Nutritional content of infant commercial foods and formulas available in Iceland 2016

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Ágrip

Bakgrunnur og markmið: Aðgengi og úrval af tilbúnum barnamat og mjólkurblöndum á íslenskum markaði fer stöðugt vaxandi. Efasemdir eru uppi um að tilbúinn barnamatur uppfylli næringarþörf ungbarna eða sé hvetjandi til að örva hæfileika þeirra til að borða matvæli sem hentar þeirra aldri. Markmið verkefnisins er að búa til gagnagrunn sem inniheldur tilbúinn barnamat og mjólkurblöndur á íslenskum markaði haustið 2016.

Aðferðir: Upplýsingum um tilbúinn barnamat og mjólkurblöndur (n=248) var safnað með því að taka myndir af vöruumbúðum eða sækja gögn af vefsíðum framleiðenda. Almennar upplýsingar og næringargildi var skráð í Microsoft Excel. Þriggja daga vigtaðar matardagbækur fengnar úr Iceage2 rannsókninni voru notaðar tl að meta neyslu á tilbúnum barnamat og mjólkurblöndum meðal níu mánaða íslenskra ungbarna (n=25).

Niðurstöður: Forelduð matvæli voru í meirihluta á íslenskum markaði með 70% hlutfall af heild, þar af var ávaxtamauk með 44% hlutfall. Flestar vörur voru ætlaðar ungbörnum frá 4+ mánaða (29.4%) og 6+ mánaða (34.4%), bornar fram í pokum eða krukkum. Meðalorkuinnihald var lægst fyrir flokkinn sem innihélt forelduð matvæli með meðalorkugildi (SD) 63.3 (14.5) kkal í 100 g. Mjölvörur voru ríkar af orku og næringarefnum og teljast fullnægjandi matvæli fyrir ungbörn. Meðalneysla af tilbúnum barnamat hjá níu mánaða íslenskum ungbörnum var 30% af daglegri neyslu. Neysla á forelduðum matvælum stóð upp úr (46.6%), þar sem neysla á ávaxtamauki var langmest (30.2%).

Ályktun: Megintilgangur með viðbótarfæðu er að veita fullnægjandi magn af orku og næringarefnum til að uppfylla þarfir ungbarns. Uppistaðan á íslenskum markaði er foreldaður barnamatur sem reynist hafa lægsta orkugildið af öllum flokkum barnamatar. Sá matur nær ekki að þjóna þeim tilgangi að auka orku- og næringargildi í mataræði ungbarna. Samt sem áður er neyslan fyrir þennan tiltekna vöruflokk langalgengust.

Abstract

Background and aims: The availability and selection of infant commercial foods and formulas in Iceland is constantly increasing. There are some doubts that infant commercial foods meet infants' nutritional requirements or provide encouragement to develop their ability to eat food that suits their age. The objective of this thesis is to construct a database containing infant commercial foods and formulas on the Icelandic market in the autumn of 2016.

Methods: Information on infant commercial foods and formulas (n=248) was collected by taking photos of product packaging or obtained from manufacturers' websites. General information and nutritional content was listed in Microsoft Excel. 3-day weighing food records from the Iceage2 study were used to estimate consumption of infant commercial foods and formulas among Icelandic nine-month-old infants (n=25).

Results: The market mainly consists of ready-made foods, with a 70% proportion of total, of which 44% were fruit puree. Most of the products were aimed at infants from 4+ months (29.4%) and 6+ months (34.3%), served in sachets or jars. The average energy content was lowest for the ready-made foods with a mean (SD) energy content of 63.3 (14.5) kcal per 100 g. Powdered meals were rich in energy and nutrients and were considered as sufficient complementary food. The mean consumption of infant commercial foods among Icelandic nine-month-old infants was 30% of their daily intake. Consumption of ready-made foods had the largest share (46.6%), of which consumption of fruit puree was highest (30.2%).

Conclusion: The main purpose of complementary feeding is to provide enough energy and nutrients to fulfil infants' requirements. The market mainly supplies ready-made foods that turned out to have the lowest energy content of all food groups and would not serve the intended purpose of enhancing the energy and nutrient density in infants' diets. Yet, consumption of ready-made foods was the most common form of consumption.

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Abbreviations

CODEX	Codex Alimentarius Commission
E%	Percent of total energy intake
ISGEM	The Icelandic Food Composition Database
NNR	Nordic Nutrition Recommendations
SD	Standard deviation
WHO	World Health Organization

1 Introduction

During infancy, the variance of the diet increases, moving from a milk-based diet to the gradual introduction of solid foods. The transition where infants are introduced to solid foods in addition to breast milk is defined as complementary feeding [1, 2]. Complementary feeding is recommended from six months of age, but until then exclusive breastfeeding is advised [3]. When breast milk alone is not sufficient to meet the infant's nutritional requirements, complementary foods are expected to fill the gap between the total nutritional needs and the amounts provided by breast milk. Adequate complementary feeding is therefore important [2].

Complementary foods are normally of two types: infant commercial foods and homemade foods. The availability of infant commercial foods is increasing which indicates higher demands and consumption. There are concerns that consumption of infant commercial foods threatens the quality and nutritional diversity of infants' diet [4]. Despite the wide selection of infant commercial foods, there are few studies that exist on the consumption of such foods and their nutritional value. However, studies that have been conducted in industrialized countries, for example in Germany [5] and the US [6, 7] show high consumption of infant commercial foods. In terms of nutritional value, a study performed in the UK [8] concluded that the infant food market in the UK mainly consists of sweet and soft mashed foods that would not serve the required purpose of enhancing the nutrient density of infants' diet.

New dietary guidelines for infants were published recently by the Directorate of Health in Iceland where the consumption of infant commercial foods is discussed [9]. It could be assumed that the share of infant commercial foods and formulas in Icelandic infant's diet is increasing, based on the wide selection on the food market nowadays. The most recent nationwide study on Icelandic infant nutrition was carried out in 2005-2007 [10]. Only a few infant commercial products were on the market at that time, based on the database which was used to calculate infants' intake of nutrients.

Up-to-date food composition databases are necessary to observe changes related to the nutrition of individuals [11]. Due to a constantly high consumption of infant commercial foods and an increased selection on the market [4] it is important that a reliable national database for infant commercial foods and formulas exists. Thereby, it is possible to keep track of what the market has to offer at each time and to perform dietary surveys on infant nutrition and consumption. The aim of this thesis was to construct a database containing infant commercial foods and formulas on the Icelandic market in the autumn of 2016, with the following specific aims:

1) To describe types of infant commercial foods and formulas, based on ingredients, texture and age groups.
2) To summarize the nutritional content in different types of infant commercial foods and formulas in terms of energy, carbohydrates, fibre, added sugar, fat, protein, iron, vitamin D, iodine and zinc.
3) To examine the quantity of infant commercial foods and formulas consumption in a sample of Icelandic nine-month-old infants from the Iceage2 study.

2 Review of the literature

2.1 Recommendations on infant nutrition

2.1.1 Breastfeeding

The World Health Organization (WHO) [3], the Directorate of Health in Iceland [9] and Nordic Nutrition Recommendations (NNR) [12] recommend that infants should be exclusively breastfed for the first six months of life. Exclusive breastfeeding means that an infant receives only breast milk, and no other foods or liquids, with the exceptions of vitamins- and mineral supplements or medicines, if necessary [1].

Breastfeeding is an ideal way to achieve optimal growth, development and health of infants [3, 4]. The Nordic countries have relatively high proportion of breastfeeding compared to the rest of the world [4, 12]. Almost every mother breastfeeds her infant the first days after birth and 58-80% of infants at six months of age are still breastfed [12]. Yet, although these high rates of breastfeeding of infants is evident in the Nordic countries, there is a need for more effective promotion of exclusive breastfeeding during the first six months of life [12, 13].

The Directorate of Health in Iceland published a report about breastfeeding and infant nutrition in Iceland based on data on infants born in 2004-2008 [13]. The findings showed that 98% of infants were breastfed in the first week of life and that 86% of infants were exclusively breastfed. However, at six months of age relatively few were exclusively breastfed; only 8% of infants. These results are quite similar to studies that have been conducted by the Unit for Nutrition Research and The National University Hospital of Iceland, where the diets of population based cohorts of Icelandic infants were examined [10, 14]. These studies showed that in 1995-1997, 5% of infants were exclusively breastfed at six months of age [14] and that in 2005-2007, 4% were exclusively breastfed at that age [10].

2.1.2 Complementary feeding

From six months of age, when breast milk no longer meets the nutritional needs of the infant, WHO [3] recommends that infants' diet should move towards healthy and safe complementary feeding up to two years of age or beyond. Complementary feeding is defined as the period when infants are given foods and liquids along with breast milk. Complementary food is defined as any food, whether processed commercial food or homemade food that is suitable in addition to breast milk or infant formula [1, 2]. Continued breastfeeding is optimal for infants at this age as it remains a critical source of nutrients and protective factors [3, 12, 15].

The years from birth to two years of age is a critical time for infants when it comes to optimal growth, health and development [16]. From six months of age most infants are developmentally ready for other foods and complementary feeding becomes necessary to meet their nutritional needs. Adequate nutrition and complementary feeding during infancy and early childhood is well recognized as an important predictor of better health later in life [15].

Knowledge among parents and other caregivers about successful complementary feeding is important to ensure that infants' nutritional needs are met for proper health, growth, and development. According to the WHO, there are important factors to consider about complementary foods [3]:

- **Timing:** Introduce complementary foods when infants' need for energy and nutrients increases and exceeds what breast milk can provide.
- **Adequate:** Meaning that foods provide sufficient energy and nutrients to meet infants' nutritional needs
- **Safety:** The importance of hygiene, proper handling, storage and preparation
- **Properly fed:** Food is given in accordance to the infant's signals about appetite and satiety. Foods are of appropriate texture for the infant's developmental stage. Also, the infant should be activated and encouraged to self-feed by offering finger foods, or other tools that suit its age and maturity.

2.2 Developmental stages in infant feeding

2.2.1 4-6 months of age

Breastfeeding is the most ideal way to ensure proper nutrition for infants during the first six months of life. However, if breast milk alone is not sufficient or an infant does not receive breast milk during the first four months of life, the Directorate of Health in Iceland recommends infant formula as the only source of nutrition or in addition to breast milk [9]. Solid food should not be introduced before the age of four months. If breast milk does not provide enough energy and nutrients between 4-6 months of age, infants are allowed to receive small portions of complementary food, even rather than formulas. It is most important that complementary feeding does not affect breastfeeding. At four months of age, formula-fed infants can be introduced to small portions of other foods in addition, to adapt them to different taste and texture. Formulas always taste the same, unlike breast milk which varies depending on what the mother eats. Solid food must suit infants' age and development [9].

2.2.2 6-9 months of age

At six months of age a major improvement happens in the development of physical skills and eating skills. Infants can start to eat pureed, mashed and semi-solid foods by moving food forward and backward in their mouth with the tongue in order to swallow [15, 17]. It is desirable to diversify the variety of food relatively quickly after six months of age. The Directorate of Health in Iceland recommends that basic ingredients, such as fruits, vegetables and various kinds of iron fortified cereals without additional flavors, are the starting point [9]. Suggested first vegetables are boiled and mashed potatoes, carrots and beets and pureed fruits, such as bananas, apples and pears. Other vegetables can gradually be added, for example broccoli, cauliflower and peas. It is recommended that food products that are low in fat, like porridge and vegetable- and fruit puree, are fortified with fat, such as vegetable oil or butter, to increase the energy density [9].

Other food should regularly be added to the infant diet to ensure adequate energy and nutrients. At around eight months, most infants have the ability to eat finger foods, by picking up little pieces, holding them in their hands and eating by themselves. They can also eat thicker pureed food and soft mashed food. The ability to move the tongue from side to side appears and they can start using the jaw to mash food in their mouth [17]. Then it is time to start introducing foods such as meat, fish, eggs and bread. Choosing diverse toppings and animal products between days is recommended to increase the probability that the infant nutritional need is met. There is no reason to delay or exclude the introduction of food that could potentially cause allergic effects, even if the infant is at high risk of developing allergies, except if allergy has already been confirmed. Infants that are not receiving breast milk or need milk in addition to breast milk are now ready to get a follow-on formula which is intended for infants older than six months [9].

2.2.3 9-12 months of age

Infants at this age can eat almost all types of healthy food [9]. A varied diet should be a priority and infants should be encouraged to try different food combinations with various textures and taste. At this age, infants are learning what is important concerning food and habits [18]. Appropriate feeding is important and can have a positive effect on short and long-term health status and shape later taste and food preferences [19, 20].

Between 9-12 months, the diet moves to bite-size pieces of table food where infants at this age have more skills at chewing and biting through a variety of textures. They are also able to self-feed by using their fingers, a spoon, a fork or other utensils that are developmentally appropriate [15, 17]. The Directorate of Health in Iceland recommends food products that are rich in iron along with food containing vitamin C to enhance iron absorption [9]. It is desirable to continue giving the infant iron fortified porridge while the variety of the diet is increased. Together with breast milk, infants can receive follow-on formula and water to drink. Cow's milk and other dairy products can be used for cooking, but they are not recommended for infants under one year of age to drink or to blend with porridge. Dairy products are low in iron and since iron rich food is necessary for infants at this age, it is important to be selective and choose food items in other food categories [9].

2.3 Formulas intended for infants

Formulas intended for infants are available in either powdered or liquid forms that are usually based on milk from cows or other animals, or a mixture of other ingredients that are appropriate for infants [21, 22]. Infant formulas are different depending on which age they are intended for. Formulas are either designed for infants from birth to six months of age [21] or for infants older than six months [22]. Formulas that are designed for infants from birth to six months are called infant formula [21] and formulas intended for infants older than six months of age are called follow-on formula [22]. In Iceland and other Nordic countries, it is recommended to use infant formulas and follow-on formulas that are prepared according to the Codex Alimentarius Commission (CODEX) standards [12]. The CODEX standards for

infant formulas and follow-on formulas are made to ensure appropriate composition, quality and safety [21, 22].

Infant formula is designed to be a substitute for breast milk and to fulfil all nutritional needs of infants up to six months and promote normal growth and development. [12, 21]. According to the CODEX, follow-on formulas are designed for use as a liquid part of the complementary foods for infants from six months and for young children up to three years, but they are not a breast milk substitute. Follow-on formula should contain essential ingredients that are optimal for infants older than six months to achieve proper growth and development [22]. The CODEX standard also sets regulations about the minimum and maximum levels of nutrient content that are considered to be appropriate for certain age groups [22, 23].

2.4 Infant commercial foods

Infant commercial foods are intended for infants as they progress towards a mixed family diet [24]. Infant commercial foods are available as a complete meal or as an addition to a meal. There are many different types of infant commercial foods, such as cereal-based, food in jars, cans or pouches, fruit and/or vegetable drinks and dry-finger foods like snack, fruits, vegetables and biscuits. Some of the products are fortified with vitamins and/or minerals [25].

The Directorate of Health in Iceland recommends the use of homemade food rather than infant commercial food on a daily basis. The use of infant commercial foods can be convenient for parents because they are quick and easy to prepare and they are an acceptable alternative for infant feeding but should be given in moderation, i.e. not every day. However, these recommendations do not apply to commercial porridge and formulas [9]. There is limited knowledge in infant studies about the quantity of consumed infant commercial foods. However, the few studies that exist illustrate high consumption [5-7].

To ensure that commercial infant food contains the appropriate composition and meets the demands of safety, the European Commission has defined specific regulations [24]. Infant commercial foods should be specially aimed towards infants and young children during complementary feeding, a period when they are adapting to ordinary food. The European Commission sets rules on criteria for the composition of carbohydrate, protein, fat, vitamins and minerals, and minimum and maximum levels [24]. There are also specific regulations about hygiene, the use of food additives and the presence of contaminants in commercial infant foods. [26]. The Icelandic regulation on food for infants and young children (708/2009) [27] is based on regulations of the European Commission, and states specific provisions regarding composition and ingredients, including fortifications of nutrients and pesticide residue.

2.5 Energy and nutrient needs during infancy

2.5.1 Energy requirements

Daily energy need is relatively high in infancy, as rapid growth, development and physical activity characterize the first year of life [17]. Total energy requirements for infants are based on resting energy expenditure and energy expenditure caused by growth and physical activity. Between 6-12 months of age, breast milk can provide one half or more of infants' energy need, and in the second year breast milk can provide on average 35% to 40% of the total energy need. During the first two years of life, breast milk is a key source of energy as well as an ideal source of high quality nutrients [28].

The reason why parents start early with complementary feeding is often that they believe that their infant needs more energy in addition to breast milk [29, 30]. A study conducted in Iceland showed that the energy intake of infants that were exclusively breastfed at six months was comparable to that in a group of complementary fed infants. Based on these findings, it seems that complementary feeding does not increase the total energy intake, but instead replaces breast milk [31].

Complementary food should be more energy dense than breast milk. That means that in order to meet infants' energy requirements, complementary food needs to contain a minimum energy density of 0.8 kcal/g. If complementary food is more energy diluted than breast milk, the total energy intake will not be enough to meet the infant's need. If the infant does not receive breast milk along with solid foods during the first year of life, the quality and quantity of infants' total nutrient intake could be reduced [18].

2.5.2 Carbohydrates

Carbohydrates are organic compounds which provide energy to living cells and are infants' main fuel source. The main types of dietary carbohydrates are starch, fiber and sugars. Carbohydrates are essential for optimal growth, development and health. However, the health effects of dietary carbohydrates are related to their quality. High quality dietary carbohydrates are those that are rich in fiber, provide nutrients and contain small amounts of added sugar. High quality carbohydrates are found in food products such as whole-grain cereals, fruits, vegetables, pulses, nuts and seed [12, 17]. According to the Icelandic food based dietary guidelines, recommendations for carbohydrates are that they should make up approximately 45-60% of the total energy intake for infants from 6-23 months old [32].

Fiber

Dietary fiber is generally related to health benefits and there is scientific evidence that the intake of appropriate amounts of dietary fiber from a variety of foods is important for children [12, 17]. However, there are no specific recommendations intended for infants about the daily intake of dietary fiber. According to the Icelandic recommendations, the appropriate intake of dietary fiber for children from two years of age is 2-3 g/MJ [32].

Added sugar

Added sugar refer to all sugars that are added to food during procession, preparation and manufacturing [33]. According to the Icelandic recommendations, intake of added sugar should be kept below 10 E% for all age groups. Regarding infants, it is strongly recommended that sweets and sugary foods, such as sweet drinks and cereals that contain sweet mixtures, are avoided [32]. The WHO has suggested a recommendation about reducing the intake of added sugar to below 5 E%, because of strong evidence about the relationship between added sugar intake and body weight, non-communicable diseases and dental caries [33]. The intake of added sugar may also reduce the intake of other food that contains higher levels of essential nutrients per unit of energy content. Added sugar provides only energy and almost no nutrients. A high intake of added sugar may therefore affect the intake of essential nutrients and lead to poor dietary quality. It is especially important to keep the intake of added sugar as low as possible for infants, because of their low energy requirement but high nutrition density need [12, 33].

2.5.3 Fat

Fat is an important part of the diet, especially in infancy, because it provides essential fatty acids, facilitates the absorption of fat soluble vitamins and increases the energy density of the diet [15]. An adequate supply of fatty acids is important to ensure the optimal growth of the infant brain and neurological development. The composition and quality of fatty acids in infants' diet is also important as a major determinant of growth, development and long-term health [34].

Infants' need for fat is proportionally high in the first months of life, due to the rapid growth rate. Breast milk and infant formulas can provide half or more of the total energy intake. There are no recommendations for infants younger than six months because exclusive breastfeeding is considered a sufficient source of fat [12]. During complementary feeding, this high energy density is often reduced in the diet as the amount of protein and carbohydrates increases. If the proportion of fat is too low in infants' diet it might result in insufficient energy intake [12, 18]. According to the Icelandic food based dietary guidelines, the recommended intake of fat is 30-45 E% for infants at the age of 6-11 months and 30-40 E% from 12-36 months. The intake of trans fatty acids should be kept as low as possible and the intake of saturated fatty acids should be less than 10 E% [32].

2.5.4 Protein

Appropriate protein intake in infancy and childhood is important to maintain normal growth and health [12]. Lack of protein in early life can have long-term negative effects on growth and neurodevelopment [35]. On the other hand, high protein intake during infancy is convincingly related to rapid growth and increased risk of obesity in childhood and adolescence [36-38]. In Iceland, it is recommended that the daily intake of protein should be 7-15% of the total energy intake for infants from 6-11 months and 10-15 E% for infants between 12-23 months of age [32]. Higher protein intake than 15 E% during the first two years of life has been related to greater risk for overweight in childhood and adolescence [12, 36].

It was a tradition in Iceland to provide cow's milk during complementary feeding [14]. Due to the evidence of there being an association between obesity and high protein intake in infancy [36-38], the

Icelandic infant dietary recommendations were revised in 2003 and the use of iron-fortified formulas was recommended from six months of age during complementary feeding. Furthermore, avoiding the use of cow's milk and other dairy products during the first year was recommended [10]. After the infant dietary recommendations were published, an Icelandic iron-fortified follow-on formula was launched. Compared to regular cow's milk, the Icelandic iron-fortified follow-on formula is higher in iron, lower in protein and the concentration of iron, vitamin C and D is higher. These changes were considered to have given good results, including a reduced protein intake in infancy and the prevention of obesity later in life [10, 12].

2.5.5 Iron

Iron deficiency is generally acknowledged as the most common nutritional deficiency all around the world and it is also the most common cause of anaemia worldwide. Iron deficiency during early childhood may have serious effects on health later in life that can be irreversible [12, 28]. Iron deficiency can lead to poorer cognitive functions and affect physical and mental development. It is also associated with slower growth, negative behavioral performance, increased susceptibility to infection and decreased auditory and visual function [39-42]. Iron is therefore a critical micronutrient for infants and young children. Infants have high requirements for iron, and according to the Icelandic food-based dietary guidelines, the recommended intake of iron is 8 mg/d for infants between 6-23 months of age [32].

After six months of age the iron status of infants becomes depleted because the iron stores that infants are born with get exhausted. Infants that are breastfed longer than six months do not need to be given iron supplements if they receive solid food that contains iron. However, infants that are not breastfed after six months are advised to drink iron-fortified follow-on formulas in addition to solid food [9].

Absorption of iron in the human body is poor compared to many nutrients and depends on the composition of meals. Iron is more easily absorbed if consumed with food that contains vitamin C. An adequate intake of vitamin C might therefore ensure sufficient iron absorption. Breast milk contains low amounts of iron but the absorption is high, about 50%, while it is only 10% from cow's milk and 4% from fortified infant formula [43]. However, the iron status in Icelandic infants has improved in recent years, which might be explained by a shift from cow's milk to iron-fortified follow-on formula in their diet [44]. Still, however, the average iron consumption of Icelandic infants is slightly too low, only 6.1 mg/d for infants at nine months of age and 6.3 mg/d for infants at 12 months of age [10].

2.5.6 Vitamin D

Sufficient vitamin D is important for infants' well-being and growth, and essential for bone health [45], to promote calcium absorption and to regulate blood calcium levels [17]. Whether breast milk alone does fulfill infants' need for vitamin D has often been questioned [46]. In order to ensure that infants get all the nutrients they need, the Directorate of Health in Iceland [32] and NNR [12] recommend that infants living in the Nordic countries should receive vitamin D as a supplement from 1-2 weeks of age in addition to breast milk and other food. These recommendations are based on the fact that sun exposure is insufficient in the Nordic countries, and the amount of vitamin D in breast milk does not fulfill infants'

need for vitamin D. Vitamin D recommendations are 10 μg/d for all infants and young children, given in the form of drops or fish liver oil [12, 32].

An Icelandic research from 2014 [47], that assessed vitamin D intake and status in one year old infants, demonstrated that 92% infants were considered vitamin D sufficient and no infants were classified as vitamin D deficient. Results showed that supplements, either vitamin D drops or fish liver oil, provided 56% of total vitamin D at 9-12 months and 38% of total vitamin D came from fortified products. Infants not using supplements or fortified products had a significantly lower vitamin D intake than all other infants in the research. These findings underline the importance of vitamin D supplements and/or fortified products in Icelandic infants' diet [47].

2.5.7 Iodine

Iodine is an essential nutrient in the diet. Iodine is needed in the body for the production of thyroid hormones, triiodothyronine (T_3) and thyroxine (T_4). Thyroid hormones are necessary for normal growth, development and metabolism during infancy [17]. Young infants are at high risk for the effects of iodine deficiency because of their rapid growth and development. Iodine deficiency in infants and young children can lead to brain damage and irreversible mental retardation. Therefore, it is important to ensure good iodine status among infants [48].

According to the Icelandic recommendations, the daily intake of iodine for infants between 6-11 months is 50 μg and 70 μg for infants between 12-23 months [32]. During the first six months, infants' need for iodine is met adequately by breast milk. The concentration of iodine in breast milk depends on the mother's diet [12, 49]. After six months of age, the majority of the iodine intake of Icelandic infants comes from fish and milk and other dairy products [50].

2.5.8 Zinc

Zinc is a key element for the optimal growth and development of infants [51]. An adequate zinc status has been related to maintaining bone density and normal immune and cognitive function [17]. Zinc deficiency in infancy can cause impaired immune response, increased infections and growth retardation [52]. Apoptosis is also increased by zinc deficiency. Zinc deficiency has more negative consequences during periods of increased metabolism such as in infancy. A dietary intake of zinc is therefore an essential part of infants' diet [17, 51, 52].

The need for zinc is relatively high in the first months of life, when rapid growth and weight gain occurs. Breast milk contains approximately 2.5 mg/L during the first four months and thereafter the concentration decreases to approximately 0.7 mg/L. Breast milk contains adequate amounts of zinc for infants in the first six months [12]. According to the Icelandic food-based dietary guidelines, the daily recommendations for zinc is 5 mg for infants between 6-23 months of age [32].

Findings from an Icelandic study on children born in 2005 showed that the average consumption of zinc was slightly below the daily recommendations [10]. The average intake at nine months was 3.2 mg and 3.8 mg at one year of age. Icelandic infants under one year of age do not eat much meat, which

may be the reason for this low consumption of zinc. Evidence supporting the recommendations are somewhat lacking, and some concerns have been raised that safe levels of zinc intake may be too high [10].

2.6 Food composition databases

Food composition databases play a key role in nutrition research. Food composition databases are for example used to estimate the intake of nutrients and other food components. Food composition databases are also needed for the formulation of food-based dietary guidelines to improve a population's diet [53]. Food composition databases provide information about the nutrient values of food, including energy, macronutrients (e.g. protein, carbohydrate, fat) and their components (e.g. sugars, starch, fatty acids), minerals and vitamins [54]. It must be noted that if there are gaps and missing values in the database it will led to a bias of nutrient intake estimations [55]. Food composition databases are usually specific for a particular country. There is a wide range of foods composition databases worldwide, covered with a variety of food types and food categories [54]. Different methods are used to compile information about nutritional content in food, such as chemical analysis of food samples, using nutritional values from other food composition databases, values on food labels or information obtained from manufacturers [54]. Food identification is important and includes food names, descriptions of food, food coding and food groups. Food identification is intended to facilitate the search and to ensure the correct choice. Each compositional value should be defined by a unit (e.g. g, mg or μg) and a denominator (e.g. per 100 g) [55].

Up-to-date food composition databases are necessary to observe changes related to the nutrition of individuals [11]. An Icelandic food composition database for infant commercial foods and formulas available in Iceland was last created in 2005 for a study that investigated Icelandic infant nutrition in 2005-2007 [10]. This particular database included 53 different types of infant commercial foods and formulas and has not been updated since then. The Icelandic food composition database (ISGEM) [56] and the Public health institute's recipe database were both updated for the Icelandic national dietary survey that was performed in 2010-2011 [57], but neither of them included infant commercial foods.

2.7 Consumption of infant commercial foods among infants

Globally, the sales and availability of infant commercial foods are increasing [4]. Infant commercial foods are both convenient and usually inexpensive, which attracts the consumers. Nowadays, such food is getting more common as a part of infants' diet, both in high- and low-income countries. Consumption of infant commercial foods may present a threat to the quality and diversity of infants' diet [4]. Nonetheless, only few studies exist on the consumption of infant commercial foods in industrialized countries. Results from a German study showed high consumption of infant commercial food among infants between 6-24 months of age. Overall, 59,3% of the total consumption by the study sample was infant commercial foods [5]. In addition, research performed in the US showed a high usage of infant commercial foods. About 73% of infants between 4-6 months of age consumed commercial baby foods with a mean of 187

g/d. Infant commercial foods were consumed by 95% of infants between 7-8 months and provided on average 20% of the total energy, and from 9-11 months of age 87% of infants consumed infant commercial foods [6]. Another study from the US also showed a high consumption of infant commercial foods. According to the results, 81% of infants who participated in the study had consumed infant commercial foods in the past 24 hours [7]. A study that used data from the European Childhood Obesity Project, including data from five European countries; Germany, Belgium, Italy, Poland and Spain, published findings about total dietary intakes from infant commercial foods. Results revealed that half of the reported food intake in all countries was from infant commercial foods and a large portion was sweetened. It must be noted that the use of infant commercial food varies widely between countries [58].

2.8 Nutritional intake from infant commercial foods

Infants have high energy and nutrients requirements and complementary foods must be nutrient dense to fulfill their needs [16]. Due to the increased usage of infant commercial food, concerns have been raised about their impact on the health of infants and whether they are nutritionally adequate [4]. Some infant commercial food products are of good quality, nutrient dense and fortified to meet the high nutrient requirements of 6-23 month old infants. Meanwhile, other products are processed snack foods, such as chips, biscuits and cookies, which are typically high energy dense but low in micronutrients. Consumption of processed snack foods leads to a reduced appetite for more nutritious and diverse foods [4].

Knowledge concerning the nutritional contribution of infant commercial foods to the diet of infants is scarce and inconsistent [59]. Regarding nutritional content, research performed in the UK found that the market of infant commercial foods mainly supplied sweet and soft foods that will not enhance the nutrient density of infants' diet. In comparison to home-made food, infant commercial foods on the UK market were much less nutrient dense [8]. Findings of research that estimated the sodium and sugar content of US infant commercial foods showed that the majority of vegetables, dinners, fruits and dry cereals were low in sodium and added sugars. However, food products such as snacks, desserts and juice drinks were of potential concern due to their high sugar or sodium content [60]. In contrast, Spanish research concluded that infant commercial foods had higher energy density, a better ratio between the macronutrients and a similar sodium content compared to UK home-made infant food [61]. In addition, another research from the UK found that infant commercial foods were related with better nutritional adequacy and not associated with a less diverse diet [59].

The consumption of infant commercial foods has been shown to influence infants' dietary patterns in the US with higher vegetable variety [7]. In terms of higher vegetable variety and consumption of infant commercial foods, there are some conflicting results. Research from Germany showed that infants at 12 months of age fed with commercial foods had significantly higher vegetable variety than those fed with home-made meals [62]. In contrast, another research performed in Germany demonstrated an association between higher consumption of infant commercial foods and lower intake of vegetables [63].

In sum, the literature is inconsistent, and further studies are needed to investigate short- and long-term consequences of the consumption of infant commercial foods [59]. No such research, which summarizes the consumption and nutritional intake of infant commercial foods, has been conducted in Iceland. Information on the diet and nutrition of infants and young children is necessary when implementing a national health program. However, based on the evidence that exists, the Directorate of Health in Iceland considers that the consumption of infant commercial foods, that is, food served in sachets and jars, should be in moderation among infants [9].

3 Methods

3.1 Construction of the infant commercial foods and formulas database

Information was sought on infant commercial foods and formulas available in Iceland during the period of October-November 2016. The selection was made by visiting various supermarkets and grocery stores in Reykjavík city and nearby. To access information photos were taken of food packaging and labelling of products intended for infants and young children. Products were packed in boxes, sachets, jars, plastics, glass bottles, bags or paper-based packaging. All data was collected into a Microsoft Excel sheet to make it accessible to create a food composition database. The infant food composition database ended up containing data for 248 different types of infant commercial foods and formulas from 20 various manufacturers.

General information about each product was listed by using product description and packaging, including product name, manufacturer's name, type of food product (e.g. cereal, fruit, vegetable, yogurt, meat, fish, pasta, juice, oil, snack and formula), texture, recommended age, fortification and nutritional content. The database was designed to contain detailed information about nutritional content of infant commercial foods per 100 g or 100 ml edible portion. For each product, the following nutritional information was documented, if stated: energy values (kJ and kcal), protein, fat (saturated, monounsaturated and polyunsaturated fats), carbohydrate (sugars, added sugar, fiber), vitamins (A, B1, B2, B6, B12, C, D, E, K, niacin, folic acid, biotin and pantothenic acid) and minerals (calcium, phosphorus, magnesium, sodium, potassium, iron, zinc, copper, iodine, manganese, selenium, fluorine and inositol). Nutritional content for each product was collected from either food labelling or the manufacturer's website. In cases where data was missing for vitamins and minerals, an email request was sent to manufacturers. In a few cases data was collected from the Norwegian food composition database.

3.2 The IceAge2 study

To calculate infants' nutrient intake from commercial foods and formulas, data were obtained from the IceAge2 study. The basis was a 3-day weighing food record for 25 infants aged nine months from April 2015-April 2017.

The overall aim of the IceAge2 study is to observe growth and development of body composition in infancy. The IceAge2 study is an observational study where infants who fulfill the inclusion criteria into one of the two study groups are invited to participate. The two predefined study groups are infants that are exclusively breastfed at 5 ½ months of age and infants that are complementary fed, receiving a minimum of 100 g/d of solid foods, at 5 ½ months of age. The IceAge2 study is still open and ongoing, that is, potential participants are currently being recruited by invitation and no study results have been published. The goal is to enroll 100 infants.

Among other factors considered in the study, parents or other caregivers keep a 3-day weighing food record assessing the infants' diet at age 5 ½, 9 and 12 months. The consumption quantities of food and drinks are determined at every mealtime using electronic scales (Philips HR 2385, Hungary or

Austria, precision 1 g). The exact types and manufacturers of infant commercial foods and formulas are registered. The amount of breastmilk consumed is assessed by test-weighing.

In this study, the 3-day weighing food records at the age of nine months were used to estimate the consumption of infant commercial foods in Iceland. It must be noted that the study sample was neither big (n=25) nor representative of the overall Icelandic infant population. It is possible that parents and other caregivers who are more ambitious about infant feeding might be more willing to participate in the IceAge2 study. However, it was considered ideal to use the 3-day food records to test the infant commercial foods and formulas database while gaining a slight sense of nine-month-old Icelandic infants' diet and composition of infant commercial foods and formulas.

3.3 Analysis of data

Food products were classified into five major food groups: ready-made foods (174 products), formulas (24 products), powdered meals (22 products), dry-finger foods (21 products) and others (7 products). By using name, packaging and product description, products could then be classified into subcategories in every food group. Ready-made foods contained five different subgroups: fruit puree, vegetable puree, fruit- and vegetable puree, fruit porridge/yogurt with fruits and complete meals with meat/fish/pasta/vegetable. Ready-made foods included prepared food that was served in jars, sachets or plastic boxes. The group of powdered meals included different kinds of porridge flour that needed a reconstitution with milk, water or other appropriate liquid. Powdered meals were split into two subgroups that consisted either of pure cereals or cereal mixed with fruit. Dry-finger foods were also divided into two subgroups: biscuits or snacks and dried fruits. Dry-finger foods were small pieces of food such as snacks, biscuits, bars and dried fruits. Formulas were divided into two subgroups: infant formulas and follow-on formulas. Both types of formulas are served in either liquid- or powder-form. Products that did not match the categories above were classified as "other" and included food types such as juices and oils. All nutritional analysis was given per 100 g or 100 ml edible part of the food. Nutrition values for porridge flour, powdered formulas and other foods that needed reconstitution with liquid were given on the assumption that preparation was done in accordance with instructions on the food packaging.

To estimate the average consumption of infant commercial foods from the Iceage2 study, the 3-day food record was entered into the ICEFOOD calculation program based on ISGEM and the infant commercial foods and formulas database resulting from this present study. The program ICEFOOD calculates the amount of nutrients and foods per day for each individual. ICEFOOD automatically takes into account nutrients degradation while cooking.

All statistical analyses were done using Microsoft Excel. Result are shown as mean and standard deviation (SD) or as percentages (%).

3.4 Author's contribution

1. *Collecting and entering data to create infant commercial food composition database*

   Work on this master's thesis started in the autumn of 2016. From September to October 2016, the author collected all the data for the infant commercial foods and formulas composition database. Data was then entered into Excel sheets, from October to December 2016, to make it accssible to create a food composition database.

2. *Entering food records from IceAge2 into ICEFOOD*

   The author used a total of two weeks to enter data, one in March and another one in April 2017. Together with a BSc student in Nutrition, the author entered 25 3-day food records from the Iceage2 study into the program ICEFOOD to calculate the intake of infant commercial foods and formulas among Icelandic nine-months-old infants.

3. *Analysis and interpretation of data*

   Analysis of data on the infant food composition database was made in February 2017 using Microsoft Excel. March 2017 was mostly used for interpretation of results. New food records were constantly coming in so their analysis did not start until the middle of March and lasted until the end of April 2017. The interpretation of the 3-day food records was summarized shortly thereafter.

4. *Writing the thesis*

   Documentations and the writing of the thesis was carried out during the early months of 2017, from January to April.

4 Results

4.1 General characteristics of the database

Characteristics of products are shown in *Table 1*. In this study 248 different infant commercial food products were identified from 20 various manufacturers. There were five prominent manufacturers on the market, with an overall proportion of 75.8%. Nestlé was the biggest manufacturer on the market with 18.5% of all products. Nestlé also had the widest selection and was the only manufacturer that had at least one product in every food group. The second largest manufacturer was Semper (16.1%) and thereafter HiPP (15.7%), Ella's kitchen (12.9%) and Holle (12.5%). It was noteworthy that most of the products were imported; there was only one Icelandic brand on the market with 4 different products.

Of these 248 products, ready-made infant foods were in the majority with a 70.2 % proportion, thereafter formulas with a 9.7% proportion, powdered meals 8.8%, dry-finger foods 8.5% and others 2.8% (*Table 1*). The infant commercial food products were grouped by age (months) as shown in *Table 1*. Products intended for infants aged 0-6 months were only found in the food group of infant formulas, a total of 15 products (6.0%). The two largest age groups were 4+ months of age and 6+ months, with a major part of products in the ready-made food group. Nearly 30% of the products were targeted for 4+ months of age and 34% were targeted for 6+ months of age. Products in the age groups of 7+, 8+ and 12+ months were also common, but rather less so in the age groups of 5+, 9+, 10+ and 15+. There were 13 products where age was not mentioned on the food label.

Table 1: Number and proportion of products at each age group sorted by food types

Age group	**Database Total**	**Ready-made foods**	**Formulas**	**Powdered meals**	**Dry-finger foods**	**Others**
(months)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
0+	15 (6.0)	0 (0)	15 (6.1)	0 (0)	0 (0)	0 (0)
4+	73 (29.4)	59 (23.8)	0 (0)	9 (3.6)	0 (0)	5 (2.0)
5+	1 (0.4)	1 (0.4)	0 (0)	0 (0)	0 (0)	0 (0)
6+	85 (34.3)	69 (27.8)	8 (3.2)	8 (3.2)	0 (0)	0 (0)
7+	17 (6.9)	15 (6.1)	0 (0)	1 (0.4)	1 (0.4)	0 (0)
8+	16 (6.5)	13 (5.3)	0 (0)	2 (0.8)	1 (0.4)	0 (0)
9+	3 (1.2)	2 (0.8)	1 (0.4)	0 (0)	0 (0)	0 (0)
10+	3 (1.2)	0 (0)	0 (0)	0 (0)	3 (1.2)	0 (0)
12+	21 (8.5)	4 (1.6)	0 (0)	2 (0.8)	15 (6.1)	0 (0)
15+	1 (0.4)	1 (0.8)	0 (0)	0 (0)	0 (0)	0 (0)
None	13 (5.2)	10 (4.0)	0 (0)	0 (0)	1 (0.4)	2 (0.8)
Total	248 (100)	174 (70.2)	24 (9.7)	22 (8.8)	21 (8.5)	7 (2.8)

4.2 Nutritional content

4.2.1 Energy density and macronutrients

Table 2 illustrates the average (SD) energy density and nutritional content of macronutrients in different food groups and subgroups. Minimum (min.) and maximum (max.) levels for each group are also given to better evaluate the variations within groups. There were no missing data in the food composition database for the following: energy, fat, carbohydrates, sugars and protein. Values for fiber were given for a total of 180 products (72,5%). It was noteworthy that none of the 248 products contained added sugar.

As shown in *Table 2*, the average energy content of ready-made foods was the lowest of all food groups. Of ready-made foods, fruit porridge and yogurt had the highest energy value and almost twice as high as vegetable puree, which had the lowest energy value. Complete meals had higher protein and fat content compared to other products of ready-made foods and the lowest sugar level. Complete meals could be considered the most ideal products in this particular food group in terms of combinations of macronutrients. On average, ready-made products that included fruits had markedly higher sugars level than others.

As expected, all types of formulas were very similar in terms of energy and nutritional content. The average energy content of follow-on formulas was slightly higher than that of infant formulas, which can be explained by a difference in the amount of carbohydrates. However, infant formulas appear to contain a slightly higher level of fat compared to follow-on formulas and the probable reason for this is that the difference of energy density is not greater between the two subgroups of formulas. On average, the levels of sugar, fiber and protein were nearly the same (*Table 2*).

The powdered meals had relatively high energy values, especially compared to similar food groups that are intended to provide satiety, such as ready-made foods and formulas (*Table 2*). However, there were substantial differences regarding energy and nutrients values within the subgroups. Pure cereal porridge had 25% higher energy values than cereal porridge with fruits. Pure cereal also had higher carbohydrates and fat content and a lower level of sugars. There were no major differences between subgroups in the levels of protein and fiber.

The food group that had the highest energy density overall was the dry-finger foods, which had an especially high carbohydrate and sugar content. The two subgroups of dry-finger foods were quite different; biscuits and snacks had a much higher energy, fat and protein content while dried fruits had much higher sugar and fiber levels. Biscuits and snacks was the subgroup with the highest energy and macronutrient values of all products, besides the oil in the “others” food group, but making a further comparison is not worthwhile due to different purpose of these products (*Table 2*).

The food group called “others” included products that did not have anything in common with other products. As shown in *Table 2* this particular food group eventually ended up with two different types of food, fruit juices and oils. It was not considered appropriate to compare these two subgroups with each other or with other food groups because of different properties and the low number of samples. As expected, fruit juices had very low energy and nutritional values. The main ingredient in fruit juices were simple carbohydrates (sugars). Only one oil targeted at infants was found on the market. Therefore, the values that are given in *Table 2* are for this one particular oil.

Table 2: Mean (SD) and min./max. levels of energy and macronutrients in selected foods* per 100 g

Food group	n	Energy (kcal)	Min./Max.	Fat	Min/Max.	Carbohydrates	Min./Max.	Sugars	Min./Max.	Fiber**	Min./Max.	Protein	Min./Max.
Ready-made foods	174	63.3 (14.5)	109.0/470.0	1.1 (1.1)	0.0/4.1	11.4 (3.6)	3.2/20.2	7.5 (4.6)	0.3/16.3	1.7 (0.5)	0.4/3.6	1.3 (1.2)	0.0/5.0
Fruit puree	77	62.0 (10.6)	186.0/404.0	0.3 (0.4)	0.0/3.0	13.6 (2.3)	9.3/19.6	11.1 (2.1)	5.8/16.3	1.8 (0.4)	0.8/3.3	0.5 (0.2)	0.0/1.1
Vegetable puree	19	40.5 (12.7)	109.0/292.0	0.8 (0.9)	0.1/3.0	6.2 (2.0)	3.2/10.7	2.6 (1.2)	0.3/4.3	2.2 (0.4)	1.3/2.8	1.1 (0.6)	0.5/3.0
Fruit- and veg. puree	12	49.8 (5.6)	154.0/248.0	0.4 (0.1)	0.2/0.5	10.1 (1.5)	6.6/12.0	8.7 (1.4)	6.2/11.0	2.0 (0.5)	1.4/2.8	0.6 (0.3)	0.0/1.2
Fruit porridge or yogurt with fruits	23	80.2 (1.0)	230.0/470.0	1.5 (0.2)	0.3/2.4	14.4 (0.8)	11.0/20.2	9.3 (0.5)	5.5/13.1	1.4 (0.1)	0.4/2.0	1.5 (0.3)	0.9/2.9
Complete meals with meat/fish/pasta/veg.	43	69.8 (12.7)	159.0/458.0	2.5 (0.7)	0.6/4.1	8.3 (2.1)	4.8/16.3	2.0 (0.7)	0.6/3.4	1.5 (0.5)	0.8/3.6	3.0 (0.6)	1.1/5.0
Formulas	24	67.6 (1.3)	276.0/292.0	3.4 (0.2)	2.8/3.6	7.8 (0.8)	7.0/9.5	6.1 (1.8)	4.5/7.8	0.2 (0.2)	0.0/0.6	1.5 (0.2)	1.2/1.9
Infant formula	15	66.9 (0.7)	276.0/287.0	3.5 (0.1)	3.3/3.6	7.4 (0.3)	7.0/7.9	6.1 (2.1)	5.8/7.8	0.2 (0.2)	0.0/0.6	1.4 (0.2)	1.2/1.9
Follow-on formula	9	68.8 (1.2)	280.0/292.0	3.2 (0.3)	2.8/3.5	8.5 (0.8)	7.2/9.5	6.0 (1.1)	4.5/7.6	0.2 (0.2)	0.0/0.5	1.5 (0.1)	1.3/1.8
Powdered meals	22	140.8 (39.6)	207.0/892.0	4.2 (1.8)	0.2/6.8	21.0 (6.4)	6.6/35.0	7.6 (2.8)	0.1/12.5	1.0 (0.5)	0.2/1.7	4.2 (1.0)	1.7/6.3
Pure cereal porridge	12	159.6 (36.4)	480.0/892.0	5.1 (2.3)	0.2/6.8	23.4 (6.3)	15.0/35.0	7.2 (3.2)	0.1/9.6	0.9 (0.6)	0.3/1.7	4.4 (1.2)	2.2/6.3
Cereal porridge with fruits	10	118.2 (32.6)	207.0/742.0	3.2 (1.0)	1.7/5.3	18.2 (5.2)	6.6/26.1	8.0 (3.1)	2.4/12.5	1.1 (0.5)	0.2/1.7	4.0 (0.9)	1.7/4.9
Dry-finger foods	21	343.6 (70.9)	1151.0/1965.0	6.0 (6.3)	0.0/14.2	65.7 (6.0)	62.0/85.7	28.7 (12.9)	3.6/42.0	5.6 (2.9)	0.0/8.0	3.8 (2.6)	0.0/9.2
Biscuits/snacks	8	414.9 (34.0)	1494.0/1965.0	11.5	0.0/14.2	69.8 (8.2)	62.0/85.7	14.3 (9.2)	3.6/32.0	3.4 (2.6)	0.0/7.8	6.1 (2.8)	0.0/9.2
Dried fruits	13	299.8 (47.2)	1151.0/1650.0	2.6 (4.5)	0.2/11.0	63.2 (1.7)	62.2/68.3	37.6 (2.1)	32.0/42.0	7.2 (1.9)	3.0/8.0	2.4 (1.0)	1.9/4.9
Other	7	472.8		50.1		5.5		5.0		0.6		0.1	
Juice	6	45.7 (12.0)	149.0/292.0	0.1 (0.2)	0.0/0.5	11.0 (3.1)	8.0/17.0	10.0 (3.7)	7.0/17.0	1.2 (1.2)	1.2/1.2	0.2 (0.2)	0.1/0.5
Oil***	1	900.0		100.0		0.0		0.0		0.0		0.0	

*n=248 products

**n=180, available for 124 ready-made foods, 18 formulas, 16 powdered meals, 20 dry-finger foods and 2 products in others

***n=1, values given for one particular product. Average and SD are undefined

4.2.2 Micronutrients

While collecting data it soon became apparent that a considerable amount of information on nutrients was missing on product packaging, especially for micronutrients. Repeated requests were sent to manufacturers to provide additional nutrition information, without any results. As shown in *Table 3,* the following micronutrients were examined: iron, vitamin D, iodine and zinc.

Unfortunately, there were only two food groups where sufficient information for micronutrient was given; formulas and powdered meals. For the rest of the food groups, information about micronutrients was either very limited or not given. Where values were missing in a large number, data was not analyzed for those food groups.

Table 3: Mean (SD) and min./max. levels of micronutrients in selected foods per 100 g

Food group	Iron (mg)	Min./Max.	Vit. D (µg)	Min./Max.	Iodine (µg)	Min./Max.	Zinc (mg)	Min./Max.
Formulas	0.8 (0.3)	0.4/1.2	1.1 (0.1)	0.9/1.3	13.6 (2.8)	9.1/18.0	0.6 (0.1)	0.4/0.7
Infant formula	0.6 (0.2)	0.4/1.2	1.1 (0.1)	0.9/1.3	12.3 (2.4)	9.1/16.0	0.5 (0.1)	0.4/0.7
Follow-on formula	1.0 (0.2)	0.8/1.2	1.2 (0.1)	0.9/1.3	15.6 (2.1)	12.0/18.0	0.6 (0.1)	0.4/0.7
Powdered meals	2.5 (1.0)	0.7/4.0	2.1 (0.3)	1.7/3.0	21.4 (5.9)	15.0/33.0	1.1 (0.5)	0.8/2.8
Pure cereal porridge	2.9 (0.6)	2.5/4.0	2.0 (0.2)	1.8/2.3	25.2 (7.1)	15.0/33.0	1.4 (0.7)	0.8/2.8
Cereal porridge with fruit/yogurt	2.1 (1.2)	0.7/3.0	2.2 (0.4)	1.7/3.0	18.2 (1.6)	15.9/21.3	0.9 (0.1)	0.8/0.9

Table 3 illustrates average content (SD), and min. and max. levels of micronutrients in the two food groups that had sufficient data. As regards formulas, iron levels were a bit different between subgroups, where follow-on formulas had on average a 40% higher iron content than infant formulas. The reason is probably that follow-on formulas are intended for infants older than six months when dietary iron is needed to prevent iron deficiency. The level for iodine was also higher (21%) in follow-on formulas compared to infant formulas. In terms of vitamin D and zinc, values were similar.

Overall, micronutrient values were higher in powdered meals than formulas (*Table 3*). However, levels between subgroups in powdered meals were varied. Pure cereal porridge had on average a 28% higher iron and iodine content and a 36% higher zinc content while cereal porridge with fruit or yogurt turned out to contain a 9% higher vitamin D level.

The only information on micronutrients that was available for all products regarded sodium. The sodium level was generally low in all food groups (data not shown). As expected, the sodium level was highest for biscuits and snacks, that belong to the group of dry-finger foods, with an average sodium content of 0.6 g.

4.3 Consumption of infant commercial foods

Overall, the mean daily intake of all foods and drinks among Icelandic nine-month-old infants in a sample from the IceAge2 study (n=25) was 883.9 g, of which 612.9 g (69.3%) were home-made foods or breast milk and 271.0 g (30.7%) were infant commercial foods or formulas. All the 3-day diet records included at least one portion of infant commercial food each day, with one exception where an infant received only home-made foods for a day. The maximum daily consumption of infant commercial foods was 803 g (data not shown).

A more detailed daily consumption of infant commercial foods and formulas is shown in *Table 4*. The consumption of ready-made foods was by far the highest (46.6%) among infants aged nine months. Of ready-made foods, fruit puree had the highest proportion, 30.2% of the total (data not shown). Next came formulas with a proportion of 28.8% and then powdered meals (23.9%). The consumption of dry-finger foods was minimal (0.2%), as was the intake of other food types (0.5%) like fruit juice and baby weaning oils.

Table 4: Mean (SD) consumption (g/day) and proportion (%) of daily intake of infant commercial foods and formulas

Food group	**Mean (SD)**	**% of infant commercial foods and formulas**
Ready-made foods (g/day)	126.2 (43.9)	46.6
Formulas (g/day)	78.0 (46.0)	28.8
Powdered meals (g/day)	64.8 (26.8)	23.9
Dry-finger foods (g/day)	0.6 (0.7)	0.2
Other (g/day)	1.4 (3.4)	0.5

5 Discussion

5.1 Main results

This study demonstrates the wide selection of infant commercial foods and formulas available in Iceland for different age groups and describes their main features and nutritional content. Results showed that the market mainly consists of ready-made commercial foods that are intended for infants from four and six months of age. However, ready-made foods turned out to be more energy and nutrient dilute than breast milk and formulas. The consumption of infant commercial foods among nine-month-old infants in a sample from the IceAge2 study was quite high, i.e. 30% of the total daily food intake. The consumption of infant commercial foods was in accordance with the selection available on the market, that is, the consumption of ready-made foods was the highest of all food groups among infants. Results indicate that infant commercial foods are widely used by parents and other caregivers and that many of these products do not meet infants' requirements for energy and nutrients.

5.2 General characteristics of the database

This study provides a good overview of infant commercial foods and formulas available on the market. To the best of the author's knowledge this is the first Icelandic study that aims to summarize the variety and nutritional content of infant commercial foods. Because of the wide variety, it was impossible to collect information for all products on the market but the number of products in this study covers the majority. Despite a wide range of infant commercial foods there were only few manufacturers that dominated the Icelandic market and none of them were local. Surprisingly, there were only two Icelandic producer, who had a minimal selection. At the same time, however, this provides a great opportunity to bring to the market products that are produced in Iceland. Evidence from an Icelandic report [64] indicated that there is a market for Icelandic infant commercial products and mothers would feel more confident knowing that food is produced in Iceland.

Interestingly, many products (n=73) were targeted and labeled as being suitable from four months of age, especially when considering recommendations published by the WHO [3], the Directorate of Health in Iceland [9] and NNR [12] about introducing complementary food at six months of age under normal circumstances. A study conducted in the UK showed similar results, where 44% of total products were aimed at infants from four months [8]. It can be assumed that such remarks on food labels would encourage the introduction of complementary foods before six months of age. The majority of products that were targeted for infants at four months of age were fruit puree (n=29), which can be described as sweet foods because of high sugars levels. Overall, 50% (n=135) of the infant commercial foods included fruits in the name of the products. A preference for sweet is present from birth [65] and may be the reason why manufacturers use fruits in such large quantities in producing infant commercial foods; they are trying to make them more palatable.

It is also noteworthy how many age groups infant commercial foods are aimed at. Some of the age groups only include few products and two of them only count one product, 5+ months and 15+ months. When data was examined further, there were no special indicators why they should not belong to other age groups containing similar products. What causes this could not be determined.

5.3 Nutritional content

5.3.1 Energy density and macronutrients

Complementary foods are required to fill the gap between the total nutritional needs of the infant and the amounts provided by breast milk [18]. The main purpose of complementary foods is therefore to provide greater energy density than breast milk, that is, at least 0.8 kcal per gram among sufficient amounts of essential nutrients [18]. Yet the largest food group, the ready-made foods, supply on average only 0.63 kcal per gram, which is not sufficient. Ready-made foods are low in energy and will therefore not serve the intended purpose of enhancing the energy and nutrient density in infants' diet. Dry-finger foods are high in energy but contain low-quality macronutrients and are not meant to be used as a complete meal in infants' diet.

Powdered meals, on the other hand, provide on average 1.4 kcal per gram, and this could be considered as appropriate complementary foods in terms of energy. However, the energy and nutrient density differs considerably between types. Pure cereal porridge is much more energy and nutrient dense then porridge with fruits or yogurt. These results support the recommendations [9] about choosing commercial porridge without added flavorings, not only in terms of energy and nutrients density but also because they do not develop the infants' sweet taste perception as much [65].

The Directorate of Health in Iceland [9] recommends that fat, e.g. vegetable oil, is added to porridge, fruit puree, vegetables puree and other foods that are low in fat. In fact, infant commercial foods do not contain a high proportion of fat, except dry-finger foods such as snacks and biscuits. Powdered meals and formulas were on average higher in fat than ready-made foods. Ready-made foods cannot be considered as a good source of fat and do not meet infants' requirements. Ready-made foods are served in jars, cans or pouches, so customers most likely assume that they do not need any additional energy or nutrients. Powdered meals, on the other hand, contained a slightly larger amount of fat than ready-made foods and the advantage of powdered meals is that they need to be reconstituted with liquid and it is therefore more convenient to add fat.

Infant commercial foods have it in common that they are rich in carbohydrates, but with varied amounts and proportions of sugars and fiber. As expected, products including fruits contained high levels of carbohydrates and sugars. Powdered meals and dry-finger foods were also high in carbohydrates. Overall, levels of sugars might be considered as too high for some of the products, but most important is the fact that none of the products included added sugar.

If results from this study are compared to the UK study [8] that aimed to describe the nutritional content of infant commercial foods available in their country, the outcome is much the same. Nutritional values for food groups such as ready-made foods, formula milk and dry-finger foods were quite similar. The UK research concluded that infant commercial foods would not add to the nutrient density of infants' diet. These results raise the question whether infant commercial foods are suitable to be chosen as a complementary food, especially if mothers are justifying introducing foods earlier than six months with their feeling that their infants need more energy in addition to breast milk. Healthcare providers should at least inform parents and other caregivers about the pros and cons of using infant commercial foods and what is preferred when choosing between such products. Most of the infant commercial foods seems to be more energy and nutrient dilute than breast milk and formulas.

Overall, the energy content of infant commercial foods varied between types and food groups. According to these results, it would not be considered optimal to use ready-made foods extensively. Ready-made foods do not provide enough energy density to fulfil infants' daily need. However, there is no need to avoid ready-made foods completely, but according to the results they are not appropriate for daily use. Ready-made foods should be used in moderation, as recommended by the Directorate of Health in Iceland [9].

5.3.2 Micronutrients

Sadly, there was a lack of information available about micronutrients content. There were only two food groups that provided sufficient information about the certain micronutrients that were examined in this study; formulas and powdered meals. Values between infant formulas and follow-on formulas were slightly different. Levels for micronutrients were higher for follow-on formulas. Interestingly, follow-on formulas had a considerably higher iron content. Follow-on formulas are designed for infants older than six months [22], right about when iron stores become depleted and the requirements for iron and other micronutrients become higher [17]. The purpose of follow-on formulas is apparently to fill up the increased need for nutrients after that age.

Since formulas are designed to be breast milk substitute or an addition, values for formulas were ideal to compare with powdered meals. Powdered meals had on average higher values than formulas in all categories of micronutrients and may therefore well be considered as an optimal choice during the period of complementary feeding. Powdered porridge is commonly fortified with iron and other micronutrients, which is one of the reasons why it is recommended [9] to use infant commercial porridge, without added flavorings, instead of homemade porridge in the first year of an infant's life.

The reason for these particular micronutrients being selected for examination in this study is that the intake of vitamin D, iron and zinc was detected to be lower than recommendations suggest in the latest study that investigated Icelandic infants' nutrition status [10]. Iodine intake was, however, not investigated in this particular study but considering how common and damaging the effects of iodine deficiency can be in infancy [48] it would be interesting to examine this. Due to major changes on the market in terms of infant commercial foods and their wide selection, changes can be expected in Icelandic infants' diet since the last study was performed. Since the infant commercial food database has not been updated since 2005 it was important to evaluate the nutritional content of these products in order to investigate the nutritional status of Icelandic infants. However, the lack of data makes it difficult to estimate the infants' exposure to micronutrients and can result in biased estimation. These results indicate that there is a need for further analysis of infant commercial foods.

5.4 Consumption of infant commercial foods

The results indicated a high consumption of infant commercial foods among nine-month-old infants. Every infant in the sample received a certain amount of infant commercial foods every day, with one day as an exception, and these foods provided on average about 30% of the total food intake. The consumption of ready-made foods was most common, especially fruit puree, that had the highest

proportion of all food types. The intake of formulas and porridge was also quite high. The consumption of dry-finger foods was minimal, which is positive.

The overall rate of infant commercial foods consumption among Icelandic nine-month-old infants can be considered rather high, especially if the recommendations are kept in mind. Likewise, studies from Germany [5] and the US [6, 7] have previously reported a high consumption of infant commercial foods. The Directorate of Health in Iceland [9] recommends a moderate intake of ready-made foods, especially for infants between 8 to 9 months that need to get used to food with different texture that suits their age and developmental stage [9]. However, the results show a high usage which is contrary to recommendations.

The consumption of fruit puree made up the majority of consumption of all infant commercial foods. If the infant commercial foods database is examined it turns out that what characterizes commercial fruit purees is that they are commonly designed for infants from four and six months old. They are also often served in either sachets or jars which means that the food provides little variety in texture. These results are in accordance with a similar study performed in the UK [8]. Soft pureed food does not give infants much practice or encouragement in developing the ability to eat food with different kinds of texture or thickness. Infants at this age are developmentally able to eat almost all kinds of healthy food and it should be a priority [18]. However, based on these results it can be concluded that the usage of soft pureed infant commercial foods is high among the study sample and they are not receiving food that suits their age or ability to chew and swallow.

Overall, ready-made foods were generally less energy dense than other infant commercial foods. Yet the most commonly used commercial foods considered in this study were products that supply less energy and macronutrients than formulas and breast milk. This is a cause for concern because such foods will not add to the nutrient density or encouragement for infants to progress to suitable family foods.

5.5 Limitations

A lot of work was put in creating the infant commercial food composition database. A number of attempts were made to get access to detailed nutritional information by sending requests to manufactures, both here in Iceland and abroad. This turned out to be unsuccessful and therefore the food composition database ended up containing a number of gaps because of missing data, especially for micronutrients. It must be assumed that missing data can distort the resultant nutrient estimations. The infant commercial food composition database includes all the main/principal products on the market in Iceland 2016. Due to the wide variety on the market some products will most likely be missing. However, it will be considered as enough data to get a comprehensive overview.

6 Conclusion

This study demonstrates a wide selection of infant commercial foods and formulas available on the Icelandic market in 2016. The market consists mainly of soft pureed ready-made foods (70.2%) that are served in sachets or jars, and are aimed at infants from the age of four months. Commercial ready-made foods do not provide the encouragement needed for infants to progress to a family food-based diet, thus introducing different flavors, texture and thickness, nor diverse energy and macronutrients to fulfill infants' nutritional need. Nonetheless, there were some products on the market that could help to improve the energy and nutritional status of infants, that is, if they contain an optimal nutrient composition and are appropriately fortified. As can be derived from this study, different kinds of porridge and formulas are examples that can be considered as sufficient complementary foods.

It turned out that consumption of infant commercial foods and formulas among Icelandic nine-month-old infants was high, about 30% of the total consumption. Given that parents choose infant commercial foods in abundance during complementary feeding, healthcare providers should advise parents to look carefully at the food labels and to be aware that a minority of infant commercial foods provide additional nutrient density to the diet. Parents choosing to use infant commercial foods also need to be advised on appropriate ingredients and recipes. First of all, health providers should encourage parents and other caregivers to prepare high nutrient dense family foods with sufficient energy according to recommendations and limit snacks, biscuits, ready-made foods and other similar foods that are low in nutrients but high in energy.

In terms of constantly high consumption of infant commercial foods, the results raise a concern related to little knowledge about detailed nutritional content in these products, especially for micronutrients. Further investigations are therefore required to ascertain whether these products are sufficient or not, as well to be able to estimate the relevant nutritional status among Icelandic infants.

The bottom line is that infant commercial foods include a wide range of products that are of varied quality. Infant commercial foods, that is, ready-made foods and dry-finger foods should be used in moderation and only in addition to appropriate home-made foods as recommended by the Directorate of Health in Iceland.

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