ABSTRACT

M.Sc. MARIAN LOUISE TWISS HO Animal Science
Nutrition

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Sodium, potassium, magnesium, copper and iron content are also given. The values obtained agree well with published data for similar animals except for the iron values, which are variable, and in some cases, high. Sodium and potassium were determined by flame photometry, and copper, magnesium and iron by atomic absorption spectroscopy.

AMINO ACID AND SELECTED MINERAL CONTENT OF BIRDS, FISH AND MAMMALS OF NORTHERN CANADA

by

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfilment of the requirement for the degree of Master of Science

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Montreal

July 1971

Suggested title for bound copy

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Sodium, potassium, magnesium, copper and iron content are also given. The values obtained agree well with published data for similar animals except for the iron values, which are variable, and in some cases, high. Sodium and potassium were determined by flame photometry, and copper, magnesium and iron by atomic absorption spectroscopy.

ACKNOWLEDGEMENTS

I wish to express my gratitude to my director, Dr. Florence A. Farmer, School of Food Science, for her guidance and encouragement.

I am grateful also to Mr. M. Huberty for his technical assistance; and to the following persons for their suggestions regarding chemical methods: Dr. A. Ceycre, Mr. M. A. Amer and Mr. Bruce Lauer.

Also to Mrs. M. Couture, special appreciation is extended for the excellent transcription of this thesis.

I am indebted to McGill University for the financial support given to me during my final year by the Faculty of Agriculture.

Finally, I wish to thank my husband, Jim, for his patient, continual technical and moral support.

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I. INTRODUCTION

Today, with increased emphasis on nutrition by the individual, by governments, and by the medical profession, the need for reliable, comprehensive food composition tables has become imperative. Food composition tables are used by dietitians and nutritionists in the development and evaluation of diets for both normal and therapeutic purposes.

Food composition tables, however, are far from complete. One area particularly lacking is the composition of many animals found in northern Canada. These birds, fish and mammals form a major portion of the diet of Canadian Eskimos and Indians. Without the necessary information it is difficult for dietitians and nutritionists in the north to carry out their work.

The object of this study, therefore, is to provide information on the composition of northern Canadian birds, fish and mammals. Thus, values obtained for the content of amino acids and several minerals of some of these animals are presented in this thesis. It is hoped that the data will be incorporated into existing food composition tables to extend their use.

Usually there is little concern regarding the amino acid content of high animal protein diets such as are consumed by Eskimos and Indians in northern Canada. However, as stated by Stegink and Baker (1970), the incidence of inborn errors of amino acid metabolism may be high in Eskimos. Therefore, knowledge of the amino acid make-up of the foods ingested is necessary to treat some types of inborn errors of metabolism.

Data involving the mineral content of foods is also useful in the calculation of diets, and the determination of dietary adequacy in both health and disease. Sodium values are used in the calculation of low sodium diets for cardiac and renal disease.

Scott and Heller (1964) indicated that iron deficiency occurs among Eskimos in southeast Alaska, making knowledge of the iron content of northern animals necessary.

As well as sodium and iron determinations, magnesium, potassium and copper determinations were also attempted, because of available time and equipment.

It may also be noted that the consumption of northern animals is no longer confined to residents of northern Canada. Foods such as arctic char chowder, arctic whitefish, white whale meat and muktuk are now

appearing in canned form on supermarket shelves throughout the rest of Canada.

This research has been supported in part by a grant from the Department of National Health and Welfare, through the Ministère de la Santé, Québec.

II. REVIEW OF LITERATURE

2.1 FOOD COMPOSITION TABLES

The objective of national food composition tables is to provide values representative of foods on a year-round, country-wide basis (Mayer, 1960; Watt and Murphy, 1970). Although the composition of any food will be influenced considerably by climate, botanical variety, storage, processing and environment (Chatfield, 1949; Watt and Murphy, 1970), the values obtained from composition tables are used extensively by nutritionists and dietitians.

Because of continual advances in nutritional knowledge, improvements in analytical methods and processing, food composition tables need to be revised periodically (Watt, 1964). Missing values, and values for foods not previously included, have to be added (Paul and Southgate, 1970). The need for additional information is always present, especially data on foods used by certain ethnic, cultural, and religious groups (Watt and Murphy, 1970), and for foods grown and processed in specific areas (Wu Leng, 1962).

In particular there is a lack of information on the composition of the animals of northern Canada and northern United States. The available food composition tables (U.S. Department of Agriculture Handbook No. 8 (1963); Nutrition Division Department of Health and Welfare Table of food values recommended for use in Canada (1951); Nutrition Division, FAO, 1970; Harvey, 1969; Church and Church, 1966) contain little information.

Some values for northern meats have been reported by Heller and Scott (1967); Mann et al. (1962); Rodhal (1954); and Farmer and Neilson (1967, 1970a). These have yet to be included in the major food composition publications.

Currently much emphasis is being placed on the determination of amino acid values for foods, not only because of protein quality investigations (Orr and Watt, 1957; Todhunter, 1960), but also because of the increased interest and knowledge of inborn errors of amino acid metabolism (Watt and Murphy, 1970).

Also needed is more information on the sodium, potassium and magnesium content of foods (Watt and Murphy, 1970). Sodium, especially, is of great importance to therapeutic dietetics in the determination of low sodium diets.

Manalo and Jones (1966), in a comparison between analyzed and calculated values of food composition, found that laboratory analysis gave significantly different results for some nutrients. This in no way invalidates food composition tables, however, because in most cases an approximation is adequate. Indeed, this is the purpose of food composition tables.

2.2 PROTEIN REQUIREMENTS

2.2.1 Report of a Joint FAO/WHO Expert Group

The FAO/WHO Expert Group (1965) states that there are two components which combine to make up the protein requirement of an individual: a basal amount of protein below which normal health and growth cannot be achieved, and an additional amount to provide for stress. Also to be considered are the extra demands necessitated by major injuries and disease, and the further addition made to allow for individual variability when the requirement for a group or a population is being estimated.

The diet must supply adequate protein for maintenance (to replace obligatory loss in the urine, feces, skin and menstrual blood), for growth in children and pregnancy, and for lactation.

The Group uses the factorial approach, and thus has determined separately the component protein requirements.

2.2.1.1 Obligatory Nitrogen Losses

Nitrogen is excreted in the urine and feces and through the skin. Urine is the most important excretory route quantitatively. The body can adjust its urinary nitrogen output to balance a wide range of nitrogen intakes, to maintain nitrogen equilibrium. Below a critical level of nitrogen intake adjustment becomes impossible, resulting in negative balance. Nitrogen excretion at this level is termed "endogenous" nitrogen and measures about 2 mg N per basal kcal, or 3 g N per day in adult man. In infants, however, the ratio is not considered to be applicable. Infants apparently have the same basal urinary nitrogen loss as adults, but their basal (resting) caloric output per kg body weight is greater. Therefore, in infants, the ratio is decreased to 1 mg nitrogen per basal kcal.

Metabolic fecal nitrogen is derived mainly from the secretions and sloughed-off cells of the digestive tract. The Group has chosen a figure of 30 mg N per kg body weight per day as an estimate of metabolic fecal nitrogen.

Nitrogen lost from the skin is excreted as skin, hair, nails, and sweat. The Group calculates the daily loss for adult males to be 20 mg N per kg body weight.

The same figure is applied to females as well because the lower skin losses in women are offset by menstrual blood loss.

2.2.1.2 Nitrogen Requirements for Growth

The Group uses the figure 2.9% for the nitrogen content of the weight gained during growth for children over one year of age. The efficiency of formation of protein during growth is taken to be 100%, because the requirements are expressed in terms of the FAO reference protein (whole hen's egg), which is defined as being 100% utilized.

The same considerations have been applied to determine the requirements of pregnancy.

2.2.1.3 The Effects of Stress on Protein Requirement

The Group recommends a 10% increase to cover the increased protein requirements imposed by minor stress. In populations not free from endemic disease, and not living in a favorable environment, the protein requirement may be increased even further.

2.2.1.4 Individual Variability

Due to the intrinsic variation in obligatory nitrogen loss among individuals, the Group has taken 10%

as a reasonable approximation to one standard deviation, and 20% as a rough equivalent of two standard deviations within which 95% of the population would fall.

2.2.1.5 Calculation of Requirements

Protein requirement is theoretically best related to lean body mass, an estimate of which can be calculated by determining weight raised to the power 0.73. However, for practical purposes the Group considers the use of body weight adequate as the loss in precision is made insignificant by the range of individual variation.

Thus the calculation for determination of protein requirement can be expressed by the following equation:

$$R = (U_B + F_B + S + G) \times 1.1$$

where,

- R = the requirements of nitrogen per kg body weight per day
- U_B = the basal urinary nitrogen loss per kg body weight per day
- F_B = the basal fecal nitrogen loss per kg body weight per day
- S = the nitrogen lost from the skin per kg body weight per day
- G = the nitrogen increment during growth per kg body weight per day

1.1 = an addition of 10% for stress

R x 6.25 = the requirement in terms of reference protein (g per kg body weight per day)

The protein requirements defined in terms of the reference protein (whole hen's egg) are given in Tables 2.2.1.5.A and 2.2.1.5.B.

TABLE 2.2.1.5.A. Protein requirements in terms of reference protein

Age (years)	g per kg body weight per day		
	Average	-20%	+20%
Children			
1-3	0.88	0.70	1.06
4-6	0.81	0.65	0.97
7-9	0.77	0.62	0.92
10-12	0.72	0.58	0.86
Adolescents			
13-15	0.70	0.56	0.84
16-19	0.64	0.51	0.77
Adults	0.59	0.47	0.71

Additional allowance for pregnancy = 6 g per day in the second and third trimesters.
Additional allowance for lactation = 15 g per day.

TABLE 2.2.1.5.B. Daily protein requirements of infants

Age (months)	g protein per kg body weight
0-3	2.3
3-6	1.8
6-9	1.6
9-12	1.2

The upper level (+ 20%) is expected to meet the requirements of almost the total population. At the lower level (-20%) all but a small proportion of the population will experience protein deficiency.

2.2.1.6 Factors Affecting Protein Requirements

According to the Group, arctic conditions do not seem to necessitate an increase in protein intake although caloric requirements are increased. However, heavy work and certain conditions may do so.

2.2.2 Dietary Standard for Canada

To calculate the protein requirement for Canadians (given in Table 2.2.2.A), the Canadian Council on Nutrition (1964*) followed the outlines established by the FAO/WHO Expert Group (1965). The Council used whole hen's egg as the reference protein, and the same formula as the Group, except that a factor of 1.3 was used to allow for individual variability, and an additional factor of 1.43 was used to bring the requirements to the terms of the average Canadian diet.

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*Although the last major revision of the Standard was in 1964, the protein requirements were re-evaluated in 1968.

TABLE 2.2.2.A. Daily protein requirements for Canadians*

Age	g protein per kg body weight
Both sexes	
1-2	1.30
2-3	1.20
3-5	1.10
5-7	0.97
7-9	0.93
Boys	
9-12	0.86
12-15	0.82
15-19	0.73
Girls	
9-12	0.86
12-15	0.80
15-19	0.74
Male adults	0.67
Female adults	0.70

*Total Canadian requirement = (U + F + S + G) x 1.3 x 1.43 x body weight in kg.

Allowance for pregnancy = the normal requirement plus 8.6 g per day.

Allowance for lactation = the normal requirement plus 22.9 g per day.

2.2.3 U.S. Recommended Daily Dietary Allowances

The U.S. Recommended Dietary Allowances of the National Academy of Sciences (1968) recommended that the protein allowance be decreased from 1.0 g per kg body weight per day to 0.9 g (Sebrell, 1968, 1969). The

nitrogen balance technique which had been used in the past was discarded, and the 1968 allowance is based on average protein requirement plus 30% to cover the needs of most individuals.

The efficiency of utilization of proteins in the United States diet is 70% of that of the ideal protein. The ideal protein requirement for a 70 kg man is taken as 35 g per day, although the complete derivation of this figure is not given. Including the 30% for variability, which gives a figure of 45.5 g per day, and the 70% efficiency of utilization, the allowance comes to 65 g protein per day, or 0.9 per kg body weight per day for a 70 kg man.

The recommended protein allowance for infants is derived from the protein content and efficiency of utilization of breast milk.

2.3 AMINO ACID REQUIREMENTS

2.3.1 Historical Background

Using the nitrogen balance technique, the original work on the determination of requirements of original amino acids was carried out by W. C. Rose and his associates for men, and by R. M. Leverton, M. E. Swendseid, and by E. T. Jones, and their associates, for women.

Rose and his associates first established the essential amino acids, valine and methionine (Rose et al., 1950), threonine (Rose et al., 1951b), isoleucine (Rose et al., 1951a), leucine, phenylalanine (Rose et al., 1951c), lysine and tryptophane (Rose et al., 1954), before going on to determine quantitative requirements.

The essential amino acid requirements for men, as determined by Rose and his associates, are summarized in Table 2.3.1.A. All values were obtained using diets containing the eight essential amino acids, plus sufficient extra nitrogen to allow the synthesis of the non-essential amino acids.

TABLE 2.3.1.A. The amino acid requirements of young men (Rose et al., 1955)

Amino acid	Range of requirements observed g per day	Tentative minimum value g per day	Definitely safe value g per day
L-tryptophane	0.15-0.25	0.25	0.50
L-phenylalanine	0.80-1.10[a]	1.10	2.20
L-lysine	0.40-0.80	0.80	1.60
L-threonine	0.30-0.50	0.50	1.00
L-methionine	0.80-1.10[b]	1.10	2.20
L-leucine	0.50-1.10	1.10	2.20
L-isoleucine	0.65-0.70	0.70	1.40
L-valine	0.40-0.80	0.80	1.60

[a]Values do not include tyrosine. Tyrosine has been shown to spare the phenylalanine requirement by 70 to 75% (Rose et al., 1955a).

[b]Values do not include cystine. Cystine has been shown to spare the methionine requirement by 30 to 89% (Rose et al., 1955b).

Rose et al. (1954) determined for each of their subjects, the smallest amount of each amino acid which would allow a positive nitrogen balance, and then designated the value for the individual with the highest requirement as the "tentative" minimal need. To define the "safe" value they multiplied the minimum value by two. Their values, thus, are probably somewhat high (Hegsted, 1963).

The essential amino acid requirements for young women are summarized in Table 2.3.1.B.

TABLE 2.3.1.B. The daily amino acid requirements of young women (Rose, 1957)

Amino acid	Range of requirements recorded mg	Tentative minimum proposed mg	Reference
L-tryptophane	82-157	160	Leverton et al. (1956e)
L-phenylalanine	120-220[a]	220[a]	Leverton et al. (1956d)
L-lysine	400-500	-	Jones et al. (1956)
L-threonine	103-305	310	Leverton et al. (1956c)
L-methionine + L-cystine	350-550[b]	-	Swendseid et al. (1956)
L-leucine	170-620	620	Leverton et al. (1956a)
L-isoleucine	250-450	-	Swendseid and Dunn (1956)
L-valine	465-650	650	Leverton et al. (1956b)

[a]Values determined with diets containing 900 mg tyrosine.

[b]Values determined with diets containing 200 mg cystine.

In contrast to Rose, Leverton et al. (1956c) designated the minimum requirement as the smallest intake of each amino acid which maintained all the subjects in nitrogen equilibrium. Nitrogen equilibrium was defined as the zone in which nitrogen excretion was within 95-105% of the intake, rather than at the point where excretion and intake were numerically equal. Thus, their requirements are considerably lower than those proposed by Rose. Hegsted (1963) used the above data of Leverton, Swendseid and Jones to calculate amino acid requirements for young women, by determining the regression between nitrogen balance and amino acid intake, and arrived at similar estimates.

Rose (1957) and Hegsted (1963) both conclude that the differences in estimates for men and women are probably due to the methods used, and that there is probably little difference between sexes, for protein requirement, except that caused by difference in lean body mass.

Although endogenous nitrogen excretion is relatively constant (Calloway and Margen, 1971), amino acid requirements among individuals are highly variable (Hegsted, 1963). Calloway and Margen (1971) also state that provided the small amounts of essential amino acids required for maintenance are supplied to the body, the pattern of amino

acids taken to meet the remainder of the nitrogen requirement is of little consequence.

Hegsted (1968a) comments that amino acid requirements have been obtained while feeding high levels of total protein, and that perhaps values are different under conditions of low protein intake. Fisher et al. (1969) found the requirements of tryptophane and lysine to be lower than those previously reported, when a low level of nitrogen was fed.

2.3.2 Report of a Joint FAO/WHO Expert Group: the Reference Amino Acid Pattern

Because amino acids form many complex interrelationships, and many compete with one another for transport, it is misleading to define absolute requirements for an individual. However, the FAO/WHO Expert Group (1957, 1965) recognized the need for a pattern of essential amino acids in protein, based on the requirements of man, to which the amino acid pattern of foods and diets could be compared. The Group (1965) chose the amino acid pattern of whole hen's egg (Table 2.3.2.A) to be used as the reference pattern because egg protein has a biological value similar to that of breast milk and is almost totally digested, and utilized when fed under appropriate conditions.

TABLE 2.3.2.A. Essential amino acid patterns for whole hen's egg

Amino acid	A/E ratio: mg per g of total essential amino acids		E/T ratio: mg amino acid per g total nitrogen	
isoleucine	129		415	
leucine	172		553	
lysine	125		403	
total "aromatic" amino acids	195		627	
phenylalanine		114		365
tyrosine		81		262
total sulphur-containing amino acids	107		346	
cystine		46		149
methionine		61		197
threonine	99		317	
tryptophane	31		100	
valine	141		454	
total essential amino acids			3215	

The Group, when expressing the amino acid reference pattern calculates two factors: (a) the A/E ratio, and (b) the E/T ratio. The A/E ratio is the proportion of an individual essential amino acid to the total essential amino acids, and can be expressed as mg essential amino acid per gram of total essential amino acids, or as g nitrogen from a specific amino acid per g of nitrogen. Total essential amino acids includes cystine and tyrosine to an amount not exceeding that provided by methionine and phenylalanine respectively.

The E/T ratio is defined as the proportion of essential amino acids to the total nitrogen. It is expressed as mg of essential amino acids per g of total nitrogen or per g of conventional protein (N x 6.25).

Both essential and non-essential amino acids must be accounted for. It must be remembered that although major emphasis is placed on the need for essential amino acids, it is possible for the amount of non-essential nitrogen to be the limiting factor.

2.4 EVALUATION OF PROTEIN QUALITY

2.4.1 Chemical Methods

With amino acid values available for many proteins it is possible to use chemical methods to estimate protein quality. Chemical methods consist of comparing the amino acid pattern of a test protein with that of a reference protein.

Although the amino acid pattern of a protein is closely related to the quality of the protein, it must also be remembered that the nutritive value is dependent on the availability of the amino acids to the animal as well (Carpenter, 1958; Morrison, 1964; Pike and Brown, 1967). Severe heat, for example, such as is involved in evaporation and sterilization processes, can decrease the availability of some amino acids. Lysine and the sulphur

containing amino acids are particularly susceptible (National Research Council, 1963). Mild heat, such as is used in home cooking, however, generally has little effect on amino acid availability (Schweigert et al., 1949; Cuthbertson, 1958; Blum et al., 1966; Liu and Ritchey, 1970).

As well, usually only the essential amino acids are considered, although the total nitrogen content is important. Thus the non-essential amino acids and non-protein nitrogen may contribute to give higher biological values than would be indicated by the essential amino acid pattern alone (Block and Mitchell, 1946).

2.4.1.1 Chemical Score

Chemical score was devised in 1946 (Block and Mitchell, 1946; Mitchell and Block, 1946) to evaluate protein quality without having to feed the test protein to animals. The content of each of the essential amino acids of the test protein is expressed as the percentage of a standard protein and the lowest percentage is taken as the chemical score. Egg protein was chosen as the reference protein because it is almost completely utilized by the growing rat and by man (Block and Mitchell, 1946). The amino acid with the lowest score is also considered to be the limiting amino acid of the protein.

Block and Mitchell (1946) found a high degree of correlation between chemical score and biological estimation.

McLaughlin et al. (1959) suggested a simplified method of chemical score determination whereby only three amino acids (lysine, methionine and cystine) are measured. They were able to demonstrate a high correlation between lysine concentration and protein efficiency ratio (PER) and between methionine plus cystine concentration and PER.

The FAO commonly uses chemical score to evaluate protein quality (Report of a Joint FAO/WHO Expert Group, 1965). The FAO chemical score is calculated as follows: First, add up the contributions of all the essential amino acids, together with those of cystine and tyrosine. Then, calculate the percentage contributions of the potentially limiting amino acids to the total. Finally, compare these percentages with the corresponding ones for the reference protein (egg protein).

2.4.1.2 Essential Amino Acid Index

The essential amino acid (EAA) index as proposed by Oser (1951) is based on the contribution of all the essential amino acids to protein quality, rather than just the most limiting amino acid, as in chemical score.

Egg protein is used as the reference protein, and the assumption is made that no essential amino acid is present in less than a concentration of 1% of that found in egg protein, so that the index will never equal zero.

The EAA index is defined as the geometric mean of the nutritional egg ratios where the egg ratio is as previously defined by Block and Mitchell (1946) (Oser, 1951).

$$\text{EAA Index} = \sqrt[n]{\frac{100a}{a_e} \times \frac{100b}{b_e} \times \cdots \times \frac{100j}{j_e}}$$

where n = number of amino acids; $a, b \ldots j$ = the per cent of each of the essential amino acids in the food protein; and $a_e, b_e \ldots j_e$ = the per cent of the respective amino acids in the standard whole egg protein. Amino acid contents are usually expressed on a nitrogen = 16 basis. An example of the calculation of the EEA index can be found in Oser (1959).

Mitchell (1954) found that the EAA index correlates well with biological value and chemical score.

2.4.2 Biological Methods

Biological evaluation is the only reliable method for determination of protein quality, because biological methods, unlike chemical methods, account for the ability of the protein to be absorbed and utilized by the body.

Usually growth or nitrogen balance methods are used, although more recently methods involving plasma amino acid levels have come into being (McLaughlin, 1963). Although growth and nitrogen-balance methods are often considered to be separate from one another, Bender (1958) points out that there is actually no distinction between the two because nitrogen balance measures the protein tissue laid down by the animal, and this is related to weight increase.

2.4.2.1 Biological Value

Biological value (BV) is determined by nitrogen balance, and was defined by Thomas (1909) as the percentage of absorbed nitrogen retained in the body. Mitchell (1924a) applied the method to growing rats, and thus the present definition is as follows: BV is the percentage of absorbed nitrogen retained in the body for maintenance and for growth. It can be expressed mathematically as:

$$BV = 100 \times \frac{I - (F - F_m) - (U - U_e)}{I - (F - F_m)}$$

where I is nitrogen intake, F is fecal nitrogen, F_m is metabolic fecal nitrogen, U is urinary nitrogen, and U_e is endogenous urinary nitrogen (Bender, 1958; Pike and Brown, 1967). Metabolic fecal nitrogen and endogenous urinary nitrogen are both measured when the subject is maintained on a nitrogen-free diet (Mitchell, 1924a).

The protein being evaluated must be fed at or below the level needed for maintenance in order to achieve maximum efficiency of utilization (Mitchell, 1924b; Sheffner, 1967). Above this level the protein may be used to supply energy. Oser et al. (1960) recommends a 10% dietary level for proteins of good quality, and a 15% level for those of lesser quality.

One criticism of BV is that it does not include a correction factor for incomplete absorption (Sheffner, 1967).

2.4.2.2 Protein Efficiency Ratio

Developed by Osborne et al. in 1919, protein efficiency ratio (PER) correlates weight change with amount of protein ingested in the growing animal. As originally proposed, food proteins were compared by determining the maximum ratio of gain in weight to protein ingested when foods supplying different percentages of protein were fed. To simplify matters, it has become customary to give protein at the 10% level (Bender, 1958; Block and Mitchell, 1946). PER is thus defined as the gain in weight in grams / grams protein ingested. PER has been criticized by Mitchell (1924c, 1944), Block and Mitchell (1946), Bender (1956), Allison (1955), Morrison and Campbell (1960), and Middleton et al. (1960).

No allowance is made for maintenance requirements of the test animal. Not all the protein will be used for growth; some will be utilized for maintenance. Results vary with the total food intake and with the level of protein in the diet. Good quality proteins will show reduced PER values as the protein content of the diet is increased from 10 to 15%, whereas the reverse is true for proteins of poor quality (Middleton et al., 1960). It is assumed that the gain in weight is composed entirely of protein; however, this is not the case. Also, proteins which do not promote growth cannot be measured. Other factors causing variation include the deviation of the experiment, the age of the animals and the sex. Females tend to give maximum PER values at lower dietary protein levels than do males (Morrison and Campbell, 1960).

PER is most commonly used in feeding experiments with small animals and infants (Sheffner, 1967) and its main attribute is simplicity. Because of the many sources of variation it is questionable as to its accuracy.

2.4.2.3 Net Protein Utilization

The net protein utilization (NPU) method for the determination of protein quality was devised by Bender and Miller (1953a, 1953b), and is defined as the nitrogen retained by the body divided by the nitrogen intake.

Thus NPU is equivalent to biological value times digestibility, and measures both the digestibility and the biological value (Pike and Brown, 1967). Expressed mathematically (Miller and Bender, 1955):

$$NPU = \frac{\text{body N of test group} - \text{body N of non-protein group} + \text{N consumed by non-protein group}}{\text{N consumed by test group}}$$

Miller and Bender (1955) used carcass analysis to determine nitrogen retention; however, in the case of humans, where carcass analysis is impossible, nitrogen balance data is used, and the formula is expressed as follows (Pike and Brown, 1967):

$$NPU = \frac{I - (F - F_o) - (U - U_o)}{I}$$

where I = nitrogen intake, F = fecal nitrogen, U = urinary nitrogen, F_o = metabolic fecal nitrogen U_o = endogenous urinary nitrogen, when subjects are on a nitrogen-free diet.

Bender (1956) found a close correlation between NPU and PER so long as food intake was adequate when PER was determined. He mained that PER correlates closely with food intake; whereas NPU is independent of food intake.

Chapman (1959) and Sabry (1964) reported that while values obtained by NPU, by PER and NPR (net protein ratio)

were similar, there was much greater variation observed between replicates of an NPU determination than in PER and NPR determinations.

2.4.2.4 Net Protein Ratio

Net protein ratio (net protein retention), abbreviated NPR (Bender and Doell, 1957), is a modification of the PER method of protein quality determination. NPR attempts to account for maintenance requirements, and thus is able to permit evaluation of poor proteins which do not promote growth. NPR values are calculated by feeding one group of rats a diet containing 10% of the test protein, and another group no protein. After ten days the algebraic difference between the weight gains is divided by the protein intake of the protein-fed group. Given mathematically (Bender, 1958):

$$NPR = \frac{\text{Weight increase of animals on test protein} - \text{weight loss of non-protein group}}{\text{weight of protein consumed}}$$

According to Morrison (1964), NPR has some advantage over PER in that it gives a more accurate estimation of the slope of the regression line; however, NPR values correspond so closely with PER values (Morrison et al., 1962) that there may be little advantage in using NPR over PER.

2.4.2.5 Net Dietary Protein Value

Net dietary protein value (ND-pV) is obtained by multiplying NPU by the dietary protein concentration (nitrogen in the mixture assayed x 6.25) and was proposed in 1958 by Platt and Miller. ND-pV is said to represent the utilizable protein in the diet and is a function of both quality and quantity.

2.4.2.6 Liver Protein Utilization

Liver protein utilization (LPU), as proposed by Mokady et al. (1969), is analogous to NPU except that it uses liver nitrogen content rather than total body nitrogen content in order to indicate protein quality. The method is based on estimation of changes in nitrogen content of the liver in relation to nitrogen consumption, and it introduces a control group to account for nitrogen consumption for maintenance. The authors found a highly significant correlation between LPU and NPU and recommend LPU as a simplified method.

2.4.2.7 Relative Growth Index

Relative Growth Index (RGI), or slope-ratio technique, was proposed by Hegsted and Chang (1965a, 1965b), who questioned standard bioassay procedures which do not use a standard. RGI is defined as the slope of the regression between dose and response expressed as a

percentage of the slope obtained with a protein of maximal nutritive value. The standard protein used by Hegsted and Chang was lactalbumin.

In follow-up papers, Hegsted and Worchester (1967) used young rats to evaluate the technique, found it to be satisfactory, and gave suggestions to improve precision (Hegsted et al., 1968).

A similar method was proposed by Derse (1958, 1960) with casein used as the control protein.

2.4.2.8 Plasma Amino Acid Ratio

Howell (1906) and Charkey et al. (1953) noted a relationship between protein content of the diet, and the levels of free amino acids in the plasma. When a protein is fed, the plasma amino acid levels rise in accordance with the amount and amino acid pattern of the protein (McLaughlin, 1963). An amino acid present in the diet in an amount in excess of its requirement will result in an accumulation of that amino acid in the blood, and an amino acid present in limited quantity will be found in small amounts (Almquist, 1954).

Making use of the above information, Longenecker and House (1959, 1961) developed the plasma amino acid ratio (PAA ratio) method for determination of protein quality. To calculate the PAA ratio, the relative changes

in concentration for each PAA after ingestion of protein are divided by the amino acid requirement of the subject, and multiplied by 100 (Longenecker and House, 1961).

PAA ratios appear to agree well with chemical scores (Longenecker and House, 1961), however, other dietary constituents such as glucose or butter may influence PAA concentrations (McLaughlin, 1963).

Stockland et al. (1970) suggest that their experiments with lysine indicate that a period of "metabolic adaptation" to different feeding methods may be necessary to obtain a useful relationship between the dietary amino acid level, and the response of the plasma amino acids.

Because a deficiency of a particular amino acid in a protein is reflected by the low level of that amino acid in the plasma, McLaughlin (1964) and McLaughlin et al. (1967) have suggested using the PAA ratio to predict the limiting amino acid of a protein.

2.5 DETERMINATION OF AMINO ACIDS

Chemical methods of protein quality determinations and treatment of some inborn errors of metabolism depend on knowledge of the amino acids present in food.

There are several methods available to determine amino acid content of foods. These include column

chromatography, electrical transport, counter-current distribution, spectrophotometric analysis, paper chromatography, thin-layer chromatography, microbial assay, isotope dilution, and gas-liquid chromatography, of which this author will briefly mention microbial assay, column chromatography, and spectrophotometric analysis.

2.5.1 Hydrolysis

Before amino acid analysis, however, the protein must be hydrolyzed to release the amino acids. Hydrolysis can be carried out using acid, alkali or enzymes. Regardless of which is used, hydrolysis gives more sources of error than does the analysis itself (Lillevik, 1970).

When acid is used for hydrolysis, ammonia is liberated from the amide linkages of aspargine and glutamine, resulting in their destruction. Through the formation of humin, a complex insoluble black polymer (West *et al.*, 1966), tryptophane is also destroyed (Horn *et al.*, 1953; Lillevik, 1970). There may also be limited destruction of serine, threonine, cystine, tyrosine, proline, aspartic acid, glutamic acid, lysine, and arginine (Lillevik, 1970).

Alkaline hydrolysis is rarely used because a large number of amino acids are destroyed, although tryptophane is stable (West *et al.*, 1966).

Enzymatic hydrolysis is used mainly when partial hydrolysis is desired (Lillevik, 1970).

2.5.2 Microbial Assay

Microbial assay (Snell, 1957) depends on the use of microorganisms with requirements for specific amino acids. In a basal culture medium with a known amount of amino acid, the growth of such an organism is proportional within limits, to the amount of amino acid present. Using various concentrations of the amino acid, the growth of the organism is measured. A standard curve is prepared, from which the amount of amino acid in the unknown can be determined.

2.5.3 Column Chromatography

Column chromatography as a method of separation and determination of amino acids was devised by Martin and Synge in 1941. The method involves adsorption of the hydrolyzed protein (amino acids) on a column of sulfonated polystyrene resin which acts as a cation exchanger. Those amino acids with the strongest positive charge will be bound most strongly, while those with a negative charge will emerge first from the column. Other factors such as polarity of the side chains (West *et al.*, 1966) will also influence the rate of elution. The amino acids are pushed along the column by a buffer of specified pH, which

supplies ions for the ion exchange. Some amino acid analyzers have two columns using different resins and buffers of different pH; one for acidic and neutral amino acids, and the other for basic amino acids.

When the amino acids leave the column they react with ninhydrin to give a colour which is measured on a recording photometer. The time of appearance of each peak on the record chart identifies the amino acid, and the area under the peak is proportional to the amount of amino acid in the sample.

An excellent and simple review of the principles of amino acid separation by ion exchange, and of the ninhydrin reaction is contained in the Theory Section, Beckman 120 Field Service Engineering Manual.*

2.5.4 Spectrophotometric Analysis

Spectrophotometric methods are based on the specific light absorption, exhibited by the coloured derivatives of the amino acids. Tyrosine and tryptophane can be directly determined by spectrophotometry without prior hydrolysis (West et al., 1966).

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*Obtainable from Beckman Instruments Inc., Spinco Division, 1117 California Avenue, Palo Alto, California 94304.

2.6 INBORN ERRORS OF AMINO ACID METABOLISM

Disturbances of amino acid metabolism (inborn errors of metabolism), although rare, are of great interest, and much time and effort have been devoted to their study. Inborn errors of metabolism are the mutation of certain genes which result in abnormal structural (non-enzyme) protein, or enzyme defects. The number of inborn errors of amino acid metabolism is large, and to deal with them thoroughly is out of the question at this time. A good review and summary by Rosenberg and Scriver (1969) is available.

Depending on the type of error, treatment may involve substrate restriction, i.e., dietary removal of foods containing the amino acid known to be accumulating in the body. If this is the case, it becomes necessary for the amino acid composition of the foods involved to be known so that their ingestion can be limited.

Although Stegink and Baker (1970) found the serum amino acids of northern Alaskan Eskimo infants and children to be normal, they indicate that preliminary studies suggest a high incidence of inborn errors of amino acid metabolism in Eskimo children. Those errors with high incidence in Eskimos known already include pseudo-cholinesterase deficiency (Gutsche *et al.*, 1967),

hereditary methemoglobinemia (Scott and Hoskins, 1958), and salt-losing congenital adrenal hyperplasia (Hirschfeld and Fleshman, 1969). Although none of the above three requires dietary restriction it is possible that due to inbreeding in isolated areas, there may be other errors which do require dietary treatment.

2.7 MINERAL REQUIREMENTS

Requirements are given for five minerals: sodium, potassium, magnesium, copper and iron. These are the minerals for which values have been obtained for northern meats.

2.7.1 Sodium Requirement

The human diet always contains a certain amount of sodium, usually about 3-7 g per day, a large part of which is in the form of sodium chloride (Pike and Brown, 1967).

The urine is the main route of sodium excretion, although small amounts are lost through the feces, sweat, tears, and other body secretions.

Except in pathological conditions such as cardiovascular disease where an excess of sodium can be harmful, and in severe heat or gastrointestinal disease where the body is sodium depleted, the daily sodium intake is given little consideration. The normal diet supplies adequate

amounts. Thus, there have been no estimates, and there is little need to define sodium requirements for the normal population (Forbes, 1964; Pike and Brown, 1967).

2.7.2 Potassium Requirement

Although potassium is an element essential to the body, no dietary requirement is specified (Williams, 1969). The average North American diet, which contains about 2-4 g potassium daily, appears to supply adequate amounts. Potassium is widely distributed in natural foods, and potassium deficiency is unlikely to occur as a result of suboptimal dietary intake (Guthrie, 1967). Potassium intake, therefore, is generally only considered in pathological conditions such as hyperkalemia (elevated serum potassium) which occurs as a result of renal failure, and hypokalemia (low serum potassium) which can result from prolonged wasting disease or gastrointestinal disease (Williams, 1969).

2.7.3 Magnesium Requirement

The human body contains about 25 g of magnesium, making it one of the major mineral constituents of the body (Hegsted, 1968b); however, the requirement for magnesium has yet to be firmly established. Most authorities (Leverton, 1961; Hathaway, 1962; Wacker and Vallee, 1964; Hegsted, 1968b) recommend an intake of

approximately 300-400 mg per day, which is the amount of magnesium contained daily in the average North American diet.

In contrast, Seelig (1964) maintains that 5 mg magnesium per kg body weight per day (300 mg per day) is too low, and that the majority of the population may be in a state of suboptimal magnesium nutrition. After reviewing the literature on magnesium balance, she recommends a daily intake of 6-10 mg magnesium per kg body weight.

The U.S. Recommended Daily Allowances (1968) advocates an intake of 350 mg per day for adult men, and 300 mg per day for adult women. These figures are based on balance studies and will maintain positive balance.

Although magnesium deficiency has been produced experimentally in man, it is rarely seen under normal conditions. However, a deficiency can occur in man as a result of severe malabsorption or gastrointestinal disease (Pike and Brown, 1967).

2.7.4 Copper Requirement

Although copper deficiency is not uncommon in animals, it has yet to be produced in man (Morrison and Campbell, 1963). According to Cartwright and Wintrobe (1964), of the 2.0 to 5.0 mg of copper ingested daily, 0.6 to 1.6 mg is absorbed. From 0.5 to 1.3 mg is excreted

in the bile, and 0.01 to 0.06 mg in the urine.

The daily copper requirements, obtained by Priev (1966) using balance trials, are given in Table 2.7.4.A.

TABLE 2.7.4.A. Copper requirements

Age (years)	Copper requirement (mg/day)
6 months - 1 year	0.5-0.6
1- 3	1.5-2.0
3-10	2.0-2.5
10-14	2.0-3.0
over 14	2.5-3.5

For girls 6 to 10 years of age Engel et al. (1967) recommends a copper intake of 2.5 mg per day, which corresponds well with Priev's data. The 2.5 mg intake would include the copper necessary for growth, skin loss, and a margin of safety.

The Canadian Council on Nutrition (1964) states that copper balance in adults will occur with a daily intake of 2-3 mg. The Council, although indicating that insufficient information is available to determine copper requirements, recommends an intake of copper 1/10-1/5 that of the recommended iron allowance. Iron and copper appear to be interrelated. The iron requirements of Canadians are given in Section 2.7.5.

2.7.5 Iron Requirements

Iron is an element, the requirement of which has not yet been fully established because of the large number of factors involved. The human body contains about 4-5 g of iron, most of which is contained in the haemoglobin of the blood (Moore and Dubach, 1962). The excretion of iron is limited, and although small amounts are lost in the urine, in sweat and body secretions, and in the desquamated cells of the skin and gastrointestinal tract, iron balance is controlled by the rate of absorption (Moore and Dubach, 1962). Absorption is so varied among individuals, and is affected by so many factors, that a definite requirement is very difficult to establish (Moore and Dubach, 1962).

The average iron intake (obtained through survey data) appears to be between 10 and 30 mg per day (Moore, 1964). Of this, about 10-15% is generally believed to be absorbed (Pike and Brown, 1967).

However, iron requirements have been estimated by various authorities. The recommendations of the American Medical Association (1968) are given in Table 2.7.5.A.

The U.S. Recommended Daily Allowances (RDA) (Sebrell, 1969) are given in Table 2.7.5.B.

TABLE 2.7.5.A. Estimated dietary iron requirements (AMA, Council on Food and Nutrition, 1968)

	Absorbed iron requirement mg/day	Daily food iron* requirement mg/day
Normal men and non-menstruating women	0.5-1.0	5-10
Menstruating women	0.7-2.0	7-20
Pregnant women	2.0-4.8	20-48[a]
Adolescents	1.0-2.0	10-20
Children	0.4-1.0	4-10
Infants	0.5-1.5	1.5 mg/kg[b]

*Assuming 10% absorption.

[a]This amount of iron cannot be derived from the diet and should be met by iron supplementation in the latter half of pregnancy.

[b]To a maximum of 15 mg.

TABLE 2.7.5.B. Recommended daily dietary allowances, 1968

Age (years)	Iron requirement (mg/day)	
	Males	Females
Birth - 1/6	6	6
1/6 - 1/2	10	10
1/2 - 3	15	15
3 - 10	10	10
10 - 12	10	18
12 - 18	18	18
18 - 55	10	18
55 +	10	10

The RDA is based on 10% absorption of food iron, and for men is readily obtainable from a normal diet. For women, however, the recommended 18 mg per day will be difficult to obtain; however, if obtained will enable the women to store sufficient iron to make iron supplementation during pregnancy unnecessary (Sebrell, 1969).

The RDA for iron have been criticized recently. Hegsted (1970), because of the great variability of iron absorption and availability, questions the validity of including iron in the Recommended Daily Allowances.

Beaton et al. (1970), on the basis of iron balance studies with menstruating women, recommends an intake of only 11-12 mg iron per day for women, rather than the 18 mg recommended in the RDA. In direct contrast, Hegsted (1970) has said that the RDA for iron for women should be higher.

Iron intakes recommended by the FAO/WHO Expert Group (1970) are based on estimates of physiological losses of iron from the body, and of increments in body iron during growth. The recommended intakes are designed to meet the demands of 95% of the population, and are expressed in terms of three types of diet according to the content of animal foods. The types of diet, with related iron absorption percentages are given in Table 2.7.5.C., and the iron requirements themselves in Table 2.7.5.D.

TABLE 2.7.5.C. Absorption of iron from diets containing different proportions of foods of animal origin

	Assumed upper limit of iron absorption by normal individuals
Less than 10% of calories from foods of animal origin	10%
10-25% of calories from foods of animal origin	15%
More than 25% of calories from foods of animal origin	20%

TABLE 2.7.5.D. Recommended daily intakes of iron (FAO/WHO, 1970)

	Absorbed iron required mg	Recommended intake according to type of diet		
		Animal foods below 10% of calories mg	Animal foods 10-25% of calories mg	Animal foods over 25% of calories mg
Infants				
0- 4 months	0.5	a	a	a
5-12 months	1.0	10	7	5
Children				
1-12 years	1.0	10	7	5
Boys				
13-16 years	1.8	18	12	9
Girls				
13-16 years	2.4	24	18	12
Menstruating women[b]	2.8	28	19	14
Men	0.9	9	6	5

[a] Breast-feeding is assumed to be adequate.

[b] For non-menstruating women the recommended intakes are the same as for men.

The absorbed iron requirement for the first half of pregnancy is about 0.8 mg per day; during the second half it is about 3 mg per day; and during lactation 1 mg per day. An additional 250 mg of iron is lost at delivery; however, the Group suggests that if the recommendations made for menstruating women are followed throughout pregnancy and lactation, the iron absorbed in excess of the requirement during the first half of pregnancy and during lactation could be utilized to cancel the deficit.

The Group is also of the opinion that for women whose iron intake throughout life has been at the recommended levels (see Table 2.7.5.D.), the daily intake of iron during pregnancy and lactation should be the same as that recommended for non-pregnant, non-lactating women of child-bearing age.

The Group admits, however, that few women fall into such a category.

The Canadian Council on Nutrition (1964) recommends the daily intakes of iron listed in Table 2.7.5.E. These intakes should cover body losses, which are very low, and negative balance should not occur, although there is a great variation in absorption of iron.

TABLE 2.7.5.E. Recommended daily intakes of iron

Age	Iron, mg/day	
	Males	Females
Birth - 10 years	5	5
11 - 16 years	12	12
17 years onward	6	10
3rd trimester of pregnancy and lactation		3 extra

III. EXPERIMENTAL PROCEDURE

3.1 GENERAL PREPARATION OF SAMPLES

The samples of meat, fish and poultry were collected from various locations in the Canadian Arctic, and were shipped frozen to Montreal, where they remained frozen until analyzed.

The frozen samples were thawed, the inedible parts removed, and the edible portion ground and mixed three times in an Electrolux grinder. A weighed portion plus additional water required to bring the moisture content to about 30% was homogenized in a Waring blendor. The samples were then freeze-dried as described by Farmer and Neilson (1967), making the samples easy to store and to use.

The freeze-dried samples were stored in individual screw-top glass jars in the freezer. To prevent moisture uptake, activated alumina in terylene mesh bags, surrounded by plastic, was added to each jar as described by Farmer and Neilson (1970a).

The sample of ring seal was high in fat which was removed with ethyl ether before freeze-drying (Farmer and Neilson (1970a).

The samples of arctic hare, white whale meat and white whale liver were classified as "dog food." However, as other samples of the same animals were unavailable, it was decided to analyze the dog food. It was felt that the values obtained would be similar to those of the same animals considered fit for human consumption.

3.2 CRUDE PROTEIN DETERMINATION

Protein was determined by Macrokjeldahl* (A.O.A.C., 1965) on the samples of pintail duck, snow goose, common loon, arctic char, losh fish, lake trout, arctic hare, muskrat, reindeer steak, bearded seal, white whale and arctic ground squirrel; and by Microkjeldahl (A.O.A.C., 1965) for partridge, beaver, caribou, moose, snowshoe rabbit, ringed seal and walrus.

3.3 AMINO ACID DETERMINATION

3.3.1 Hydrolysis of samples

The freeze-dried samples were hydrolyzed in duplicate with 6 N HCl as outlined in the Instruction Manual for the Beckman Model 120 Amino Acid Analyzer,[1] with the following modifications. Samples of 100 mg, and 10 ml of

*Carried out by technician.

[1]Spinco Division, Beckman Instruments Inc., Palo Alto, California.

6 N HCl were used. The tubes were sealed in an oxygen-gas flame, but were not evacuated. Nor was nitrogen bubbled through the samples. It was felt that these steps were unnecessary for food samples destined for food composition tables (Anastassiadis, 1970, personal communication).

The samples were hydrolyzed at 110°C ± 1° in a Fisher Isotemp oven.[2] After cooling, the hydrolysates were evaporated to dryness with a rotary flash evaporator.[3] The residues were washed out of the flask and dissolved in 5.0 ml of pH 2.2 citrate buffer, and filtered through a Millipore Filter,[4] into screw-top glass jars. The samples were then stored at -6°C.

Before analysis, the samples were diluted with pH 2.2 citrate buffer by a factor of five.

3.3.2 Column Chromatography

The protein hydrolysates were analyzed by column chromatography on a Beckman 120C Amino Acid Analyzer,[5]

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[2]Fisher Isotemp Oven, Senior Model. Fisher Laboratory Appliances, Montreal, Quebec.

[3]Model FE2, Rotary Flask Evaporator, Buchner Instruments, Fort Lee, U.S.A.

[4]Millipore Filter Corporation, Bedford, Mass.

[5]Beckman 120C Amino Acid Analyzer. Beckman Instruments Inc. Palo Alto, California.

according to the Instruction Manual, with the exception that PA28 resin[6] was used in place of AA15 resin. 0.5 cc of sample was applied to each column.

3.3.3 Tryptophane Analysis

Tryptophane is destroyed by acid hydrolysis and therefore could not be determined by automatic analyzer. Thus tryptophane analysis was carried out by the photometric method of Shaw and McFarlane (1938). Sample size of 25 mg was used, with 1 ml 10% NaOH. To read absorbance a Coleman Hitachi 124 Double Beam Spectrophotometer[7] at 550 mu was used.

3.4 DETERMINATION OF SELECTED MINERALS

3.4.1 Hydrolysis

The freeze-dried samples (250 mg), in beakers each covered with a watch glass, were heated with 10 ml concentrated nitric acid, until the solution became pale, clear orange in colour, according to the method of Hoffman (1970). The samples were then cooled, and the watch glasses

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[6]Beckman Custom Research Resin. Spinco Division of Beckman Instruments Inc. Palo Alto, California.

[7]Coleman Instruments, 42 Madison Street, Maywood, Illinois 60153.

rinsed with distilled water into the beakers. The watch glasses were replaced, and the samples reheated until they turned a pale yellow colour. After cooling, the samples were washed into large test tubes, brought up to 50 ml with distilled water, covered with Parafilm,[8] and stored at room temperature.

3.4.2 Atomic Absorption Analysis

The prepared samples were analyzed by atomic absorption spectroscopy for copper, iron and magnesium using a Unicam SP90 Atomic Absorption Spectrophotometer,[9] as outlined in the Unicam Atomic Absorption Methods.[9]

3.4.3 Flame Emission Analysis

The samples as prepared above were analyzed by flame emission photometry for sodium and potassium, using the Unicam SP90 Atomic Absorption Spectrophotometer,[9] as outlined in the Unicam Atomic Absorption Methods.[9]

Because the samples were high in sodium and potassium, the necessary dilutions were made and accounted for accordingly.

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[8]Parafilm, American Can Company, Neenah, Wisconsin.

[9]Unicam Instruments Limited, York Street, Cambridge, England. Available from Canadian Laboratory Supplies Limited.

IV. RESULTS AND DISCUSSION

4.1 AMINO ACID DETERMINATION

The samples analyzed for amino acids are described in Table 4.1.A, and the amino acid content, expressed as g of amino acid per 100 g of protein, is given in Table 4.1.B. One sample of each animal was analyzed in duplicate.

Values obtained for the tryptophane content of the meats are very low, and therefore are not included in Table 4.1.B. They are given in Appendix Table 1. The low values probably are a result of interference of the dark colour of the samples with the colorimetric readings.

Values for cystine are also unavailable. A peak for cystine was not recorded on the recording photometer of the amino acid analyzer. As explained in the Literature Review, cystine is particularly sensitive to acid hydrolysis, and therefore probably was destroyed during hydrolysis.

Because the amino acid composition of many meats is still unknown, or unpublished, comparisons of data obtained with published data are fairly general. The values taken from the literature and used for comparison are given in Appendix Table 2.

TABLE 4.1.A. Samples analyzed for amino acids

Common name	Scientific name	Location	Description*
Birds			
Duck, pintail	Anas acuta	Inuvik	entire bird
Goose, snow	Chen hyperborea	Kendall Is.	adult bird minus head and gizzard
Loon, common	Gavia immer	Mackenzie delta	whole bird minus sub-cutaneous fat
Partridge	Alectoris graeca		entire bird minus skin and lungs
Fish			
Char, arctic	Salvelinus alpinus		fully dressed
Losh fish	Lota lota	Tuktoyaktuk	centre section, including entrails
Trout, lake	Salvelinus namaycush	Tuktoyaktuk	entire fish, including entrails
Mammals			
Beaver			thigh section
Caribou	Rangifer arcticus	Baffin Is.	large piece of dark red muscle
Hare, arctic	Lepus americanus	Starnes Fiord N.W.T.	dark red meat (dog food)
Moose	Alces alces		muscle

(table continued)

TABLE 4.1.A. (continued)

Common name	Scientific name	Location	Description*
Mammals (cont.)			
Muskrat	Ondatra zibethica	Mackenzie delta	muscle
Rabbit, snowshoe	Lepus americanus	Tuktoyaktuk	entire rabbit
Reindeer	Rangifer tarandus groenlandicus	Tuktoyaktuk	rump steak
Seal, bearded, meat	Erignathus barbatus	Spence Bay	meat
Seal, bearded, liver		Sachs Harbour	liver
Seal, ringed, meat	Pusa hispida	Sachs Harbour	pelvic area
Squirrel, arctic ground	Citellus parryi	Ya Ya River	entire animal minus one leg
Walrus	Odobenus rosmarus	Igloolik	back
Whale, white, meat	Delphinapterus leucas	Starnes Fiord N.W.T.	meat (dog food)
Whale, white, liver		Starnes Fiord N.W.T.	liver (dog food)
Whale, white			canned

*before being freeze dried all inedible portions were removed

TABLE 4.1.B. Amino acid content of northern Canadian birds, fish and mammals (grams amino acid per 100 grams edible protein[1])

	% Protein	Alanine	Arginine	Aspartic acid	Glutamic acid	Glycine	Histidine
Birds							
Duck, pintail	23.7	6.73	6.73	11.26	16.27	5.08	2.69
Goose, snow	23.1	6.16	6.22	9.00	14.86	6.34	2.78
Loon, common	22.4	5.71	6.26	8.80	13.47	5.47	2.61
Partridge	44.3	5.99	6.61	9.07	15.34	5.21	5.65
Fish							
Char, arctic	20.8	6.41	6.62	10.60	14.57	6.34	5.23
Losh fish (burbot)	24.9	6.97	7.13	11.94	18.06	6.87	2.22
Trout, lake	22.4	6.37	5.99	10.32	15.05	5.99	3.35
Mammals							
Beaver	21.3	5.85	6.90	9.27	16.42	5.04	4.48
Caribou, raw	26.1	6.48	6.54	10.53	16.72	5.09	3.93
Hare, arctic[2]	24.6	5.58	5.89	8.71	14.03	5.38	2.77
Moose	23.4	6.58	7.37	10.72	18.45	4.99	3.84
Muskrat	19.9	6.68	5.41	10.07	14.63	6.47	3.39
Rabbit, snowshoe	21.9	6.23	6.17	10.27	15.85	5.70	4.21
Reindeer, steak	20.7	6.94	7.35	10.36	17.22	6.02	3.59
Seal, bearded, meat	28.4	6.25	5.69	9.34	15.09	4.70	7.57
Seal, bearded, liver	22.8	6.86	4.80	9.78	13.24	6.01	3.16
Seal, ringed, meat[3]	23.2	7.20	6.08	9.12	15.19	8.32	3.84
Squirrel, ground	21.1	5.99	5.87	9.28	15.53	5.74	2.96
Walrus	26.0	5.81	6.30	9.30	16.88	5.38	4.77
Whale, white, meat[2]	27.8	6.09	5.11	8.98	15.02	5.47	5.32
Whale, white, liver[2]	25.2	7.15	5.81	9.71	12.27	6.74	4.07
Whale, white, canned	29.9	5.63	5.41	8.61	14.73	5.90	5.46

(table continued)
(see footnotes at end of table (p.55))

TABLE 4.1.B. (continued)

	% Protein	Isoleucine*	Leucine*	Lysine*	Methionine*	Phenyl-alanine*
Birds						
Duck, pintail	23.7	5.08	9.36	8.81	2.75	4.71
Goose, snow	23.1	4.71	8.39	7.91	2.42	4.23
Loon, common	22.4	4.20	8.32	8.48	2.38	4.36
Partridge	44.3	4.48	8.96	9.13	2.80	4.42
Fish						
Char, arctic	20.8	4.04	8.44	10.18	3.00	4.39
Losh fish (burbot)	24.9	5.12	9.24	9.66	3.43	4.75
Trout, lake	22.4	4.45	8.13	9.17	2.91	4.39
Mammals						
Beaver	21.3	4.98	9.21	10.70	2.61	4.60
Caribou, raw	26.1	5.32	9.84	9.89	2.31	4.86
Hare, arctic[2]	24.6	4.25	8.09	7.89	2.41	4.00
Moose	23.4	5.48	10.05	10.35	2.92	4.93
Muskrat	19.9	4.45	9.22	9.01	1.91	4.67
Rabbit, snowshoe	21.9	4.81	8.96	8.67	2.08	4.51
Reindeer, steak	20.7	5.18	9.69	9.28	2.51	5.01
Seal, bearded, meat	28.4	4.92	10.72	10.84	2.16	5.14
Seal, bearded, liver	22.8	4.62	10.14	9.05	2.00	5.65
Seal, ringed, meat[3]	23.2	4.48	9.91	8.32	2.24	5.12
Squirrel, ground	21.1	4.45	8.38	8.31	2.51	4.38
Walrus	26.0	4.83	9.97	11.13	2.51	5.20
Whale, white, meat[2]	27.8	4.75	9.96	10.43	1.19	4.65
Whale, white, liver[2]	25.2	3.66	11.45	8.43	1.74	5.76
Whale, white, canned	29.9	4.30	9.33	9.88	2.15	4.58

(table continued)
(see footnotes at end of table (p.55))

TABLE 4.1.B. (continued)

	% Protein	Proline	Serine	Threonine*	Tyrosine**	Valine*
Birds						
Duck, pintail	23.7	4.59	4.22	5.14	3.92	5.45
Goose, snow	23.1	4.83	3.99	4.47	3.20	4.89
Loon, common	22.4	4.83	3.96	4.44	3.09	4.04
Partridge	44.3	3.81	3.86	4.76	3.69	5.54
Fish						
Char, arctic	20.8	4.25	4.18	5.02	3.49	5.58
Losh fish (burbot)	24.9	4.70	5.18	5.23	3.80	5.39
Trout, lake	22.4	3.84	4.06	4.72	3.51	5.05
Mammals						
Beaver	21.3	4.29	4.04	4.54	3.48	4.85
Caribou, raw	26.1	4.40	4.11	5.15	3.76	5.50
Hare, arctic[2]	24.6	4.35	3.48	4.25	3.23	4.35
Moose	23.4	4.63	4.08	5.24	4.20	6.21
Muskrat	19.9	4.77	4.35	4.88	3.07	5.30
Rabbit, snowshoe	21.9	4.81	4.04	4.99	3.50	5.34
Reindeer, steak	20.7	4.76	4.18	5.01	3.76	5.77
Seal, bearded, meat	28.4	3.59	3.65	4.26	3.04	5.03
Seal, bearded, liver	22.8	5.28	4.62	5.04	3.83	6.20
Seal, ringed, meat[3]	23.2	6.24	4.48	4.48	1.92	5.28
Squirrel, ground	21.1	4.45	4.00	4.51	3.35	4.71
Walrus	26.0	4.40	3.79	4.65	3.30	4.40
Whale, white, meat[2]	27.8	3.72	3.30	4.08	2.89	4.39
Whale, white, liver[2]	25.2	5.23	5.17	5.06	3.78	6.74
Whale, white, canned	29.9	4.41	3.31	3.92	2.92	4.03

[1] values are representative of the entire edible animal

[2] classified as dog food

[3] boiled

*essential amino acids for man

**semi-essential amino acids for man

Values obtained for the essential amino acids of pintail duck compare favourably with those for domestic duck (Orr and Watt, 1957). Protein content is also similar, being 21.4% for domestic duck and 23.7% for pintail duck. The values for domestic duck were probably obtained using microbial assay. Pintail duck is higher than whole hen's egg (Nutrition Division, FAO, 1970) in leucine and lysine, but lower in methionine, phenylalanine and valine, on a g amino acid per 100 g protein basis. However, on edible portion basis, pintail duck, which contains 23.7% protein, is higher in all the essential amino acids than is hen's whole egg which contains only 12.4% protein.

The amino acid content of snow goose, on g amino acid per 100 g protein basis, compares favourably with that of chicken (Nutrition Division, FAO, 1970) and turkey (Liu and Ritchey, 1970). Methionine, glutamic acid and tyrosine are slightly lower, and may have been partially destroyed during hydrolysis. Methionine is unstable also during ion exchange (Lillevik, 1970). Protein content of snow goose, chicken and turkey is similar; however, snow goose contains nearly twice as much protein as does hen's whole egg. Therefore, on a g amino acid per 100 g protein basis, snow goose is lower in most essential amino acid than is egg, but on a total edible portion basis, snow goose is more than adequate in the essential amino acids.

The essential amino acid pattern of common loon compares well with that of domestic duck; however, when compared with chicken and turkey, the loon is lower in glutamic acid, isoleucine and valine. Protein contents of the four are similar. On a g amino acid per 100 g protein basis, loon is lower in most of the essential amino acids, but higher in lysine, than is hen's whole egg. Like the other birds, the common loon is, however, twice as high in protein as is hen's whole egg.

Partridge contains amino acids in amounts similar to chicken and turkey, although histidine is higher and isoleucine lower in partridge. Partridge, however, contains a very high percentage of protein (44.3%). Thus, partridge, when compared to hen's whole egg on an edible portion basis, is very high in the essential amino acids, especially lysine.

Arctic char and lake trout values compare favourably with general values for all types of fresh fish and for Clupeiformes salmonoidel given by the Nutrition Division of FAO (1970). Compared to whole hen's egg on a g amino acid per 100 g protein basis, the two fish are generally lower in the essential amino acids, except for lysine which is higher. On an edible portion basis, however, arctic char and lake trout are higher in the essential amino acids because they contain considerably more protein than does hen's egg.

Losh fish (burbot) values obtained, when compared to values given by Church and Church (1966) are generally higher in the essential amino acids except for isoleucine and valine, which are similar. A value of 24.9% protein was obtained, whereas Church and Church (1966) report only 17.4% protein for losh fish. Losh fish compares to hen's whole egg in a manner similar to the other fish and birds previously mentioned.

The amino acid pattern for beaver is similar to that of beef, pork and lamb (Kiernat et al., 1964; Nutrition Division of FAO, 1970), but is higher in histidine and lysine. Beaver is also considerably higher in protein than beef, lamb or pork. The pattern of essential amino acids, compared to that of hen's whole egg is similar to that of the birds and fish. Beaver is high only in lysine when compared on a g amino acid per 100 g protein basis, but on edible portion basis, beaver is much higher than egg in all the essential amino acids, because it contains 21.3% protein, compared to 12.4% for egg.

Muskrat compares well with pork, lamb and beef, except that it is slightly lower in arginine and methionine. Methionine, as mentioned earlier, is easily destroyed during hydrolysis, and is unstable during ion exchange. Muskrat compares to hen's whole egg in a manner similar to the other meats. Muskrat is considerably higher in protein (19.9%) than is egg (12.4%).

The amino acid pattern for caribou compares favourably with that for beef, lamb and pork. On a g amino acid per 100 g protein basis, caribou is higher in lysine than whole hen's egg, the same in threonine, and lower in the other essential amino acids. Caribou, however, contains 26.1% protein, whereas hen's whole egg contains only 12.4%.

Reindeer steak and moose also compare well with beef, lamb and pork in amino acid content. They are, however, considerably higher in protein. Both compare well with egg protein, although they are higher in lysine. Again, on an edible portion basis, reindeer steak and moose are higher in the essential amino acids than egg, because they are higher in protein.

Caribou, reindeer and moose are probably higher in protein than pork, lamb and beef, because of less fat. The wild meat is not marbled with fat as is meat from domestic animals.

The amino acid pattern of arctic ground squirrel fits well with those of the other samples tested, and thus would appear to be reasonable. Arctic ground squirrel contains 21.1% protein, compared to 12.4% for egg.

The values for bearded seal meat and ringed seal meat (cooked) align well with those of the other samples. Ringed seal meat contains somewhat greater amounts of

alanine, glycine and proline than does bearded seal. Bearded seal is high in histidine; however, according to Sirny et al. (1950) the histidine content of the different meats varies considerably, and is low in beef. Ringed seal meat and bearded seal meat compare to hen's whole egg in a manner similar to the meats already mentioned. Although the ringed seal sample was cooked, there should be little effect on amino acid pattern as explained in the Review of Literature. Both species of seal are considerably higher in protein than hen's egg, being 28.4% protein for bearded seal and 22.8% for ringed seal.

Walrus compares favourably with beef, pork and lamb, being high only in histidine. Walrus is, however, higher in protein than the three domestic animals.

The amino acid content of white whale meat (dog food) differs considerably from some of the values given in the Nutrition Division of FAO publication (1970), which reports lower values for alanine, glutamic acid, glycine, histidine and lysine, and higher values for methionine and isoleucine. A value of 8.50 g isoleucine per 100 g protein is reported for white whale by the Nutrition Division of FAO (1970). This seems high compared to the isoleucine content of other mammals. Also, the value obtained for canned white whale corresponds well with the value obtained for fresh white whale, which suggests that the FAO value

for isoleucine which was determined on a single sample may be out of line. The per cent protein also varies considerably.

The amino acid content of arctic hare compares fairly well with that of domestic rabbit (Nutrition Division of FAO, 1970) on a g amino acid per 100 g protein basis, although arctic hare is somewhat lower in aspartic acid and glutamic acid. Snowshoe rabbit is higher in glycine and histidine, and lower in leucine than domestic rabbit. Both fall into the same category as do the other meats when compared to hen's whole egg. Both are high in lysine and adequate in leucine. Again, both are considerably higher in protein than is hen's whole egg.

Amino acid content was obtained for bearded seal liver, and for white whale liver. Both contain more lysine than does beef or pork liver (Orr and Watt, 1957). Bearded seal liver contains less arginine and white whale liver less glutamic acid, but more histidine than does beef or pork liver. Compared to hen's whole egg, both contain more leucine and lysine, adequate phenylalanine and threonine and less of the other essential amino acids. Bearded seal liver and white whale liver are, however, considerably higher in protein than is hen's whole egg.

In general, the values obtained for the amino acid content of meats, fish and birds from the Canadian north seem to agree well with those of similar species. The wild animals contain a higher percentage of protein than do the domestic animals, probably because wild animals usually contain less fat. Northern animals have a greater energy expenditure than do domestic animals for several reasons. They use energy to search for food (which is scarce in the first place), to keep warm, and to escape from predators.

Compared to hen's whole egg (Nutrition Division of FAO, 1970) on a g amino acid per 100 g protein basis, the meats are generally high in lysine, adequate in leucine, and low in the other essential amino acids. The wild animals are considerably higher in protein than egg which contains only 12.4% protein. Therefore, on an edible portion basis, the meats would contain adequate amounts of the essential amino acids.

It is unfortunate that no meaningful values were obtained for cystine and tryptophane because the sulphur-containing amino acids (cystine and methionine) (Canadian Bulletin on Nutrition, 1964) and tryptophane (Pike and Brown, 1967) are likely to be the most limiting amino acids when chemical score is calculated. However, in view of the fact that meats in general are of high quality

protein, calculation of chemical score is not necessary to conclude that the meats, fish and birds of the Canadian arctic are also of high quality protein.

4.2 MINERAL ANALYSIS

Values for sodium, potassium, magnesium, copper and iron were obtained. The samples are described in Table 4.2.A, and the values, expressed as mg of mineral per 100 g edible portion, are given in Table 4.2.B, except for the iron values which are given in Table 4.2.C. Five samples were done in duplicate, which correlated very well. Therefore, the remainder were done singly. The values used for reference comparison are given in Appendix Table 3.

4.2.1 Sodium

Values obtained for sodium appear to agree well with those for similar animals reported in the literature. The sodium content of partridge, losh fish and ground squirrel seem to be somewhat high. Perhaps some salt was added at the time of capture, although it seems unlikely. Many factors, resulting in discrepancies, are involved: the time of year and the age of the animal when killed, the location, the cut of the meat, and the treatment and processing of the meat.

The canned foods all have salt added in varying amounts.

TABLE 4.2.A. Description of samples analyzed for mineral content

Common name	Scientific name	Location	Description* as received
Birds			
Duck, pintail	Anas acuta	Inuvik	entire bird received
Goose, snow	Chen hyperborea	Kendall Is.	1. entire bird, minus gizzard
"		"	2. entire bird, minus head, gizzard removed
"		"	3. entire bird, gizzard removed
"		"	4. entire bird, gizzard removed
"		"	5. entire bird, gizzard removed, immature bird
"		"	6. entire bird, gizzard removed, immature bird
"		"	entire bird, boiled in 6 c H_2O for 2 hr, gizzard included
" gizzard		"	gizzards from 2, 3 and 4
Loon, common	Gavia immer	Mackenzie delta	entire bird, subcutaneous fat removed with feathers and therefore is not included in the analysis
Partridge	Alectoris graeca		two entire birds minus head and feathers

(table continued)

TABLE 4.2.A (continued)

Common name	Scientific name	Location	Description* as received
Fish			
Char, arctic	Salvelinus alpinus		raw, fully dressed, donated by Quebec United Fishermen
"			1. half of above sample cooked for 35 minutes in 3 c boiling water
"		Monk Is.	2. Received boiled canned [a]
Losh (burbot)	Lota lota	Tuktoyaktuk	entire fish minus entrails
Trout, lake	Salvelinus namaycush	Spence Bay	1. centre section, including entrails
"		Tuktoyaktuk	2. entire fish, including entrails
"		Igloolik	3. centre section
"			canned,[a] Ookpik brand, steak style, salt added
"		Igloolik	boiled, mid-section including skin, bones, fins
" paste			canned[a] with shortening, cereals, spices and salt
" balls			canned[a] Cocktail Fish Balls in mustard sauce. Includes lake trout, shortening, cereals, wheat flour, water, mustard, salt and spices, Ookpik brand

(table continued)

TABLE 4.2.A (continued)

Common name	Scientific name	Location	Description* as received
Fish (continued)			
Whitefish	Coregonus clupeaformis		1. fillet
"		Tuktoyaktuk	2. entire fish, minus entrails
Mammals			
Beaver	Castor canadensis		two thigh sections
Caribou	Rangifer arcticus	Spence Bay	1. coarse textured meat
"		Baffin Is.	2. meat, little connective tissue
"		Baffin Is.	rump meat
"		Baffin Is.	boiled meat, included cooking water
Moose	Alces alces		meat
Muskrat	Ondatra zibethica	Mackenzie	1. entire animal, arrived partly thawed
"		Mackenzie	2. entire animal
"		Mackenzie	3. entire animal, partially thawed
"		Mackenzie	4. entire animal, partially thawed
"		Mackenzie	5. entire animal, partially thawed
"		Mackenzie	6. entire animal, partially thawed
"		Mackenzie	7. entire animal, partially thawed

(table continued)

TABLE 4.2.A (continued)

Common name	Scientific name	Location	Description* as received
Mammals (continued)			
Muskrat	Ondatra zibethica	Mackenzie	8. entire animal, partially thawed
"		Mackenzie	9. entire animal, partially thawed
"		Mackenzie	part of sample 1, boiled in water for 5 1/2 hr
Rabbit, snowshoe	Lepus americanus (see also, hare)		entire animal
Reindeer	Rangifer tarandus groenlandicus	Tuktoyaktuk	three rump steaks
Seal, bearded, liver	Erignathus barbatus	Sachs Harbour	no details
Seal, ringed, meat	Pusa hispida	Sachs Harbour	1. sample from pelvic area arrived thawed
Seal, ringed, meat		Hall Beach, N.W.T.	2. rib section, high in fat
Seal, ringed, meat		Igloolik area	boiled rib section plus cooking water, very lean
Squirrel, ground	Citellus parryi	Ya Ya River	entire animal, minus one leg
Walrus	Odobenus rosmarus divergens	Igloolik	back meat

(table continued)

TABLE 4.2.A (continued)

Common name	Scientific name	Location	Description* as received
Mammals (continued)			
Whale, white, meat	Delphinapterus leucas	Inuvik	Beluga (white) whale
Whale, white, meat			canned[a] with salt and water, Ookpik brand
			canned[a] (stew) in tomato sauce, with carrots, onions, tomatoes, flour, shortening, water, salt and spices
Whale, white, muktuk			1. canned[a] with salt and water, Ookpik brand Muktuk is the outer skin of the Beluga (white) whale which is about 1/2" to 3/4" thick with about 1/2" of attached blubber (Heller and Scott,
			2. canned[a] muktuk Eskimo style, with added water and salt, Ookpik brand
Whale, white, sausage			canned[a] muktuk sausage with minced head, skin, heart, flipper and mild salt and sage spice, Ilkalu brand

(table continued)

TABLE 4.2.A (continued)

Common name	Scientific name	Location	Description* as received
Dog food			
Beef, stewing		N.W.T.	
Dog, Eskimo sled		Grise Fiord, N.W.T.	1. rump meat from 5-month female
"		"	2. meat
Fox, arctic	Alopex lagopus	S.Ellesmere Is.	leg and neck meat from 3 foxes
Hare, arctic	Lepus americanus (see also, rabbit)	Starnes Fiord N.W.T.	meat; little fat
Musk-ox	Ovibos moschatus	Starnes Fiord	coarse meat, no bone, little fat, from cervical region of female
Seal, ringed, liver	Pusa hispida	Starnes Fiord	
" meat		Starnes Fiord	meat, little fat, no bone
Walrus	Odobenus rosmarus	N.E.Devon Is.	rib section, coarse meat with much gristle
Whale, white, liver	Delphinapterus leucas	Starnes Fiord	
" meat		Starnes Fiord	1. dark red meat with skin
" "		Starnes Fiord	2. sample about 1/2" thick with flakey outer covering
" "		Starnes Fiord	3. mixture of meat, fat, skin, liver, lung and intestine

(table continued)

TABLE 4.2.A (continued)

Common name	Scientific name	Location	Description* as received
Dog food (continued)			
Whale, white, fat	Delphinapterus leucas	Starnes Fiord N.W.T.	
Wolf	Canis lupus	Starnes Fiord	meat from hind limb

* Before freeze-drying, the inedible parts were removed

[a] Canned by Canadian Eskimos under the supervision of the Department of Northern Affairs and Natural Resources. Donated by Quebec United Fishermen, 787 de Marché Central, Montreal.

TABLE 4.2.8. Mineral content of birds, fish and mammals of northern Canada (mg mineral per 100 g edible portion)

	Number of samples	Sodium	Potassium	Magnesium	Copper
Birds					
Duck, pintail	1	78	331	27	-
Goose, snow, raw	6	78	303	24	-
boiled	1	87	299	23	-
gizzard	1	66	245	19	-
Loon, common	1	80	261	24	-
Partridge	1	119	566	54	-
Fish					
Char, arctic, raw	1	80	345	29	-
boiled	2	63	322	30	-
canned	1	566	285	31	-
Losh fish (burbot)	1	123	458	33	-
Trout, lake, raw	3	67	401	32	-
boiled	1	46	252	23	-
canned	1	457	349	24	-
paste	1	767	166	18	4.7
balls	1	1092	153	17	-
Whitefish, raw	2	52	421	33	-

(table continued)

TABLE 4.2.8 (continued)

	Number of samples	Sodium	Potassium	Magnesium	Copper
Mammals					
Beaver	1	51	348	25	-
Caribou, raw	2	59	377	31	-
rump, raw	1	70	290	-	-
boiled	1	94	460	44	-
Moose	1	71	344	30	-
Muskrat, raw	9	82	276	22	-
boiled	1	104	254	23	-
Rabbit, snowshoe	1	86	299	29	-
Reindeer, steak	1	61	315	33	-
Seal, bearded, liver	1	132	279	24	2.5
Seal, ringed, meat, raw	1	47	349	29	4.2
raw*	1	95	121	13	3.8
boiled	1	84	260	25	-
Squirrel, ground	1	103	304	24	-
Walrus	1	76	401	30	-
Whale, white, meat	1	60	353	27	-
meat, canned	1	595	329	27	-
stew	1	144	331	29	3.4
muktuk, canned	2	835	359	29	-
muktuk, sausage	1	380	362	25	-

*high in fat

(table continued)

TABLE 4.2.B (continued)

	Number of samples	Sodium	Potassium	Magnesium	Copper
Dog food					
Beef, stewing	1	62	300	20	-
Dog, Eskimo sled	2	71	305	22	-
Fox, arctic	1	106	292	23	-
Hare, arctic	1	51	301	27	-
Musk-ox	1	70	283	19	-
Seal, ringed, meat	1	37	333	30	-
liver	1	96	333	24	3.4
Walrus	1	58	354	21	-
Whale, white, meat	3	89	287	16	-
liver	1	102	290	17	4.6
fat	1	198	139	10	-
Wolf	1	51	309	25	-

4.2.2 Potassium

Values obtained for potassium content are similar to those in the literature for similar animals, except for partridge which is high. Any of the factors mentioned with regard to sodium could account for this, however the partridge sample is high in dry matter (49.6%) which may be the reason.

Potassium values for cooked or processed foods may be lower than for raw foods because potassium, which can occur in highly soluble form, may leach out into the cooking water (U.S.D.A. Agriculture Handbook No. 8).

4.2.3 Magnesium

Magnesium values to use for comparison are more difficult to obtain than those for many other minerals. On the average, however, results obtained for the northern animals appear to be reasonable. Partridge, again, is high in magnesium. Raw caribou and reindeer contain more magnesium than do raw beef, pork and lamb, but the caribou and reindeer samples agree well with each other.

The sample of stewing beef for use as dog food has a magnesium value of 20 mg, which compares well with reference beef values.

4.2.4 Copper

Values are given for the copper content of only a few of the samples. Meats are relatively low in copper, being often lower than 1 mg per 100 g edible portion (Lindow, 1929; Hodges and Peterson, 1931), and the samples were not concentrated enough to give meaningful values when analyzed except where copper content was high. If carried out again, more than 1 g freeze-dried sample per 50 cc solution would have to be used.

Published copper contents of meats are very few in number. However, the results obtained for bearded and ringed seal liver, and white whale liver are comparable to values given for the liver of other animals by Lindow et al. (1929), Hodges and Peterson (1931), and Magny and Faliu (1967).

Lake trout paste, ringed seal meat and white whale stew also appear to be high in copper.

4.2.5 Iron

The values obtained for iron are highly variable, and therefore the individual values are given in a separate table, 4.2.C, rather than including them as averages along with the averages of the other minerals given in Table 4.2.B.

TABLE 4.2.C. Iron content of northern Canadian birds, fish and mammals (mg iron per 100 g edible portion)

	Sample No.	Iron
Birds		
Duck, pintail		6.3
Goose, snow, raw	1	73.0
	2	6.5
	3	5.8
	4	5.9
	5	8.0
	6	6.7
boiled		26.9
gizzard		14.2
Loon, common		13.4
Partridge		22.7
Fish		
Char, arctic, raw		2.0
boiled	1	3.5
	2	1.6
canned		1.5
Losh (burbot)		0.2
Trout, lake, raw	1	4.6
	2	24.2
	3	3.2
boiled		3.1
canned		0.8
paste		5.7
balls		1.4
Whitefish, raw	1	1.0
	2	7.8

(table continued)

TABLE 4.2.C (continued)

	Sample No.	Iron
Mammals		
Beaver		10.9
Caribou, raw	1	9.4
	2	6.6
boiled		9.5
rump		6.0
Moose		8.9
Muskrat, raw	1	10.8
	2	24.3
	3	15.3
	4	13.3
	5	10.7
	6	12.0
	7	14.7
	8	12.5
	9	14.0
boiled		10.4
Rabbit, snowshoe		6.5
Reindeer steak		3.9
Seal, bearded, liver		61.4
Seal, ringed, meat	1	38.1
	2	27.1
boiled		21.4
Squirrel, ground		20.9
Walrus		25.4
Whale, white, meat		30.9
canned		26.0
stew, canned		24.6
muktuk, canned	1	3.1
	2	1.1
muktuk, sausage		28.8

(table continued)

TABLE 4.2.C (continued)

	Sample	Iron
Dog food		
Beef, stewing		6.5
Dog, Eskimo sled	1	5.8
	2	5.5
Fox, arctic		9.0
Hare, arctic		6.1
Musk-ox		4.9
Seal, ringed, liver		21.8
meat		31.3
Walrus		18.3
Whale, white, liver		60.5
meat	1	20.5
	2	5.0
	3	19.0
fat		17.8
Wolf		5.5

Values used as reference comparisons came from two sources. First are the iron contents of animals published in the literature, which are included in Appendix Table 3. Second are the values previously determined by a technician in this laboratory on the same samples (those described in Table 4.2.A) but determined by the A.O.A.C. 1965 method for iron determination rather than by atomic absorption spectroscopy. The values obtained by the A.O.A.C. (1965) method are given in Appendix Table 4.

As mentioned previously, the values determined by atomic absorption spectroscopy (A.A.S.) are exceedingly varied, and in many cases appear to be high. A certain portion of iron in each sample can possibly be accounted for. The samples were ground in a grinder with plates and blade of iron and thus undoubtedly picked up some iron from this source. It seems unlikely, though, that this could account for the high degree of variability, and the excessive amounts of iron in several samples. Some of the values, however, do agree fairly well with values reported by Heller and Scott (1967) for arctic animals. The northern wild animals appear to be consistently higher in iron than are domestic animals, and it seems almost impossible to compare them.

Of the six snow goose samples, five appear to agree well, and they also agree well with the value for Canada goose given by Heller and Scott (1967). The value of 73.0

mg appears to be erroneously high, but no explanation can be given. The value 26.9 mg for boiled snow goose is also high. The values obtained by the A.O.A.C. (1965) method are lower.

Values obtained for loon and partridge are also high, especially partridge. As mentioned in section 4.1, the sample of partridge is very high in dry matter. A lower value (5.2 mg iron per 100 g edible portion) was obtained by the A.O.A.C. (1965) method.

Values obtained for raw and boiled arctic char appear to agree well with values reported in the literature for fish, and with the values obtained from the A.O.A.C. (1965) method. For canned arctic char, A.A.S. gave a value of 1.5 mg whereas the A.O.A.C. (1965) method gave a value of 5.8 mg.

For raw lake trout, the two methods give agreeing results for samples 1 and 3, however sample 2, as determined by A.A.S., is very high in iron. Sample 2 consisted of the entire fish; whereas the other two were composed only of the centre section. All edible parts, as eaten by the Eskimos, are included in the edible portion, although to many other people such parts as the head and eyes might not appear edible. As with the sample of canned arctic char, A.A.S. gave a much lower value than did the A.O.A.C. (1965) method.

Values obtained by A.A.S. for caribou agree well with the value given by Church and Church (1966) for venison. The value obtained by the A.O.A.C. (1965) method is slightly lower.

Moose agrees well with caribou in iron content, as determined by A.A.S.

Muskrat iron values obtained by A.A.S. are higher than those obtained by the A.O.A.C. (1965) method, and higher also than the value reported by Heller and Scott (1967). The A.A.S. values for muskrat do agree well amongst themselves, except for sample 2, which is high.

Wild rabbit appears to be higher in iron than does domestic rabbit. The A.A.S. values for snowshoe rabbit and arctic hare, which are the same species with different common names, agree very well.

The iron content of bearded seal liver, as determined by A.A.S., was 61.4 mg iron per 100 g edible portion, and ringed seal liver was 21.8 mg. Both values are considerably higher than the 13.8 mg of iron reported by Heller and Scott (1967) for ringed seal liver. The values obtained for seal meat are also higher than those indicated by Heller and Scott (1967).

Values obtained for white (Beluga) whale meat by A.A.S. agree fairly well with the value reported by Heller and Scott (1967).

A sample of stewing beef designated as dog food was included in the analysis, and gave an iron value of 6.5 mg, which is higher than values reported in the literature for beef.

It is difficult to come to any definite conclusions regarding the validity of the iron values by either A.A.S. or the A.O.A.C. (1965) method. On the whole, the A.A.S. values appear to agree more closely with those reported by Heller and Scott (1965) than do the values obtained by the A.O.A.C. (1965) method.

It seems that, on the average, wild animals contain more iron than do domestic animals. The sea mammals, especially, appear to be high in iron, not only their livers, but their meat as well. For this reason, it appears that the values obtained by the A.O.A.C. (1965) method are low. They are closer to the values for domestic animals than to the values for wild animals, reported in the literature.

It seems, then, that further work must be carried out to determine the iron values of northern animals conclusively. Perhaps the atomic absorption spectroscopy method needs to be modified. There may have been interference from other metals when iron was measured, although according to Christian and Feldman (1970) there is little interference from other metals in an air-acetylene flame (which was used).

V. SUMMARY

Samples of birds, fish, and mammals from northern Canada were obtained and analyzed for amino acids and some minerals. The samples include duck, goose, loon, partridge, arctic char, losh fish (burbot), lake trout, reindeer, ground squirrel, seal, walrus and whale. Some of the samples were designated as "dog food," meaning unfit for human consumption. Values for the dog foods were included, however, as it is assumed that their composition is comparable to similar animals fit for human consumption.

The amino acid analysis was carried out using a Beckman 120 amino acid analyzer. The values appeared to correlate well with those reported in the literature for similar animals. Cystine values were not obtained, because cystine was probably destroyed during hydrolysis. Tryptophane, which cannot be determined with the other amino acids due to its destruction by acid hydrolysis, was determined by spectrophotometry. The values obtained for tryptophane were very low, probably because of interference from the dark colour of the samples.

The sodium and potassium contents were determined by flame emission photometry, and the magnesium, copper and iron contents by atomic absorption spectroscopy. The sodium, potassium, and magnesium values agreed well with those reported in the literature for similar animals. Few copper values were obtained because the samples were not prepared in sufficient concentration for analysis. The copper values obtained, however, did agree well with those from the literature for similar animals.

The values for iron were highly variable, and their validity is questionable.

The data presented is intended for inclusion in future revisions of the existing food composition tables. Animals, such as those listed above, are consumed in large quantities by people living in northern Canada, and increasingly by people in other parts of Canada as well. Knowledge of the composition of such foods is essential for dietitians and nutritionists to calculate and evaluate diets which include these animals.

VI. CONCLUSIONS

Conclusions may be drawn regarding the validity of the analytical values:

1. The amino acid values obtained appear to agree well with those reported in the literature for similar animals, except for the tryptophane values which are low.

2. The sodium, potassium, magnesium and copper values obtained also agree well with those published for similar animals. The iron values obtained are, however, questionable.

APPENDIX TABLES 1 - 4

APPENDIX TABLE 1. Tryptophane content of birds, fish and mammals of northern Canada* (g per 100 g edible portion)

	Protein	Tryptophane
Birds		
Duck, pintail	23.7	0.43
Goose, snow	23.1	0.45
Loon, common	22.4	0.70
Partridge	44.3	0.47
Fish		
Char, arctic	20.8	0.94
Losh (burbot)	24.9	0.47
Trout, lake	22.4	0.25
Mammals		
Beaver	21.3	0.48
Caribou, raw	26.1	0.45
Moose	23.4	0.69
Muskrat	19.9	1.11
Rabbit, snowshoe	21.9	0.39
Reindeer, steak	20.7	1.68
Seal, bearded, meat	28.4	0.61
liver	22.8	0.66
Seal, ringed, meat	23.2	0.42
Squirrel, ground	21.1	0.66
Walrus	26.0	0.33
Whale, white, meat, canned	29.9	0.95
Dog food		
Hare, arctic	24.6	0.63
Whale, white, meat	27.8	0.47
liver	25.2	0.51

*Values are considered to be too low to be meaningful.

APPENDIX TABLE 2. Amino acid content of birds, fish and mammals from the published literature (grams of amino acid in 100 grams of protein)[1]

	Method	Ref.	% Protein	Alanine	Arginine	Aspartic acid	Cystine**
Birds							
Chicken[2]	M	(1)	20	3.41	5.57	9.17	1.31
Duck, domestic[3]		(2)	21.4	-	6.08	10.53	-
Turkey (5 samples)	CC	(3)	23.9	6.74	8.75	10.00	1.44
Fish							
Fish, fresh, all types[2]	CC	(1)	18.8	5.98	5.66	10.35	1.17
	M		18.8	7.41	6.58	9.04	0.83
Clupeiformes: salmonoidei[2] (incl. trout, salmon, whitefish)	CC	(1)	18.0	6.24	5.65	8.59	1.01
	M		18.0	5.87	5.90	8.34	1.30
Lush fish (burbot)[3]		(4)	17.4	-	-	-	-
Mammals:							
Beef		(5)	-	6.40	6.56	8.75	1.35
Beef[2]	CC	(1)	17.7	5.84	6.32	8.99	1.28
Lamb		(5)	-	6.30	6.86	8.46	1.34
Lamb[2]	M	(1)	15.6	6.61	6.88	8.78	1.28
Pork		(5)	-	6.30	6.35	8.92	1.31
Pork[2] (one sample)	CC	(1)	11.9	6.40	6.90	10.30	1.41
	M		11.9	5.50	6.37	8.93	1.12
Liver, beef or pork[3]		(2)	19.7	6.40	6.10	10.30	1.23
Rabbit, domestic[3]		(2)	21.0	-	5.60	10.13	-
Whale,[2] fresh (1 sample)	M	(1)	20.4	4.21	4.61	8.80	1.90
Hen's whole egg	CC	(1)	12.4	-	-	-	2.43

See end of table for footnotes (table continued)

APPENDIX TABLE 2. (continued)

	Method	Ref.	% Protein	Glutamic acid	Glycine	Histidine	Isoleucine*
Birds							
Chicken[2]	M	(1)	20	15.01	5.30	2.62	5.34
Duck, domestic[3]		(2)	21.4	16.99	5.04	2.27	5.18
Turkey (5 samples)	CC	(3)	23.9	17.37	5.47	3.49	5.67
Fish							
Fish, fresh, all types[2]	CC	(1)	18.8	14.11	4.82	3.54	4.78
	M		18.8	12.94	5.30	3.14	5.42
Clupeiformes salmonoidei[2] (incl. trout, salmon, whitefish)	CC	(1)	18.0	13.23	5.81	3.04	4.52
	M		18.0	13.47	5.73	2.77	5.20
Lush fish (burbot)[3]		(4)	17.4	-	-	-	5.10
Mammals							
Beef		(5)	-	14.35	7.11	2.94	5.07
Beef[2]	CC	(1)	17.7	15.28	4.86	3.41	4.82
Lamb		(5)	-	14.35	6.74	2.68	4.78
Lamb[2]	M	(1)	15.6	14.75	5.92	2.74	4.98
Pork		(5)	-	14.51	6.10	3.23	4.89
Pork[2] (1 sample)	CC	(1)	11.9	16.70	4.94	2.70	5.70
	M		11.9	14.46	5.70	3.30	5.12
Liver, beef or pork[3]		(2)	19.7	13.60	6.08	2.65	5.23
Rabbit, domestic[3]		(2)	21.0	17.28	4.56	2.26	5.15
Whale,[2] fresh (1 sample)	M	(1)	20.4	10.90	4.30	2.50	8.50
Hen's whole egg	CC	(1)	12.4	-	-	-	6.29

See end of table for footnotes

(table continued)

APPENDIX TABLE 2. (continued)

	Method	Ref.	% Protein	Leucine*	Lysine*	Methionine*	Phenyl-alanine*
Birds							
Chicken[2]	M	(1)	20	7.36	7.95	2.51	4.00
Duck, domestic[3]		(2)	21.4	7.74	8.61	2.48	3.93
Turkey (5 samples)	CC	(3)	23.9	8.58	10.00	3.50	4.67
Fish							
Fish, fresh, all types[2]	CC	(1)	18.8	7.68	9.10	2.86	3.92
	M		18.8	7.78	9.74	2.96	3.74
Clupeiformes salmonoidei[2] (incl. trout, salmon, whitefish)	CC	(1)	18.0	6.99	8.91	2.61	3.73
	M		18.0	7.66	9.79	2.94	3.82
Losh fish (burbot)[3]		(4)	17.4	7.60	8.80	2.90	3.70
Mammals							
Beef		(5)	-	8.40	8.37	2.32	4.02
Beef[2]	CC	(1)	17.7	8.11	8.90	2.70	4.40
Lamb		(5)	-	7.42	7.65	2.32	3.94
Lamb[2]	M	(1)	15.6	7.70	8.16	2.45	4.00
Pork		(5)	-	7.53	7.77	2.50	4.14
Pork[2] (1 sample)	CC	(1)	11.9	9.01	10.00	3.01	4.61
	M		11.9	7.55	8.10	2.70	4.18
Liver, beef or pork[3]		(2)	19.7	9.23	7.49	2.35	5.04
Rabbit, domestic[3]		(2)	21.0	7.79	8.66	2.58	3.78
Whale, fresh (1 sample)	M	(1)	20.4	9.10	8.40	2.40	4.40
Hen's whole egg	CC	(1)	12.4	8.82	6.98	3.36	5.72

See end of table for footnotes

(table continued)

APPENDIX TABLE 2. (continued)

	Method	Ref.	% Protein	Proline	Serine	Threonine*	Trypto-phane*
Birds							
Chicken[2]	M	(1)	20	4.14	3.90	3.97	1.02
Duck, domestic[3]		(2)	21.4	-	-	4.37	-
Turkey (5 samples)	CC	(3)	23.9	4.38	5.08	5.72	-
Fish							
Fish, fresh, all types[2]	CC	(1)	18.8	3.68	4.34	4.58	-
	M		18.8	3.76	5.01	4.50	1.12
Clupeiformes salmonoidei[2] (incl. trout, salmon, whitefish)	CC	(1)	18.0	3.79	3.89	4.37	-
	M		18.0	3.97	4.64	4.43	1.10
Losh fish (burbot)[3]		(4)	17.4	-	-	4.30	1.00
Mammals							
Beef		(5)	-	5.40	3.77	4.04	1.10
Beef[2]	CC	(1)	17.7	3.78	4.03	4.59	-
Lamb		(5)	-	4.80	3.93	4.88	1.32
Lamb[2]	M	(1)	15.6	4.67	4.19	4.69	1.26
Pork		(5)	-	4.60	3.97	5.12	1.35
Pork[2] (1 sample)	CC	(1)	11.9	4.50	4.40	5.10	-
	M		11.9	4.56	4.18	4.91	1.36
Liver, beef or pork[3]		(2)	19.7	5.14	5.23	4.75	1.50
Rabbit, domestic[3]		(2)	21.0	-	-	4.86	-
Whale, fresh (1 sample)	M	(1)	20.4	4.00	4.61	5.01	1.01
Hen's whole egg	CC	(1)	12.4	-	-	5.12	1.39(M)

See end of table for footnotes

(table continued)

APPENDIX TABLE 2. (continued)

	Method	Ref.	% Protein	Tyrosine**	Valine*
Birds					
Chicken[2]	M	(1)	20	3.34	5.09
Duck, domestic[3]		(2)	21.4	-	4.80
Turkey (5 samples)	CC	(3)	23.9	4.93	5.92
Fish					
Fish, fresh, all types[2]	CC	(1)	18.8	3.66	6.11
	M		18.8	4.06	5.52
Clupeiformes salmonoidei[2] (incl.trout,	CC	(1)	18.0	3.04	5.33
salmon, whitefish)	M		18.0	3.30	5.82
Losh fish (burbot)[3]		(4)	17.4	-	5.30
Mammals					
Beef		(5)	-	3.24	5.71
Beef[2]	CC	(1)	17.7	3.60	5.01
Lamb		(5)	-	3.21	5.00
Lamb[2]	M	(1)	15.6	3.30	5.06
Pork		(5)	-	3.02	4.97
Pork[2] (1 sample)	CC	(1)	11.9	3.95	6.21
	M		11.9	3.58	5.18
Liver, beef or pork[3]		(2)	19.7	3.75	6.29
Rabbit, domestic[3]		(2)	21.0	-	4.86
Whale, fresh (1 sample)	M	(1)	20.4	3.30	5.01
Hen's whole egg	CC	(1)	12.4	4.16	6.85

Ref. = (1) Nutrition Division FAO, 1970. (2) Orr and Watt, 1957.
(3) Lui and Ritchey, 1970. (4) Church and Church, 1966.
(5) Kiernat et al., 1964.

[1] Values are representative of the entire edible animal.

[2] Original values are given in mg amino acid per g nitrogen:
g amino acid per 100 g protein =(mg amino acid x 16)/1000.

[3] Original values are given in g amino acid per 100 g E.P.:
g amino acid per 100 g protein = (g amino acid x 100)/% protein.

CC = column chromatography. M = microbial assay.
* = essential amino acids for man. ** = semi-essential amino acids for man.

APPENDIX TABLE 3. Mineral content of birds, fish and mammals from the published literature (mg mineral per 100 g food)

	Reference	Sodium	Potassium	Magnesium	Copper	Iron
Birds						
Chicken, dark	(1)	67	250	23	-	1.5
dark	(2)	-	-	-	0.41	-
dark	(3)	-	-	-	0.33	-
Duck, domestic	(1)	74	285	-	-	1.3
domestic	(2)	-	-	-	0.41	-
domestic	(3)	-	-	-	0.41	-
wild	(4)	-	-	-	-	3.0
Gizzard, chicken	(1)	65	240	-	-	2.9
turkey	(1)	58	170	-	-	-
Goose, Canada	(5)	-	-	-	-	5.6
domestic	(1)	86	420	-	-	1.3
domestic	(2)	-	-	-	0.33	-
domestic	(3)	-	-	-	0.33	-
Ptarmigan	(5)	-	-	-	-	6.2
Quail	(1)	40	175	-	-	-
Turkey	(1)	66	315	-	-	1.5
	(2)	-	-	-	0.20	-
	(3)	-	-	-	0.17	-
Fish						
Buffalo fish	(1)	52	293	-	-	-
Carp	(1)	50	286	-	-	0.9
Devilfish (sculpin)	(5)	-	-	-	-	0.4

(table continued)

APPENDIX TABLE 3. (continued)

	Reference	Sodium	Potassium	Magnesium	Copper	Iron
Fish (continued)						
Flounder	(1)	-	-	30	-	-
	(2)	-	-	-	0.15	-
Haddock	(1)	-	-	24	-	-
	(2)	-	-	-	0.28	-
Herring	(1)	-	-	17	-	-
Needlefish	(5)	-	-	-	-	7.3
Trout, lake	(1)	-	-	-	-	0.8
	(2)	-	-	-	0.33	-
Whitefish	(1)	52	299	-	-	-
	(6)	-	-	-	-	1.3
	(2)	-	-	-	0.19	-
- flesh	(5)	-	-	-	-	0.2
- head	(5)	-	-	-	-	3.9
Mammals						
Beef, raw	(1)	60	355	18-24	-	2.9
cooked	(1)	65	370	15-29	-	-
steak	(2)	-	-	-	0.08	-
lean	(3)	-	-	-	0.10	-
Beef and vegetable stew	(1)	411	174	-	-	0.9
Lamb, raw	(1)	75	295	15	-	1.3
cooked	(1)	70	290	17-22	-	-
chops	(2)	-	-	-	0.42	-
chops	(3)	-	-	-	0.42	-

(table continued)

APPENDIX TABLE 3. (continued)

	Reference	Sodium	Potassium	Magnesium	Copper	Iron
Mammals (continued)						
Liver, beef	(1)	136	281	13	-	6.5
beef	(2)	-	-	-	2.15	-
beef	(3)	-	-	-	2.15	-
calves	(2)	-	-	-	4.41	-
calves	(3)	-	-	-	4.41	-
caribou	(5)	-	-	-	-	15.7
pork	(1)	73	261	16	-	19.2
pork	(2)	-	-	-	0.65	-
veal	(7)	78	338	16	10.0	4.8
Moose, flesh	(5)	-	-	-	-	5.3
Muskrat	(5)	-	-	-	-	8.6
Pork, raw	(1)	70	285	18-23	-	1.4
cooked	(1)	65	390	23-32	-	-
chops	(3)	-	-	-	0.31	-
sausage	(4)	740	140	-	-	2.3
Rabbit, domestic	(1)	43	385	-	-	1.3
Seal, bearded	(5)	-	-	-	-	12.9
ringed	(5)	-	-	-	-	19.6
ringed, liver	(5)	-	-	-	-	13.5
Squirrel, ground	(5)	-	-	-	-	4.7
Veal	(7)	62	473	14	1.4	1.7
Venison, cooked	(4)	-	-	9	-	7.8

(table continued)

APPENDIX TABLE 3. (continued)

	Reference	Sodium	Potassium	Magnesium	Copper	Iron
Mammals (continued)						
Walrus	(6)	-	-	-	-	10.0
	(5)	-	-	-	-	9.4
Whale	(1)	78	22	-	-	-
- Baleen	(5)	-	-	-	-	14.1
- Beluga (white)	(5)	-	-	-	-	25.9

References:

(1) U.S. Agriculture Handbook No.8
(2) Lindow et al., 1929
(3) Hodges and Peterson, 1931
(4) Church and Church, 1966
(5) Heller and Scott, 1967
(6) Table of Food Values Recommended for Use in Canada
(7) Magny et Faliu, 1967

APPENDIX TABLE 4. Iron content of northern Canadian animals*
(mg iron per 100 g edible portion)

	Sample number	Iron
Birds		
Goose, snow, raw	2	3.8
	3	3.7
	4	3.2
	5	3.7
	6	3.9
boiled		7.3
Loon, common		5.2
Fish		
Char, arctic, raw		2.5
boiled	1	1.8
canned		5.8
Losh fish (burbot)		1.7
Trout, lake, raw	1	4.5
canned		5.0
paste		1.9
balls		1.4
Whitefish	2	2.9
Mammals		
Caribou, raw	1	5.0
Muskrat, raw	1	6.7
	2	4.6
	3	7.1
	4	7.6
	5	7.8
	6	7.5
	7	7.9
	8	7.2
boiled		6.9
Reindeer, steak		4.8

(table continued)

APPENDIX TABLE 4. (continued)

	Sample number	Iron
Mammals (continued)		
Seal, bearded, liver		4.6
Seal, ringed, meat	1	5.4
Squirrel, ground		4.3
Whale, white, meat, canned		5.2
muktuk, canned	1	2.5
	2	5.8
sausage		8.2
Dog Food		
Beef, stewing		4.2
Dog, Eskimo sled	1	3.9
	2	3.3
Fox, arctic		3.9
Hare, arctic		3.6
Musk-ox		3.2
Seal, ringed, liver		4.7
meat		5.4
Walrus		4.6
White whale, liver		4.0
meat	2	4.3
	3	8.2
fat		1.7
Wolf		3.8

*Values obtained by A.O.A.C. (1965) method, Farmer and Neilson, 1970b, unpublished data. The samples are the same ones as listed in Table 4.2.c. See text 4.2.5 for explanation.

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