Development of a new milk product from fresh follow-on formula for young children

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Þróun nýrrar mjólkurafurðar fyrir ung börn

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Ágrip

Bakgrunnur og markmið: Ungbarnaskeiðið og fram að tveggja ára aldri er eitt af þeim tímabilum ævinnar þar sem góð næring er hvað mikilvægust til að stuðla að vexti, þroska og heilsu barnsins. Fyrstu sex mánuði ævinnar er brjóstamjólk talin vera besta næringin sem ungbörn geta fengið en um það leyti er ráðlagt að byrja að gefa börnum að smakka annan mat. Jógúrt er dæmi um holla og næringarríka vöru, en samkvæmt íslenskum ráðleggingum er börnum undir eins árs ekki ráðlagt að neyta þess þar sem það er talið vera of próteinríkt. Markmið þessa verkefnis var að búa til jógúrt sem uppfyllir næringaþörf ungbarna frá sjö mánaða til tveggja ára aldurs.

Aðferðir: Foreldrar 304 barna á aldrinum 0-6 ára tóku þátt í viðhorfskönnun á netinu þar sem meðal annars var spurt um tilbúinn barnamat. Framleiddar voru jógúrtafurðir úr stoðmjólk og venjulegri hreinni jógúrt með aðstoð sérfræðinga Mjólkursamsölunnar. Afurðirnar voru þá mældar með tilliti til efnasamsetningar (prótein, fita, kolvetni, vatn, aska), vatnsheldni litar, sýrustigs og geymsluþol þeirra metið út frá myndun mjólkursýrugerla, gers og myglu. Þá voru nærinnrauðar litrófsmælingar (NIR) og kjarnspunamælingar (NMR) einnig notaðar til að greina eðlis- og efnaeiginleika afurðanna betur. Afurðirnar voru geymdar við 0-2°C í um það bil einn mánuð frá framleiðsludegi. Afurðirnar voru þar að auki smakkaðar inni á rannsóknarstofu af nemendum sem þar voru og skyneiginleikar metnir á óformlegan hátt.

Niðurstöður: Foreldrar barna á aldrinum 7-24 mánaða voru hvað jákvæðastir fyrir nýrri jógúrtvöru sérstaklega ætlaðri ungum börnum. Niðurstöður mælinga bentu til þess að stoðmjólk ein og sér sé ekki nægilega hentugt hráefni fyrir jógúrtframleiðslu til þess að fá ákjósanlega áferð, heldur sé þörf á notkun trefja og bindiefna til þess að ná fram fullnægjandi áferð. Hins vegar bentu geymsluþolsmælingar til þess að afurðirnar séu mjög stöðugar með tilliti til mjólkursýrugerla og engin ger- eða myglumyndun átti sér stað á því tímabili sem mælingar voru framkvæmdar. Mælingarnar voru þó ekki allar jafn stöðugar hvað varðar vatnsheldni. Jógúrtafurðin úr stoðmjólk sem innihélt trefjar og sterkju hafði mestu vatnsheldnina, áferðin á henni var jafnframt líkust áferðinni á venjulegri jógúrt. Hinar afurðirnar, þ.e.a.s. jógúrt úr Stoðmjólk með trefjum og gelatíni, jógúrt úr Stoðmjólk með eingöngu trefjum, jógúrt úr Stoðmjólk með auknu próteinmagni (úr 1,8% í 2,2%) og vítamínbætta jógúrtin úr venjulegri mjólk virtust hafa minni getu til þess að halda í vatnssameindirnar og áferðin á þeim var einnig mjög þunnfljótandi. Bæði litur og sýrustig afurðanna var mjög stöðugt með geymslutíma.

Ályktanir: Rúm virðist vera fyrir nýjungar á íslenskum markaði fyrir barnamat. Þrátt fyrir að stoðmjólkin innihaldi mjög lágt magn af próteinum, þá er hægt að sýra hana og búa til jógúrt með ákjósanlegri áferð með hjálp trefja og maíssterkju.

Abstract

Background and aim: Optimal nutrition in infancy is very important for growth, maturity and infant health. Breast milk is considered to be the best food for infants up to six months of age but around this time, infants should also start to consume other types of food. Yoghurt is an example of a healthy and nutritious food product. However, infants less than one year old are not recommended to consume regular yoghurt, as it is considered too high in protein. The aim of this study was to develop a yoghurt, which fulfils the dietary needs of young children within the age range of seven months to two years.

Methods: An internet survey was performed where 304 parents of children aged 0-6 years old participated. They answered questions about their attitude towards ready-to-eat baby food products. The largest milk producer in Iceland, MS, produced products made from Support milk and from regular yoghurt, which were then assessed by their chemical composition (protein, fat, carbohydrates, water and ash), water holding capacity, colour and pH, and their stability was estimated by the survival of lactic bacteria, and formation of mould and yeast. Near infrared (NIR) spectroscopy and nuclear magnetic resonance (NMR) analysis were also performed to analyse the physicochemical properties of the products in more detail.

Results: Parents of children aged 7-24 months were most positive towards a new yoghurt product for infants. Results from measurements indicated that Support milk alone is not a convenient raw material for a yoghurt production to obtain a desirable consistency. There is a need for fibres and stabilisers to get the most adequate consistency. However, the shelf life measurements indicated a very stable product in terms of lactic acid bacteria count. No formation of moulds and yeasts was observed during the storage time but not all products were stable in terms of water holding capacity. The yoghurt with fibres and starch had the best ability to retain water, and also the most desirable consistency. The other products, i.e. the support yoghurt containing fibres and gelatine, the support yoghurt containing only fibres, the support yoghurt containing extra protein and the vitamin-enriched regular yoghurt, had little or no ability to retain water and their consistency was very thin flowing. Both the colour and pH value of all products were very stable throughout the storage time. The products were stored at 0-2°C for approximately one month period from production. The products were tasted at the research lab by students already present, and the sensory properties assessed informally.

Conclusions: There seems to be room for a new baby food product on the Icelandic market. Even though the Support milk contains very low amount of proteins, it is possible to ferment it and make a yoghurt product with the help of fibres and maize starch.

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Abbreviations

ALA	α-linolenic acid
BMI	Body Mass Index
CFU	Colony forming unit
CLA	Conjugated Linoleic acid
CPMG	Carr-Purchell-Meiboom-Gill pulse sequence
DHA	Docosahexaenoic acid
EFSA	European Food Safety Authority
EPA	Eicosapentaenoic acid
FA	Fatty acids
FAA	Free amino acids
FAD	Flavin adenine dinucleotide
FMN	Flavin mononucleotide
FOF	Follow-on formula
GI	Gastrointestinal
HMO	Human milk oligosaccharides
HPLC	High-performance liquid chromatography
ID	Iron deficiency
IDA	Iron deficiency anaemia
IF	Infant formula
IGF1	Insulin growth factor 1
LA	Linolenic acid
LAB	Lactic acid bacteria
LDL	Low-density lipoprotein
MUFA	Monounsaturated fatty acids
NE	Niacin equivalents
NIR	Near infrared spectroscopy
NMR	Nuclear magnetic resonance
PLP	Pyridoxal phosphate
PUFA	Polyunsaturated fatty acids
RDI	Recommended daily intake
RE	Retinol equivalents
SFA	Saturated fatty acids
τ	Interpulse duration
TE	Tocopherol equivalents
THFA	Tetrahydrofolic acid
WHC	Water holding capacity
25(OH)D	25-hydroxy vitamin-D

1 Introduction

The first 1000 days are often considered to be the most important days in a child's life, i.e. from conception to the second birthday. Nutrition is extremely important in this period for both cognitive and physical development in childhood (Kattula et al., 2014; WHO, 2009). During the first trimester of pregnancy, folate is, for example, very important for foetal development in the prevention of neural tube defects (Elmadfa & Meyer, 2012). Nutrition in infancy, during the first year, also lays the groundwork for a child's dietary habits later in life (Directorate of Health, 2009). Infants are born with enough iron supplies for the first 4-6 months but after six months of age, they need to consume iron rich food, such as iron enriched porridge and follow-on milk (Rao & Georgieff, 2007). Before 2003, studies on Icelandic infants and small children had shown them to have insufficient iron status, and researchers believed that it could be related to the high consumption of cow's milk in infancy (Thorsdottir, Thorisdottir, & Palsson, 2008). Protein intake was also a concern since there appears to be a relationship between a high protein intake and a high body mass index (BMI) in childhood, and most of the proteins that infants consume originates from milk (Thorsdottir et al., 2008). In 2003, the recommendations on infants' nutrition were changed, with the focus on the importance of a sufficient iron status and its effect on the growth of infants. With that in mind, a new follow-on milk was recommended after breastfeeding ceased, instead of the regular cow's milk (Thorsdottir et al., 2008). The new follow-on milk, called Stoðmjólk (Support milk) was introduced to the Icelandic consumer market in 2003. Support milk is a unique fresh product, produced from Icelandic milk, and suited to the nutritional needs of infants from six months to two years of age (Figure 1). The idea was that Support milk would replace breast milk instead of conventional whole cow's milk. Support milk has a reduced amount of protein and increased amount of carbohydrates, in the form of lactose, which makes it more similar to breast milk than whole cow's milk. It is also enriched with vitamins and minerals, including iron, vitamin A, C, D and E, copper and calcium (Mjolkursamsalan, 2003), in line with the European Food Safety Authority (EFSA) regulation on the composition of such products (European Food Safety Authority, 2014). Improvements were observed in the nutritional status of both infants and children following these recommendations. A study, performed in 2005-2007, on the diet of infants, showed that the iron status of infants had improved, and the protein intake had decreased (Thorsdottir et al., 2008). However, according to Icelandic recommendations on infants' diet, infants under 12 months of age should not be given yoghurt or other similar dairy products due to their high protein content (Directorate of Health, 2009).

Figure 1. The Icelandic Support milk (Mjolkursamsalan, 2003).

Support milk is an example of a very successful product for infants and up until 2016 it was the only Icelandic baby food product on the market. Most baby food products on the Icelandic market are imported, and more variety of Icelandic products is needed. One way to improve the Icelandic product variety would be to produce yoghurt based on Support milk intended for infants aged 6-24 months. However, the production and development faces some challenges, such as whether Support milk is fermentable despite its low protein content. The same challenges apply for whether the right texture and consistency can be acquired with a lower protein content compared to regular milk. Also, the right raw materials need to be determined, which nutrients are preferable, how the production process affects the enrichment, and so on. In this regard it is interesting that regular consumption of probiotic yoghurt has been found to have beneficial effects on childrens health (Fox, Ahuja, Robertson, Ball, & Eri, 2015; Guerin-Danan et al., 1998; Kotowska, Albrecht, & Szajewska, 2005). On the other hand, commercially produced yoghurt tends to have either a lot of added sugar or artificial sweeteners, which are not suitable for infants. Therefore, creating a yoghurt product that is produced with infants' needs in mind is needed.

This is the first study in Iceland to research the possibility of making a fermented milk product that has a nutrient content adjusted to suit infants. This study marks the first stepping-stone towards developing a stable, high quality yoghurt product for 6-24 months old children, by integration of nutritional aspects to food science and production aspects. A market analysis on products for the

youngest children gives further insight into the needs of the consumer market and its expectations. The study aimed at providing increased knowledge on how the choice of raw materials and production processes affect nutrients, texture, and other qualities of milk products intended for the youngest consumers. Benefits of this study also lie in increased knowledge on the development necessary to add a new product on the market that meets all requirements for safe and good nutrition for infants.

The aim of this study was to:

1. Study the parents' position towards dairy products made for infants 7-24 months old.
2. Find the right milk composition and ingredients that would meet the requirements of infants' nutritional needs.
3. Produce a yoghurt which is save for consumption, and acquire a desirable texture, taste, consistency, and stability for the product.

2 Review of the literature

2.1 The nutritional needs of young children

Infants are a very sensitive group when it comes to nutrition. The first year of life is characterized by rapid growth and maturity. In the first six months, infants double their weight, and triple it in the first 12 months (Atladottir & Thorsdottir, 2000). The growth is mostly determined by nutrition, not least energy and protein intake. This is the period where the body's energy and nutritional needs are proportionately at its peak, and lack of nutrients affects growth and maturity more easily (Thorsdottir et al., 2008). Furthermore, studies have shown that consumption patterns develop early in life (Fox, Pac, Devaney, & Jankowski, 2004). Therefore it is very important to choose healthy and nutritious food for young children to ensure a healthy lifestyle later on. It is recommended that infants start to consume other food than breast milk or formula between 4-6 months of age. From six months of age, most infants have already tried something new, for example porridge, and vegetable and fruit purées (Directorate of Health, 2009). Infants' diet changes rapidly during the first two years of life. It changes from being only milk-based to a much more complex diet that includes a variety of table foods, which other family members consume (Fox et al., 2004). Studies on infant's nutrition in Iceland have mainly focused on protein intake in infancy, as well as iron and vitamin-D status and showed a relationship between high protein consumption during the first year and higher BMI at six year of age (Thorisdottir, Gunnarsdottir, Palsson, Gretarsson, & Thorsdottir, 2013; Thorisdottir, Gunnarsdottir, Palsson, Halldorsson, & Thorsdottir, 2014; Thorisdottir et al., 2016). These studies have resulted in changes in nutritional recommendations during the past few years due to increased knowledge in the field. For example, recommendations of using the Support milk for infants instead of whole cow's milk has led to better iron status and lower protein consumption (Thorisdottir, Thorsdottir & Palsson, 2011). Tables 1 and 2 show the recommended daily intake (RDI) of vitamins and minerals, respectively, for 6-23 months old infants and small children.

Table 1. Recommended daily intake of vitamins for 6-23 months old infants and small children (Directorate of Health, 2013).

Age	A (RE[c])	D (µg)	E (α-TE[e])	B_1 (mg)	B_2 (mg)	B_3 (NE[f])	B_6 (mg)	Folate (µg)	B_{12} (µg)	C (mg)
6-11 months	300	10	3	0.4	0.5	5	0.4	50	0.5	20
12-23 months	300	10	4	0.5	0.6	7	0.5	60	0.6	25

*RE = retinol equivalents, TE = tocopherol equivalents, NE = niacin equivalents.

Table 2. Recommended daily intake of minerals for 6-23 months old infants and small children (Directorate of Health, 2013).

Age	Calcium (mg)	Phosphor (mg)	Potassium (g)	Magnesium (mg)	Iron (mg)	Zink (mg)	Copper (mg)	Iodine (µg)	Selenium (µg)
6-11 months	540	420	1.1	80	8	5	0.3	50	15
12-23 months	600	470	1.4	85	8	5	0.3	70	20

2.1.1 Baby food products on the Icelandic market

The demand for commercial baby food in Iceland has increased in recent years, seen by both increased product variety and number of brands (Valsdottir et al., 2011). In Iceland, most baby food is imported. An interest for Icelandic baby food products has been noted among Icelandic parents (Valsdottir et al., 2011), but until 2016, no baby food product on the Icelandic market was an Icelandic production, apart from Support milk. The imported products are all treated with either pasteurization, or other types of heat-treatment, and may be stored either frozen, cooled, or at room temperature. After opening, the products can be stored in a refrigerator (0-4°C) for up to 24 hours. Many producers sterilize the baby food in jars. That way they gain a shelf life up to 2-3 years at room temperature. However, a significant loss of nutrients can occur during sterilisation (Valsdottir et al., 2011). This also means that the current yoghurt-containing baby food products on the market do not contain any live cultures.

The products are usually divided into several stages based on the age of the infants consuming it (Figure 2). The first stage usually starts at four months of age, the second step at six months, the third step at 8-9 months of age, and the fourth step at 12 months of age. The number of stages is different between producers, as is the age-distribution. The raw material controls the stages and depends on the children's capacity of consuming it. The first stage usually contains rice, vegetables or fruits, and has a very smooth texture. The second stage can have thicker texture than the first stage, and can contain gluten (oatmeal etc.). The third stage usually contains some meat mixed with vegetables and potatoes, and the texture is somewhat thicker, and even contains small bites. Stages from 12 months of age can be for example biscuits, dried fruits etc. (Ella's Kitchen, 2014; Hipp organic, 2016; Valsdottir et al., 2011).

Figure 2. An example of baby food products (Ella's Kitchen, 2014).

The most common products are vegetable and fruit purées, but there has been an increase in the production of special meal purées, i.e. breakfast purées, dinner purées, dessert purées etc. The breakfast purées contain some fruits mixed with either yoghurt or wholegrain cereals, and belong to either the first or second stage. Dinner purées contain for example meat, potatoes, and one or more type of vegetables. Dessert purées contain either yoghurt or rice with mixed fruits, and some even contain cocoa (Ella's Kitchen, 2014; Hipp organic, 2016).

2.2 Milk components

Food components can be divided into major food components, which include macronutrients, such as protein, fat, water, ash, and carbohydrates, and minor food components, which include vitamins and minerals. Table 3 summarizes the nutritional value in Support milk and ordinary yoghurt in comparison to the EFSA regulation on minimum and maximum content of nutrients in infant formula (IF) and follow-on formula (FOF). The table also shows the nutrient content in 500 mL of Support milk, which is the recommended daily intake of milk or milk products for infants from six months to two years of age in Iceland (Directorate of Health, 2013; Directorate of Health, 2009).