche (burbot): Yes No

Flesh
- cooked (fresh or frozen) _____
- smoked/dried _____

Organs/parts
- head _____
- eggs _____
- fish-pipe (esophagus) _____
- other part/organ (names)
  - _____ _____
  - _____ _____

6. Northern Pike (jackfish): Yes No

Flesh
- cooked (fresh or frozen) _____
- smoked/dried _____

Organs/parts
- head _____
- eggs _____
- fish-pipe (esophagus) _____
- other part/organ (names)
  - _____ _____
  - _____ _____

7. Grayling (bluefish): Yes No

Flesh
- cooked (fresh or frozen) ____
- smoked/dried ____

Organs/parts
- head ____
- eggs ____
- fish-pipe (esophagus) ____
- other part/organ (names)
  - _____ ____
  - _____ ____

8. Walleye (pickerel): Yes No

Flesh
- cooked (fresh or frozen) ____
- smoked/dried ____

Organs/parts
- head ____
- eggs ____
- fish-pipe (esophagus) ____
- other part/organ(names)
  - _____ ____
  - _____ ____

9. Longnose Sucker: Yes No

Flesh
- cooked (fresh or frozen) ____
- smoked/dried ____

Organs/parts
- head ____
- eggs ____
- fish-pipe (esophagus) ____
- other part/organ (names)
  - _____ ____
  - _____ ____

10. Other fish (name/part/preparation)

_____ ____
_____ ____
_____ ____
_____ ____
_____ ____
_____ ____
_____ ____
_____ ____
_____ ____
_____ ____

11. Beluga whale: Yes No

Flesh
- cooked (fresh or frozen) ____
- smoked/dried ____

Other parts/organ (name)
- _____ ____
- _____ ____

12. Arctic Salmon (Arctic char): Yes No

Flesh
- cooked (fresh or frozen) ____
- smoked/dried ____

Organs/parts
- head ____
- eggs ____
- fish-pipe (esophagus) ____
- other part/organ (names)]
  - _____ ____
  - _____ ____

LAND ANIMALS

13. Caribou (woodland): Yes No
- Meat
  - cooked (fresh or frozen) ____
  - smoked/dried ____
- Organ/parts
  - head ____
  - brain ____
  - tongue ____
  - liver ____
  - blood ____
  - stomach ____
  - bone: ____
    - marrow ____
    - bone in soup ____
    - other ____
  - kidney ____
  - other part/organ (names)
    - _____ ____
    - _____ ____

14. Caribou (barrenland): Yes No
- Meat
  - cooked (fresh or frozen) ____
  - smoked/dried ____
- Organ/parts
  - head ____
  - brain ____
  - tongue ____
  - liver ____
  - blood ____
  - stomach ____
  - bone: ____
    - marrow ____
    - bone in soup ____
    - other ____
  - kidney ____
  - other part/organ (names)
    - _____ ____
    - _____ ____

15. Moose: Yes No
- Meat
  - cooked (fresh or frozen) ____
  - smoked/dried ____
- Organ/parts
  - head ____
  - brain ____
  - tongue ____
  - heart ____
  - liver ____
  - kidney ____
  - blood ____
  - bone: ____
    - marrow ____
    - bone in soup ____
    - other ____
  - other part/organ (names)
    - _____ ____
    - _____ ____

16. Rabbit: Yes No
- Meat
  - cooked (fresh or frozen) ____
  - smoked/dried ____
- Organ/parts
  - head ____
  - liver ____
  - blood ____
  - brain ____
  - other part/organ (names)
    - _____ ____
    - _____ ____

17. Beaver: Yes No

Meat
- cooked (fresh or frozen) ____
- smoked/dried ____

Organ/parts
- tail & feet ____
- liver ____
- blood ____
- brain ____
- other part/organ (names)
  - _____ ____
  - _____ ____

18. Muskrat: Yes No

Meat
- cooked (fresh or frozen) ____
- smoked/dried ____

Organ/parts
- tail ____
- liver ____
- blood ____
- brain ____
- other part/organ (names)
  - _____ ____
  - _____ ____

19. Lynx: Yes No

Meat
- cooked (fresh or frozen) ____
- smoked/dried ____

Organ/parts
- head ____
- liver ____
- blood ____
- brain ____
- other part/organ (names)
  - _____ ____
  - _____ ____

20. Porcupine: Yes No

Meat
- cooked (fresh or frozen) ____
- smoked/dried ____

Organ/parts
- liver ____
- blood ____
- brain ____
- other part/organ (names)
  - _____ ____
  - _____ ____

21. Dall sheep: Yes No

Meat
- cooked (fresh or frozen) ____
- smoked/dried ____

Organ/parts
- liver ____
- blood ____
- brain ____
- other part/organ (names)
  - _____ ____
  - _____ ____

22. Bear: Yes No

Meat
- cooked (fresh or frozen) ____
- smoked/dried ____

Organ/parts
- Fat ____
- blood ____
- brain ____
- other part/organ (names)
  - _____ ____
  - _____ ____

23. Other land animal (name/part/preparation)

_____ _____
_____ _____
_____ _____

BIRDS

24. Spruce hen: **Yes** **No**

Meat
- cooked (fresh or frozen) _____
- smoked/dried _____

Organ/parts
- gizzards _____
- kidney _____
- heart _____
- liver _____
- eggs _____
- other parts/organ (names)

_____ _____
_____ _____

25. Prairie chicken: **Yes** **No**

Meat
- cooked (fresh or frozen) _____
- smoked/dried _____

Organ/parts
- gizzards _____
- kidney _____
- heart _____
- liver _____
- eggs _____
- other parts/organ (names)

_____ _____
_____ _____

26. Ptarmigan: **Yes** **No**

Meat
- cooked (fresh or frozen) _____
- smoked/dried _____

Organ/parts
- gizzards _____
- kidney _____
- heart _____
- liver _____
- other parts/organ (names)

_____ _____
_____ _____

27. Black ducks/Scoter: **Yes** **No**

Meat
- cooked (fresh or frozen) _____
- smoked/dried _____

Organ/parts
- gizzards _____
- kidney _____
- heart _____
- liver _____
- eggs
- other parts/organ (names)

_____ _____
_____ _____

28. Mallards: **Yes** **No**

Meat
- cooked (fresh or frozen) _____
- smoked/dried _____

Organ/parts
- gizzards _____
- kidney _____
- heart _____
- liver _____
- eggs _____
- other parts/organ (names)

_____ _____
_____ _____

29: "Fish" ducks: **Yes** **No**

Meat
- cooked (fresh or frozen) _____ _____
- smoked/dried _____ _____

Organ/parts
- gizzards _____ _____
- kidney _____ _____
- heart _____ _____
- liver _____ _____
- eggs _____ _____
- other parts/organ (names)
  - _____ _____ _____
  - _____ _____ _____

30. Oldsquaw (squaw duck): **Yes** **No**

Meat
- cooked (fresh or frozen) _____ _____
- smoked/dried _____ _____

Organ/parts
- gizzards _____ _____
- kidney _____ _____
- heart _____ _____
- liver _____ _____
- eggs _____ _____
- other parts/organ (names)
  - _____ _____ _____
  - _____ _____ _____

31. Wigeon (whistling duck): **Yes** **No**

Meat
- cooked (fresh or frozen) _____ _____
- smoked/dried _____ _____

Organ/parts
- gizzards _____ _____
- kidney _____ _____
- heart _____ _____
- liver _____ _____
- eggs _____ _____
- other parts/organ (names)
  - _____ _____ _____
  - _____ _____ _____

32. Canvasback: **Yes** **No**

Meat
- cooked (fresh or frozen) _____ _____
- smoked/dried _____ _____

Organ/parts
- gizzards _____ _____
- kidney _____ _____
- heart _____ _____
- liver _____ _____
- eggs _____ _____
- other parts/organ (names)
  - _____ _____ _____
  - _____ _____ _____

33. Canada goose: **Yes** **No**

Meat
- cooked (fresh or frozen) _____ _____
- smoked/dried _____ _____

Organ/parts
- gizzards _____ _____
- kidney _____ _____
- heart _____ _____
- liver _____ _____
- fat _____ _____
- eggs _____ _____
- other parts/organ (names)
  - _____ _____ _____
  - _____ _____ _____

34. Snow goose (wavies): Yes No
- Meat
  - cooked (fresh or frozen) ____
  - smoked/dried ____
- Organ/parts
  - gizzards ____
  - kidney ____
  - heart ____
  - liver ____
  - eggs ____
  - other parts/organ (names)
    _____ ____
    _____ ____

35. Pintail: Yes No
- Meat
  - cooked (fresh or frozen) ____
  - smoked/dried ____
- Organ/parts
  - gizzards ____
  - kidney ____
  - heart ____
  - liver ____
  - eggs ____
  - other parts/organ (names)
    _____ ____
    _____ ____

36. Swan: Yes No
- Meat
  - cooked (fresh or frozen) ____
  - smoked/dried ____
- Organ/parts
  - gizzards ____
  - kidney ____
  - heart ____
  - liver ____
  - eggs ____
  - other parts/organ (names)
    _____ ____
    _____ ____

37. Other birds (name/part/preparation)

_____ ____
_____ ____
_____ ____
_____ ____
_____ ____
_____ ____
_____ ____
_____ ____
_____ ____
_____ ____

[in Gwich'in area only, ask:
38. Seagull eggs Yes No ____]

PLANT FOODS

39. Labrador tea ____
40. Low (grey) blueberries ____
41. High (black) blueberries ____
42. Cranberries ____
43. Gooseberries (green) ____
44. Gooseberries (purple) ____
45. Blackberries ____
46. Wild raspberries ____
47. Wild strawberries ____
48. Cloud berries/knuckleberries ____

49. Red currants _____
50. Black currants _____
51. Saskatoon berries _____
52. Rosehips _____
53. Wild peppermint _____
54. Mushrooms (get local names) _____ _____
55. Wild greens (get local names) _____ _____
56. Wild onions _____
57. Wild rhubarb _____

58. Other plant foods (names)

_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____

[Interviewer, make sure all the pages have been completed]

Variance in Food Use in Dene/Métis Communities

II. INDIVIDUAL 24-HOUR RECALL

Community _____ (number 1-28) Household number _____ Respondent's gender ___ (1=Female, 2=male)

if gender=1 then ask (and circle) whether:
Pregnant: Yes No Lactating: Yes No

Respondent's ID # _____

Self-identification: Dene____ Métis___ Other ___

Age-group: 20-40___ 41-60___ Over 60___

Interviewer's name _____ Date _____ (day/month/year)

Interviewer, please read to the respondent:
Please, recall as exactly as possible what you ate yesterday, _____(write which da of the week), from the time you first woke-up.

TIME	FOOD NAME	HOW PREPARED/INGREDIENTS	AMOUNT

ID# _____

TIME	FOOD NAME	HOW PREPARED/INGREDIENTS	AMOUNT

Interviewer, did you remember to check about:
the lard, butter, salad dressing, the milk/creamer/sugar in the drinks, any juice, alcohol, jam/honey...?
Any snacks, beverages, or foods consumed outside the home?

1. Did you take any vitamin/mineral supplements yesterday?
   If yes, what brand name?_____

2. Was yesterday, a "usual day"?
   Yes _____
   No _____ (please explain)
   _____

SMOKING QUESTIONNAIRE

ID #
SEASON

1. Are you currently smoking 1 or more cigarettes per day?

If yes, How many cigarettes per day?
How many years have you been smoking?

If no, Did you ever smoke 1 cigarette per day or more at least one year?

If yes, How many cigarettes per day?
For how many years did you smoke?
What year did you quit?

Appendix 2: Frequency of Traditional Food Use by Season

Frequency of Traditional Food Use by Season

Food and Frequency			Season			
			Winter (N=51)		Summer (N=46)	
			N	%	N	%
Whitefish	Flesh	Cooked				
none			1	2	11	23.9
<1/week			39	76.5	30	65.2
1-2/week			10	19.6	5	10.9
3-5/week			1	2		
Whitefish	Flesh	Smoked				
none			50	98	42	91.3
<1/week			1	2	4	8.7
Whitefish	Head	Cooked				
none			29	56.9	26	56.5
<1/week			19	37.3	34.8	34.8
1-2/week			3	5.9	4	8.7
Whitefish	Egg	Cooked				
none			48	94.1	33	71.7
<1/week			3	2.9	12	26.1
1-2/week					1	2.2
Whitefish	Fishpipe	Cooked				
none			51	100	45	97.8
<1/week					1	2.2
Inconnu	Flesh	Cooked				
none			40	78.4	33	71.7
<1/week			11	21.6	13	28.3
Inconnu	Flesh	Smoked				
none			50	98	46	100
<1/week			1	2		
Inconnu	Head	Cooked				
none			50	98	45	97.8
<1/week			1	2	1	2.2
Inconnu	Egg	Cooked				
none			50	98	44	95.7
<1/week			1	2	2	4.3
Trout	Flesh	Cooked				
none			21	41.2	25	54.3
<1/week			30	58.8	21	45.7
Trout	Flesh	Smoked				
none			50	98	46	100
<1/week			1	2		
Trout	Head	Cooked				
none			32	62.7	35	76.1
<1/week			19	37.3	11	23.9
Trout	Egg	Cooked				
none			50	98	46	100
<1/week			1	2		
Loche	Flesh	Cooked				
none			21	41.2	18	39.1
<1/week			30	58.8	27	57.8
1-2/week					1	2.2
Loche	Flesh	Smoked				
none			51	100	45	97.8
<1/week					1	2.2
Loche	Head	Cooked				
none			51	100	38	82.6
<1/week					8	17.4
Loche	Egg	Cooked				
none			40	78.4	29	63
<1/week			11	21.6	16	34.8
Jackfish	Flesh	Cooked				
none			18	35.3	15	32.6

<1/week			33	64.7	28	60.9
1-2/week						
Jackfish	Flesh	Smoked				
none			51	100	45	97.8
<1/week					1	2.2
Jackfish	Head	Cooked				
none			51	100	42	91.3
<1/week					4	8.7
Jackfish	Egg	Cooked				
none			48	94.1	42	91.3
<1/week			3	5.9	4	8.7
Longnose sucker	Flesh	Cooked				
none			44	86.3	33	71.7
<1/week			7	13.7	12	26.1
1-2/week					1	2.2
Longnose sucker	Flesh	Smoked				
none			39	76.5	23	56.5
<1/week			12	23.5	19	41.3
1-2/week					1	2.2
Longnose sucker	Head	Cooked				
none			45	88.2	36	78.3
<1/week			6	11.8	10	21.7
Longnose sucker	Egg	Cooked				
none			50	98	39	84.8
<1/week			1	2	7	15.2
Longnose sucker	Fishpipe	Cooked				
none			51	100	45	97.8
<1/week					1	2.2
Caribou Woodland	Flesh	Cooked				
none			45	90.8	45	97.8
<1/week			6	9.8	1	2.2
Caribou Woodland	Flesh	Smoked				
none			51	100	45	97.8
<1/week					1	2.2
Caribou Woodland	Rib	Cooked				
none			49	96.1	45	97.8
<1/week			2	3.9	1	2.2
Caribou Woodland	Head	Cooked				
none			51	100	45	97.8
<1/week					1	2.2
Caribou Woodland	Heart	Cooked				
none			50	98	45	97.8
<1/week			1	2	1	2.2
Caribou Woodland	Tongue	Cooked				
none			50	98	45	97.8
<1/week			1	2	1	2.2
Caribou Woodland	Liver	Cooked				
none			51	100	45	97.8
<1/week					1	2.2
Caribou Woodland	Kidney	Cooked				
none			51	100	45	97.8
<1/week					1	2.2
Caribou Woodland	Bonemarrow	Cooked				
none			50	98	45	97.8
<1/week			1	2	1	2.2
Caribou Woodland	Bone	Soup				
none			50	98	45	97.8
<1/week			1	2	1	2.2
Caribou Woodland	Bone	Combined				
none			51	100	45	97.8
<1/week					1	2.2
Caribou Woodland	Fat	Cooked				
none			51	100	45	97.8
<1/week					1	2.2

Caribou Barrenland	Flesh	Cooked				
none			1	2	10	21.7
<1/week			31	60.8	31	67.4
1-2/week			12	23.5	5	10.9
3-5/week			7	13.7		
Caribou Barrenland	Flesh	Smoked				
none			5	9.8	17	37
<1/week			42	82.4	26	56.5
1-2/week			4	7.8	3	6.5
Caribou Barrenland	Ribs	Smoked				
none			5	9.8	20	43.5
<1/week			44	86.3	25	54.3
1-2/week			2	3.9	1	2.2
Caribou Barrenland	Head	Cooked				
none			27	52.9	32	69.6
<1/week			24	47.1	14	30.4
Caribou Barrenland	Heart	Cooked				
none			34	66.7	30	65.2
<1/week			17	33.3	16	34.8
Caribou Barrenland	Tongue	Cooked				
none			31	60.8	32	69.6
<1/week			20	39.2	14	30.4
Caribou Barrenland	Liver	Cooked				
none			42	82.4	36	78.3
<1/week			9	17.6	10	21.7
Caribou Barrenland	Blood	Cooked				
none			45	88.2	37	80.4
<1/week			6	11.8	9	19.6
Caribou Barrenland	Stomach	Cooked				
none			44	86.3	37	80.4
<1/week			7	13.7	9	19.6
Caribou Barrenland	Kidney	Cooked				
none			44	86.3	35	76.1
<1/week			7	13.7	11	23.9
Caribou Barrenland	Bone marrow	Cooked				
none			35	68.6	29	63
<1/week			16	31.4	17	37
Caribou Barrenland	Bone	Soup				
none			28	54.9	31	67.4
<1/week			23	45.1	15	32.6
Caribou Barrenland	Bone	Combined				
none			47	92.2	46	100
<1/week			4	7.8		
Caribou Barrenland	Fat	Soup				
none			18	35.3	29	63
<1/week			33	64.7	17	37
Caribou Barrenland	Brain	Cooked				
none			32	62.7	46	100
<1/week			19	37.3		
Moose	Flesh	Cooked				
none			2	3.9	4	8.7
<1/week			43	84.3	38	82.6
1-2/week			4	7.8	4	8.7
3-5/week			2	3.9		
Moose	Flesh	Smoked				
none			11	21.6	18	39.1
<1/week			37	72.5	24	52.2
1-2/week			3	5.9	4	8.7
Moose	Ribs	Cooked				
none			17	33.3	22	47.8
1-2/week			34		66.7 24	52.2
Moose	Head	Cooked				
none			38	74.5	31	67.4
<1/week			13	25.5	15	32.6

Moose	Tongue	Cooked				
none			43	84.3	36	78.3
<1/week			8	15.7	10	21.7
Moose	Heart	Cooked				
none			37	72.5	34	73.9
<1/week			14	27.5	12	26.1
Moose	Liver	Cooked				
none			41	80.4	40	87
<1/week			10	19.6	6	13
Moose	Blood	Cooked				
none			50	98	43	93.5
<1/week			1	2	3	6.5
Moose	Kidney	Cooked				
none			49	96.1	40	87
<1/week			2	3.9	6	13
Moose	Bone marrow	Cooked				
none			36	70.6	33	71.7
<1/week			15	29.4	13	28.3
Moose	Bone	Soup				
none			31	60.8	33	71.7
<1/week			20	39.2	13	28.3
Moose	Bone	Combined				
none			48	94.1	46	100
<1/week			3	5.9		
Moose	Fat	Soup				
none			24	47.1	33	71.7
<1/week			26	51	13	28.3
1-2/week			1	2		
Moose	Brain	Cooked				
none			42	82.4	46	100
<1/week			9	17.6		
Rabbit	Flesh	Cooked				
none			11	21.6	24	52.2
<1/week			39	76.5	22	47.8
1-2/week			1	2		
Rabbit	Head					
none			25	49	34	73.9
<1/week			26	51	12	26.1
Rabbit	Liver	Cooked				
none			36	70.6	40	87
<1/week			15	29.4	6	13
Rabbit	Blood	Cooked				
none			50	98	44	95.7
<1/week			1	2	2	4.3
Rabbit	Brain	Cooked				
none			36	70.6	38	82.6
<1/week			15	29.4	8	17.4
Beaver	Flesh	Cooked				
none			45	88.2	45	97.8
<1/week			6	11.8	1	2.2
Beaver	Flesh	Smoked				
none			45	88.2	41	89.1
<1/week			6	11.8	5	10.9
Beaver	Tailfeet	Cooked				
none			46	90.2	45	97.8
<1/week			5	9.8	1	2.2
Muskrat	Flesh	Cooked				
none			44	86.3	36	78.3
<1/week			7	13.7	10	21.7
Muskrat	Flesh	Smoked				
none			41	80.4	27	58.7
<1/week			10	19.6	18	39.1
Muskrat	Liver	Cooked				
none			51	100	44	95.7

<1/week					2	4.3
Muskrat	Tail	Cooked				
none			41	80.4	46	100
<1/week			10	19.6		
Bear	Flesh	Cooked				
none			51	100	45	97.8
<1/week					1	2.2
Bear	Flesh	Smoked				
none			51	100	44	95.7
<1/week					2	4.3
Spruce hen	Flesh	Cooked				
none			49	96.1	45	97.8
<1/week			2	3.9	1	2.2
Prairie chicken	Flesh	Cooked				
none			32	62.7	28	60.9
<1/week			19	37.3	18	39.1
Prairie chicken	Flesh	Smoked				
none			51	100	44	95.7
<1/week					2	4.3
Prairie chicken	Gizzard	Cooked				
none			46	90.2	39	84.8
<1/week			5	9.8	7	15.2
Prairie chicken	Kidney	Cooked				
none			49	96.1	45	97.8
<1/week			2	3.9	1	2.2
Prairie chicken	Heart	Cooked				
none			47	92.2	41	89.1
<1/week			4	7.8	5	10.9
Prairie chicken	Liver	Cooked				
none			51	100	44	95.7
<1/week					2	4.3
Ptarmigan	Flesh	Cooked				
none			17	33.3	11	23.9
<1/week			34	66.7	34	73.9
1-2/week					1	2.2
Ptarmigan	Flesh	Smoked				
none			51	100	42	91.3
<1/week					4	8.7
Ptarmigan	Gizzard	Cooked				
none			31	60.8	21	45.7
<1/week			20	39.2	24	52.2
1-2/week					1	2.2
Ptarmigan	Kidney	Cooked				
none			46	90.2	37	80.4
<1/week			5	9.8	9	19.6
Ptarmigan	Heart	Cooked				
none			37	72.5	27	58.7
<1/week			14	27.5	19	41.3
Ptarmigan	Liver	Cooked				
none			49	96.1	38	82.6
<1/week			2	3.9	8	17.4
Mallard	Flesh	Cooked				
none			36	70.6	20	43.5
<1/week			15	29.4	26	56.5
Mallard	Flesh	Smoked				
none			51	100	44	95.7
<1/week					2	4.3
Mallard	Gizzard	Cooked				
none			47	92.2	38	82.6
<1/week			4	7.8	8	17.4
Mallard	Kidney	Cooked				
none			50	98	45	97.8
<1/week			1	2	1	2.2
Mallard	Heart	Cooked				

none			46	90.2	39	84.8
<1/week			5	9.8	7	15.2
Mallard	Liver	Cooked				
none			49	96.1	44	95.7
<1/week			2	3.9	2	4.3
Mallard	Egg	Cooked				
none			51	100	45	97.8
<1/week					1	2.2
Canvasback	Flesh	Cooked				
none			50	98	30	65.2
<1/week			1	2	15	32.6
1-2/week					1	2.2
Canvasback	Flesh	Smoked				
none			51	100	44	95.7
<1/week					2	4.3
Canvasback	Gizzard	Cooked				
none			51	100	41	89.1
<1/week					4	8.7
1-2/week					1	2.2
Canvasback	Kidney	Cooked				
none			51	100	43	93.5
<1/week					3	6.5
Canvasback	Heart	Cooked				
none			51	100	42	91.3
<1/week					4	8.7
Canada goose	Flesh	Cooked				
none			29	56.9	22	47.8
<1/week			22	43.1	24	52.2
Canada goose	Gizzard	Cooked				
none			43	84.3	34	73.9
<1/week			8	15.7	12	26.1
Canada goose	Kidney	Cooked				
none			49	96.1	41	89.1
<1/week			2	3.9	5	10.9
Canada goose	Heart	Cooked				
none			46	90.2	37	80.4
<1/week			5	9.8	9	19.6
Canada goose	Liver	Cooked				
none			48	94.1	43	93.5
<1/week			3	5.9	3	6.5
Canada goose	Fat	Cooked				
none			48	94.1	44	95.7
<1/week			3	5.9	2	4.3
Snow goose	Flesh	Cooked				
none			46	90.2	46	100
<1/week			5	9.8		
Snow goose	Gizzard	Cooked				
none			49	96.1	46	100
<1/week			2	3.9		
Snow goose	Heart	Cooked				
none			50	98	46	100
<1/week			1	2		
Pintail	Flesh	Cooked				
none			50	98	34	73.9
<1/week			1	2	12	26.1
Pintail	Flesh	Smoked				
none			51	100	45	97.8
<1/week					1	2.2
Pintail	Gizzard	Cooked				
none			50	98	42	91.3
<1/week			1	2	4	8.7
Pintail	Kidney	Cooked				
none			51	100	45	97.8
<1/week					1	2.2

Pintail	Heart	Cooked				
none			51	100	43	93.5
<1/week					3	6.5
Pintail	Liver	Cooked				
none			51	100	45	97.8
<1/week					1	2.2
Swan	Flesh	Cooked				
none			50	98	37	80.4
<1/week			1	2	9	19.6
Swan	Gizzard	Cooked				
none			50	98	44	95.7
<1/week			1	2	2	4.3
Swan	Heart	Cooked				
none			50	98	46	100
<1/week			1	2		
High blueberry						
none			50	98	46	100
<1/week			1	2		
Cranberry						
none			35	72.9	37	80.4
<1/week			13	27.1	9	19.6
Green gooseberry						
none			51	100	43	93.5
<1/week					3	6.5
Purple gooseberry						
none			51	100	40	87
<1/week					6	13
Blackberry						
none			50	98	46	100
<1/week			1	2		
Wild raspberry						
none			44	91.7	43	93.5
<1/week			4	8.3	3	6.5
Wild strawberry						
none			51	100	45	97.8
<1/week					1	2.2
Black currant						
none			51	100	45	97.8
<1/week					1	2.2
Saskatoon berry						
none			37	77.1	28	60.9
<1/week			11	22.9	17	37
3-5/week					1	2.2
Wild onion						
none			51	100	45	97.8
<1/week					1	2.2
Wild rhubarb						
none			51	100	45	97.8
<1/week					1	2.2

Appendix 3: Cd concentrations of Individual Traditional Food Items

Cd Concentrations in Traditional Food

Food	Part	Preparation	#	Location	Cd(ppm)
Moose	Flesh	Dried & Smoked	001	Jean River	0.04
			030	Slave Delta	0.04
		Raw	005	Paulette Creek	0.01
			067	Horseshore-Slave River	0.02
			062	Horseshore-Slave River	0.03
			066	Slave River	0.04
		Fried	020	Slave Delta	0.01
		Boiled	026	Slave Delta	7.82
			118	Jean River	0.00
		Smoked	035	Pine Point Highway	0.01
			038	Unidentified	0.08
		Smoked & Fried	058	Gaudet Bay	0.16
	Liver	Raw	014	Slave Delta	4.35
			063	Slave River	9.71
		Boiled	028	Slave Delta	1.21
	Kidney	Raw	015	Slave Delta	2.28
			060	Horseshoe-Slave River	3.24
			065	Slave River	50.56
		Boiled	027	Slave Delta	7.82
	Heart	Raw	016	Jean River	0.03
			061	Horseshoe-Slave River	0.08
			064	Slave River	0.12
			108	Unidentified	0.02
		Boiled	046	Slave Delta	0.11
			116	Jean River	39.90
	Intestine	Raw	068	Horseshoe-Slave River	0.15
			076	Slave River	0.19
		Boiled	079	Slave River	0.10
			083	Slave River	0.25
	Tongue	Raw	054	Gaudet Bay	0.14
	Internal fat	Raw	018	Slave Delta	0.00
Caribou	Felsh	Raw	003	Rae lakes	0.01
			008	Unidentified	0.04
			050	Snowcliff, NWT	0.02
			106	Prelude Lake	0.01
			110	Prelude Lake	0.01
		Dried & Smoked	104	Prelude Lake	0.01
	Bone marrow	Raw	006	Rae lakes	0.02
			008	Unidentified	0.02
			050	Snowcliff, NWT	0.02
	Heart	Raw	013	Rae Lake	0.01
			107	Prelude Lake	0.02
			101	Prelude Lake	0.01
	Kideny	Raw	100	Prelude Lake	1.42
			102	Prelude Lake	1.92
			111	Prelude Lake	0.45
	Liver	Raw	105	Prelude Lake	2.64
			113	Prelude Lake	0.58
	Intestine	Raw	109	Prelude Lake	0.04
			103	Prelude Lake	0.03
			112	Prelude Lake	0.00
Rabbit	Flesh	Raw		Unidentified	0.02
Bear	Flesh	Raw	119	Cheese Creek	0.00
			097	Little Buffalo River	0.01
			095	Little Buffalo River	0.01
		Smoked	099	Little Buffalo River	0.01
Loche	Flesh	Raw	114	Little Buffalo River	0.00
			117	Ft. Resol. Bay	0.00
Ptarmigan	Flesh	Raw	120	Unidentified	0.02
				Unidentified	0.01

		Fried		Unidentified	0.02
		Boiled	115	Community	0.01
Muskrat	Flesh	Raw	010	Slave Delta	0.04
Buffalo	Flesh	Raw	012	Hook Lake	0.01
Mallard duck	Flesh	Boiled	039	Little Buffalo River	0.05
Beaver	Flesh	Raw	041	Little Buffalo River	0.16
			084	Little Buffalo River	0.02
		Smoked & Boiled	057	Nyarling River	0.02
	kidney	Raw	040	Unidentified	4.14
			086	Little Buffalo River	4.36
	Liver	Raw	043	Little Buffalo River	0.55
			085	Little Buffalo River	0.34
	Intesine	Raw	042	Little Buffalo River	0.18
	Heart	Raw	087	Little Buffalo River	0.01
Whitefish	Flesh	Raw	004	Fort Resolution Bay	0.01
			011	Fort Resolution Bay	0.01
			022	Fort Resolution Bay	0.01
			092	Little Buffalo River	0.03
			093	Little Buffalo River	0.02
Jackfish	Flesh	Raw	070	Paulett Creek	0.01
			071	Paulett Creek	0.01
			045	Paulett Creek	0.41
			053	Paulett Creek	0.03
			052	Little Buffalo River	0.00
		Fried	053	Paulett Creek	0.11
	Intestine	Raw	069	Paulett Creek	0.01
			052	Little Buffalo River	0.19
			053	Paulett Creek	0.21
	Egg	Raw	053	Paulett Creek	0.01
Sucker	Flesh	Raw	078	Paulett Creek	0.00
			072	Paulett Creek	0.02
			073	Mission Island	0.01
			074	Mission Island	0.06
			075	Paulett Creek	0.01
	Flesh	Smoked	025	Fort Resolution Bay	0.16
Trout	Flesh	Raw	080	Simpson Island	0.02
Cranberry		Raw	007	Paulette Creeek	0.00
			017	Mission Island	0.00
			029	Paulette Creeek	0.00
			082	Moose Deer Island	0.00
		Jam	051	Mission Island	0.00
Mooseberry		Raw	081	Accross Portage	0.00
Rhubarb		Raw	077	Fort Resolution	0.00
			090	Fort Resolution	0.00
Berry		Raw	094	Little Buffalo River	0.01
			096	Graveyard	0.02
Garden potato		Raw	002	Fort Resolution	0.01
			037	Fort Resolution	0.01
			091	Fort Resolution	0.03

Appendix 4: Table 26. Mean Frequency of consumption of animal organs by gender
Table 27. Mean Frequency of consumption of animal organs by age

Table 26.

Mean Frequency of Consumption of Animal Organs (Days/week)
By Gender

Food		Women (43 [a])			Men (54 [a])		
		N[c]	%[d]	Mean Frequency[b]	N[c]	%[d]	Mean Frequency[b]
Woodland caribou	Liver	1	2.3	0.005 ± 0.03	0	0	0.0 ± 0.0
	Kidney	1	2.3	0.005 ± 0.03	0	0	0.0 ± 0.0
Barrenland caribou	Liver	8	18.6	0.04 ± 0.08	11	20.4	0.04 ± 0.08
	Kidney	7	16.3	0.03 ± 0.07	11	20.4	0.04 ± 0.08
Moose	Liver	7	16.3	0.03 ± 0.07	9	16.7	0.03 ± 0.08
	Kidney	1	2.3	0.005 ± 0.03	7	13.0	0.03 ± 0.07
Rabbit	Liver	6	14.0	0.03 ± 0.07	15	27.8	0.06 ± 0.1
Muskrat	Liver	0	0	0.0 ± 0.0	2	3.7	0.01 ± 0.04
Ptarmigan	Liver	3	7	0.01 ± 0.05	7	13.0	0.03 ± 0.08
	Kidney	5	11.6	0.02 ± 0.06	9	16.7	0.03 ± 0.08
Pintail	Liver	0	0	0.0 ± 0.0	1	1.9	0.004 ± 0.08
	Kidney	0	0	0.0 ± 0.0	1	1.9	0.004 ± 0.08
Mallard	Liver	1	2.3	0.005 ± 0.03	3	5.6	0.01 ± 0.05
	Kidney	0	0	0.0 ± 0.0	2	3.7	0.01 ± 0.04
Canada goose	Liver	2	4.7	0.01 ± 0.04	4	7.4	0.01 ± 0.05
	Kidney	2	4.7	0.01 ± 0.04	5	9.3	0.02 ± 0.06
Prairie chichk	Liver	1	4.3	0.005 ± 0.03	1	1.9	0.004 ± 0.03
	Kidney	0	0	0.0 ± 0.0	3	5.6	0.01 ± 0.027
Spruce hen	Liver	0	0	0.0 ± 0.0	1	1.9	0.004 ± 0.027
	Kidney	0	0	0.0 ± 0.0	0	0	0.0 ± 0.0

[a] Number of participants in food frequency questionnaires
[b] Mean ± standard deviation
[c] Number of respondents who consumed the food
[d] Percentage of respondents who consumed the food

Table 27.

Mean Frequency of Consumption of Animal Organs (Days/week)
By Age

Food		Age								
		20-40 (45 [a])			40-60 (26 [a])			60< (26 [a])		
		N[c]	%[d]	Mean frequency[b]	N[c]	%[d]	Mean frequency[b]	N[c]	%[d]	Mean frequency[b]
Caribou W.	Liver	0	0	0.0 ± 0.0	2	7.6	0.01 ± 0.04	0	0	0.0 ± 0.0
	Kidney	0	0	0.0 ± 0.0	1	3.8	0.01 ± 0.04	0	0	0.0 ± 0.0
Caribou B.	Liver	5	11.1	0.02 ± 0.06	7	26.9	0.05 ± 0.09	7	26.9	0.05 ± 0.09
	Kidney	4	8.9	0.02 ± 0.06	7	26.9	0.05 ± 0.09	7	26.9	0.05 ± 0.09
Moose	Liver	5	11.1	0.02 ± 0.06	7	26.9	0.05 ± 0.09	4	15.4	0.03 ± 0.07
	Kidney	4	8.9	0.02 ± 0.06	3	11.5	0.02 ± 0.07	1	3.8	0.01 ± 0.04
Rabbit	Liver	1	2.2	0.004 ± 0.03	10	38.5	0.08 ± 0.1	10	38.5	0.08 ± 0.1
Muskrat	Liver	0	0	0.0 ± 0.0	0	0	0.0 ± 0.0	2	7.7	0.02 ± 0.05
Ptarmigan	Liver	3	6.7	0.01 ± 0.05	3	11.5	0.02 ± 0.07	4	15.4	0.03 ± 0.07
	Kidney	3	6.7	0.01 ± 0.05	4	15.4	0.03 ± 0.07	7	26.9	0.05 ± 0.09
Mallard	Liver	3	6.7	0.01 ± 0.05	1	3.8	0.01 ± 0.04	0	0	0.0 ± 0.0
	Kidney	0	0	0.0 ± 0.0	1	3.8	0.01 ± 0.04	1	3.8	0.01 ± 0.04
Pintail	Liver	0	0	0.0 ± 0.0	1	3.8	0.01 ± 0.04	0	0	0.0 ± 0.0
	Kidney	0	0	0.0 ± 0.0	1	3.8	0.01 ± 0.04	0	0	0.0 ± 0.0
Canada goose	Liver	1	2.2	0.004 ± 0.03	3	11.5	0.02 ± 0.07	2	7.7	0.02 ± 0.05
	Kidney	2	4.4	0.01± 0.04	1	3.8	0.01 ± 0.04	4	15.4	0.03 ± 0.07
Prairie chichk	Liver	1	2.2	0.004 ± 0.03	0	0	0.0 ± 0.0	1	3.8	0.01 ± 0.04
	Kidney	1	2.2	0.004 ± 0.03	1	3.8	0.01 ± 0.04	1	3.8	0.01 ± 0.04
Spruce hen	Liver	1	2.2	0.004 ± 0.03	0	0	0.0 ± 0.0	0	0	0.0 ± 0.0
	Kidney	0	0	0.0 ± 0.0	0	0	0.0 ± 0.0	0	0	0.0 ± 0.0

[a] Number of participants in traditional food use frequency interviews.

[b] Mean ± standard deviation

[c] Number of respondents who consumed the food

[d] Percentage of respondents who consumed the food

Appendix 5: List of Scientific Names

List of scientific names

Scientific names	Common names
Alces alces	Moose
Rangifer tarandus	Caribou
Lepus americanus	Rabbit
Ursus americanus	Bear
Ondatra zibethious	Muskrat
Bison bison	Buffalo
Castor candadenis	Beaver
Lagopus mutus	Ptarmigan
Anas platyrhynchos	Mallard duck
Oxycoccus spp.	Cranberry
Viburnum edule	Mooseberry
Rheum rhaponticum	Rhubarb
Prosopium cylindraceum	Whitefish
Esox lucius	Jackfish
Catostomus catostomus	Sucker
Savelinus namaycush	Trout
Lota lota	Loche