DOI: 10.22616/foodbalt.2017.023

LACTOSE CONTENT OF BREAST MILK AMONG LACTATING WOMEN IN LATVIA

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Abstract

Human milk is the best nutrient source providing everything for the infant's development. Lactose, after the fat, is the second most energy-dense macronutrient found in the breast milk but its concentration can be affected by factors like mother's current body mass index (BMI), birth weight of an infant, duration of lactation, etc. The aim of this study was to determine lactose content in mature breast milk among lactating women in Latvia and factors affecting it. The preliminary study was carried out from November 2016 to February 2017. In total, 28 mature milk samples pooled within 24 h were collected from mothers whose off springs had reached the age of at least two months. Participants (28 mothers with singleton deliveries of 13 male and 15 female infants) were 26 to 39 years old with an average BMI 21.85±2.69. Personal information including birth weight and age of an infant, breastfeeding method (exclusive, mixed) and milk expression manner (by hand or using breast pump) was recorded. Lactose content was determined by ISO 22662:2007. Mean lactose concentration was 6.53±0.34% which is comparable to data obtained from other studies. Although breast milk composition is variable and changes according to the needs of an offspring, no significant difference in lactose content was found for age (2 to 21 months), gender or birth weight (3.53±0.63 kg) of an infant ($p>0.05$). None of the recorded maternal characteristics influenced lactose's content in milk. Also milk expression or breastfeeding method did not affect it. Preliminary results show that lactose concentration is kept relatively constant in human milk, however more samples need to be analysed for further conclusions.

Keywords: human milk, lactose, composition

Introduction

Human milk is the ideal food source for infants providing all the nutrients for growing and many other health benefits both for mother and the young one (Fewtrell, 2004; Motee, Jeewon, 2014; Torres, Park, 2013). The composition of human milk varies corresponding to many factors, including infant's birth weight, length of lactation, age of mother and her anthropometrics (Andreas et al., 2015; Soliman et al., 2014; Torres, Park, 2013). Lactose is the most abundant carbohydrate in human milk (90–95%). It is broken down into glucose and galactose prior to intestinal absorption. Comparing to other species, human milk has the highest lactose concentration (~7 g 100 mL^{-1}), serving to the high-energy demands of the brain (Coppa et al., 1993, cited by Andreas et al., 2015; Picciano, 2009; WHO, 2009). Galactose is important for synthesis of galactolipids which are essential for development of central nervous system (Chang et al., 2015). The secretion of lactose initiates concomitant excretion of a large amount of water what is needed to compensate for sweating, respiratory water loss and also for urine formation (Picciano, 2009). A small amount of disaccharide is not absorbed and promotes softer stools, regulates microbiota and may protect neonatal gut against pathogens (Cederlund et al., 2013; Dahl, 2015). Most of the lactose (~80%) in human milk is derived from plasma glucose. Maternal glucose utilization increases by ~30% during lactation (Picciano, 2009; Sunehag et al., 2002). However, mammary glands can *de novo* synthesize both lactose moieties from other substrates (remaining ~20% of lactose) (Sunehag et al., 2002, Sunehag et al., 2003).

Breast milk composition among women in Latvia is not sufficiently studied (Aumeistere, Zavadska, 2016; Broka et al., 2016). The aim of this research was to determine lactose content in mature human milk among lactating women in Latvia and factors affecting it.

Materials and Methods

Study design

The study was carried out from November 2016 to February 2017. In total, 28 mature milk samples pooled within 24 h were collected from mothers whose young ones had reached the age of at least two months. Participant group included 28 mothers (singleton deliveries of 13 male and 15 female infants) from age 26 to 39 years. Personal information of each participant was recorded, including mother's age, weight and height parameters, sex and age of an infant, breastfeeding pattern (exclusive or mixed), milk expression method (by hand or using breast pump) used during the study. Mothers were also asked to complete food frequency questionnaire – a modified inquiry form was taken from World Health Organisation coordinated Survey (WHO, 2007). Mentioned questionnaire was transformed – more food categories (cereals, vegetables, fruits, berries, nuts, canned food, etc.) were included to obtain comprehensive information about woman's dietary habits during breastfeeding.

Milk collection and analysis

Approximately 100 ml of milk pooled within 24 h was obtained by hand expression or using breast pump. Samples were kept frozen at -20 °C until analysis. Collected samples were analysed in the Laboratory of Food and Environmental Investigations of Institute of Food Safety, Animal Health and Environment BIOR. Lactose content was determined according to

ISO 22662:2007 using high-performance liquid chromatography (HPLC).

Limitations of the study

Mothers were allowed to use the most convenient milk expression method (hand expression or breast pump).

Maternal Body Mass Index (BMI) was calculated based on given information about height and weight of respondents. Anthropometric measurements were not made during this study.

Statistical analysis

Analysis were done in duplicate. Data were recorded, compiled in Microsoft Excel 2013 and reported as the mean ± standard deviation. Data statistical analysis was performed using software R version 3.3.2. Categorical variables were compared by chi-square test and continuous variables were compared by Kruskal Wallis test. Spearman's rank correlation coefficients were obtained to evaluate possible associations affecting lactose content in human milk (α=0.05).

Ethical considerations

The Study protocol was approved by Riga Stradiņš University Ethic Committee (No. 4/28.7.2016.). Written informed consent was obtained from all participants.

Results and Discussion

We investigated the relation between lactose concentration in mature milk and basic information about the mothers and babies. Table 1 represents obtained information, as well as lactose results.

Table 1

Descriptive characteristics

	Mean ± SD	**Range**
Lactose (%)	6.53±0.34	5.94–7.14
Maternal characteristics		
Age (years)	31±3	26–39
BMI (kg m^{-2})	21.71±2.70	17.85–28.55
Characteristics of the offspring		
Birth weight (kg)	3.53±0.60	1.60–4.70
Age (months)	5±4	2–21
Sex	54% female, 46% male	

Lactose concentration

Mean human milk lactose concentration was 6.53±0.34%. Our results was almost equal (6.50%) to data obtained from another recent research (Broka et al., 2016) done in Latvia. *Broka et al*. (2016) also used HPLC to determine lactose content but milk samples were collected from day 11th to 28th of lactation, including transitional milk (7 to 21 days *post partum*) (Broka et al., 2016). Our research only included samples of mature human milk (at least 2 moths *post partum*). Our results were also similar to data obtained from other countries (from 6.14 to 7.75%) (Figure 1) (p>0.05). The coefficient of variation for our results was 5.19%, which is higher than observed by Thakkar et al. (2013), Yamawaki et al. (2005), Saarela et al. (2005) and Soliman et al. (2014) (1.56%, 1.70%, 1.84% and 3.87%, respectively) but lower that observed by Chang et al. (2015), Mitoulas et al. (2002) and Shi et al. (2011) (5.63%, 9.77% and 17.50%, respectively). Deviations in results between studies could be related to distinctions in sampling. Also different methods of analysis among researches were used to determine lactose concentration

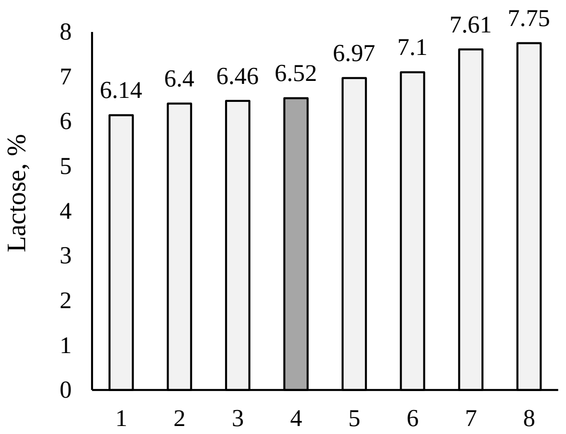

Figure 1. Lactose concentration in mature breast milk among women from different countries

1 – Mitoulas et al., 2002, 2 – Thakkar et al., 2013, 3 – Yamawaki et al., 2005, 4 – current study, 5 – Shi et al., 2011, 6 – Chang et al., 2015, 7 – Saarela et al., 2005, 8 – Soliman et al., 2014

Maternal characteristics altering lactose content

Participants in our study were 26 to 39 years old. Current maternal BMI was calculated based on given information about height and weight. It ranged from 17.85 to 28.55. Our study agrees with Kader and co-authors (1992, cited by Andreas et al., 2015) findings that lactose content in human milk is mother's age independent (Spearman's r=-0.17, p=0.39). Michaelsen and co-authors (1990) observed a positive correlation between carbohydrate content in human milk and mother's BMI. In contrary, Quinn together with co-authors (2012) spotted a negative correlation between milk sugar content and mother's BMI. No significant association between lactose content in human milk and mother's BMI was found in this study (r=-0.17, p=0.39) but it can be due to small sample size.

Offspring's characteristics altering lactose content

Our study included mothers with singleton deliveries of 13 male and 15 female babies with an average age 5 birth weight of 3.53±0.60 kg. There is an evidence that gender can alter milk composition and mother having a male offspring produce more milk which is also more energy-dense. This association is referred to difference in muscle mass (Altufaily, 2009; Fujita et al., 2012; Powe et al., 2010). However, in our study it seems that gender does not influence lactose concentration in human milk (p>0.05). Broka et al. (2016) observed that concentration of lactose was higher in samples from mothers who had neonates with low birth weight (<2.5 kg), which disagrees with our study. Broka and co-authors (2016) represented data from mothers with hospitalized infants, therefore the results cannot be used as a reference for the general population. Our study only included participants who in consent form had stated that they and their children were currently in good health Birth weight for babies in our study ranged from 1.60 to 4.70 kg. We concluded that birth weight does not influence lactose content in human milk (*r*=0.05, p=0.81). Our preliminary study included 27 infants (2 to 11 months old) and one toddler (21 months old). Soliman et al., (2014) observed that lactose content increases with an infant's age, ranging from 7.38±0.05 g dL^{-1} in the first month to 8.08±0.43 g dL^{-1} in the fourth month of child's life. Kader et al. (1972, cited by Andreas et al., 2015) also estimated that lactose production is time associated, reaching the highest concentration from fourth to seventh month of lactation. Quinn and co-authors (2012) observed moderate inverse association between human milk sugar content and infant's age. However, some studies are indicating that lactose concentration remains constant throughout lactation period (Chang et al., 2015; Mitoulas et al., 2002; Saarela et al., 2005; Thakkar et al., 2013). In addition, our research also marked a tendency that lactose concentration in human milk is not related to child's age (*r*=0.24, p=0.22).

Nevertheless, more samples are needed to verify the above mentioned findings.

Breastfeeding pattern and lactose content

The World Health Organization recommends that all children should be exclusively breastfed for the first 6 months after birth and nursing should be continued up to 2 years of age and beyond (WHO, 2009). Most mothers were still exclusively breastfeeding during the study (n=17). Only two mothers practised partial breastfeeding (breastfeeding + formula feeding) but nine mothers had started weaning. There is no consensus whether breastfeeding pattern alters lactose concentration in human milk (Dewey et al., 1984; Neville et al., 1986, both cited by Michaelsen et al., 1990; Prosser et al., 1984). Prosser et al. (1984) observed gradual decrease in lactose content commencing weaning. However, our preliminary study did not reveal connection between lactose concentration in human milk and breastfeeding manner (p>0.05).

Milk expression method and lactose content

Mothers were allowed to use the most convenient method for milk expression – breast pump (61%), by hand (21%) or combination of both methods (18%). The use of a breast pump can alter milk composition by evaporating water content (Miller et al., 2013; Morton et al., 2012). However, lactose content remains the same regardless of milk expression method (Morton et al., 2012). Also our study did not observe a change in lactose concentration depending on the milk expression method (p>0.05).

The impact of mother's diet on lactose concentration

Lactose concentration in human milk seems to be fairly insensitive to mother's nutrition (Andreas et al., 2015; Emmett, Rogers, 1997; Quinn et al., 2012). However, Prentice et al. (1983, cited by Emmett, Rogers, 1997) discovered that lactation capacity can be modified by dietary interventions. Lactose concentration decreased but fat content increased after Gambian mothers' diet was replenished with nutritionally balanced supplements. Correspondingly, total energy content of human milk remained the same (Prentice et al., 1983, cited by Emmett Rogers, 1997). Authors (Prentice et al., 1983, cited by Emmett, Rogers, 1997) pointed out that this is probably because lactose is metabolically more parsimonious for mammary glands to produce. Dagnelie et al. (1992) observed that lactose content in milk were lower for omnivorous mothers but higher for mothers consuming macrobiotic diet. The macrobiotic diet consists mainly of organically grown cereals, vegetables and pulses. Small amount of fruits, fermented foods, seeds and nuts, fish are consumed. Meat, dairy products and eggs are avoided (Dagnelie et al., 1992). Although difference in lactose content between groups was significant, energetically it was quite little (~1 kcal per 100 g) (Dagnelie et al., 1992).

Fasting also has no significant effect on the macronutrient composition of the human milk (Rakicioglu et al., 2006) suggesting that milk composition may be buffered against variation of food intake (Quinn et al., 2012).

During our study mothers were asked to complete a food frequency questionnaire. Results revealed that lactose content correlates with fresh (*r*=0.72) and canned legume (*r*=0.41), as well as salty snack (chips, roasted nuts) (*r*=0.45) and soda drinks (*r*=0.53) consumption (p<0.05). Possible explanations for results should be deeply analysed when more data will be obtained.

Although there is still no clarity how much mother's eating habits impact milk composition (Andreas et al., 2015), there is evidence that diet affects sensory quality of milk and can extend suckling duration (Mennella, Beauchamp, 1990), and also can enhance infant's satisfaction to different flavours starting the weaning (Mennella et al., 2001). Therefore, mothers should be encouraged to consume healthy but variable nutrition during breastfeeding.

Conclusions

Although some researches indicate that lactose content differ with lactation period, breastfeeding pattern or it is influenced by mother's or offspring's characteristics, our preliminary results revealed that lactose concentration in mature milk is stable and insensitive to changes. Nevertheless, more samples need to be analysed to make significant conclusions.

Acknowledgment

The study was supported by grant from the „Strengthening Research Capacity in the Latvia University of Agriculture". Contract No. 3.2.-10/44.

We thank all the mothers who agreed to participate in the study and donated milk samples.

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