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Correlation of maternal dietary intake with breast milk composition and infant growth

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Abstract

Background: Maternal dietary intake during the period of lactation has an impact on infants growth. Macronutrients in breast milk are affected by several factors such as maternal dietary intake and maternal nutritional status. This study aims to prove the association between maternal protein and fat intake with the composition of breast milk and growth of infants (age 0–6 months). **Methods:** Prospective study was conducted for 6 months in 41 mother-infant pairs who were exclusively breastfed, and visited to hospitals or health centres. The mothers age is <40 years old with normal and single pregnancy. The breast milk was collected and analyzed using Human Milk Analyzer. **Results:** There was a negative correlation between maternal protein intake and breast milk composition at 3 months old infants ($p = 0.042$), between fat intake with HAZ score at 2 weeks ($p = 0.048$), and between protein intake with HAZ score at 3 months ($p = 0.049$). Finally, there was a significant increase in WAZ and HAZ score in all sample groups. Although the maternal protein intake of our subjects were only at 83% of Indonesian's RDA average, the protein composition of breast milk and the growth of the infants was sufficient. **Conclusion:** There is correlation between maternal dietary intake with the composition of breastmilk and infant growth. Even though the calories and protein intake of the mother is lower than the RDA, the breast milk is still sufficient for the growth of infants aged 0–6 months who are exclusively breastfed.

Keywords

Maternal dietary intake, breast milk composition, infant growth

Background

Breastmilk is the best food for infants, especially until 6 months of age and important for their growth and development. Many benefits from breastfeeding including short-term and long-term can be obtained by infants. The composition of macronutrients, micronutrients, and other bioactive substances in breast milk is affected by the infant's age, mother's age, mother's physiology, and anthropometric characteristics, health status, and maternal food intake. (Bravi et al., 2016; Dror and Allen, 2018; Hu et al., 2021; Kim and Yi, 2020). Maternal dietary intake during the period of conception until the first two years of life is very important, it can affect the growth and development of the fetus and infant (Quyen et al., 2020). According to the Dietary Guidelines for Americans 2020–2025 by USDA, breastfeeding woman needs an additional of 300 kcal/day compared to non-breastfeeding woman (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020). It is almost the same as the Indonesian Recommendation of Dietary Allowance (RDA) for breastfeeding woman, who requires additional energy, i.e., 330 kcal/day, protein 20 g/day and fat 11 g/day (Ministry of Health Republic of Indonesia, 2019). Protein is an important nutrient because it makes up body tissues and organs. Our study was conducted in Indonesia, where stunting's prevalence is high. According to Indonesia's National Health Survey in 2018, low birth weight and stunting prevalences were 6.2% and 27.8% respectively (Ministry of Health Republic of Indonesia, 2018). Low protein intake in the first 1000 days of life may result in stunting and impaired cognitive function (De Sanctis et al., 2021), meanwhile excessive protein intake in early infancy is a risk factor for childhood

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obesity that can lead to coronary heart disease and metabolic syndrome in adulthood.(Larnkjaer et al., 2012; Larque et al., 2019).

Breast milk composition is differ by time to time. On average, mature breast milk contains 6.7 to 7.8 g/dl of lactose, 3.2 to 3.6 g/dl of fat and 0.9 to 1.2 g/dl of protein (Ballard and Morrow, 2013). Growth and development in infants, especially neurodevelopment and immunity, is heavily affected by the composition of breast milk. However, there are still many contradictions regarding the relationship between maternal dietary intake on the composition of breast milk (Bravi et al., 2016; Hu et al., 2021). A mother's food intake can influence her breast milk composition via several metabolic pathways that produce indirect effects. (Dorea 2002). Mothers with high protein intake has higher protein and bioactive component in breast milk (Bravi et al., 2016; Haschke et al., 2016). In contrary, other studies concluded that there was no relationship between mother's carbohydrate and fat intake with macronutrients component in breast milk (Aumeistere et al., 2019; Bzikowska-Jura et al., 2018). We can conclude that there is physiologic regulation to keep breastmilk composition constantly balanced despite the fluctuation of maternal intake. Even in extreme malnutrition, mothers can still produce adequate quantity and quality breastmilk (Quinn et al., 2012).

Higher protein intake during the first year of life results in a higher body mass index (BMI) at the age 2 (Ferre et al., 2021). High protein intake, especially milk (whey and casein), stimulates growth factors such as insulin and IGF-1 (Hoeflich and Meyer, 2017). Compared to formula-fed infants, breastfed infants have a lower IGF-1 levels, and it is associated with lower protein content in breast milk than formula milk (Caroli et al., 2021; Chellakooty et al., 2006; Savino et al., 2005). A study in Nepal stated that children who were exclusively breastfed had a 6.9 fold lower risk of stunting than children who were not exclusively breastfed (Paudel et al., 2012). Therefore this study aims to analyze the relationship between maternal dietary intake especially protein with the composition of macronutrient in breast milk, total dry matter and energy, and growth of infants (age 0–6 months) to provide a basis for further improvement of maternal and child health.

Material and methods

The subjects of this study were recruited from 9 hospitals and 5 health centres in Semarang Indonesia from May 2017 until August 2018. The design of the study was prospective. The inclusion criteria for the samples were full term infants, babies who was singleton, vigorous, have normal birthweight, and exclusively breastfed. Exclusion criteria were babies with history of asphyxia, respiratory distress, congenital malformation and smoking mothers. We prospectively follow the infants from newborn until the age of 6 months. The anthropometry of the infants (weight, length, head circumference) were measured when they were 2 week, 3 month and 6 month old. At the same time, a nutritionist collected the information of mother's dietary intake using 3-days food recall and questionnaire. The information of breast milk volume was also collected alongside with a breast milk samples.

The breast milk was extracted manually by the mothers and was taken in the morning, starting from the 9th minute, which was the transition time from foremilk to hindmilk. At least 5 ml of breast milk was collected and then stored into breast milk storage plastics (Nature, Thailand). Breast milk samples were stored at −20°C until analyzed. For the homogenization, the frozen sample was heated to 40°C in a thermostatic bath followed by centrifugation, then the composition of calories, carbohydrate, fat, protein, and total solids in the breast milk was analyzed using Human Milk Analyzer (HMA, Miris, Sweden) (Huang and Hu, 2020; Kreissl et al., 2016).

Repeated ANOVA test is used to analyze the difference in maternal food intake, breastmilk composition, and infant growth was measured at 2 weeks, 3 months, and 6 months of age. The correlation between the maternal dietary intake and the composition of breastmilk at 2 weeks, 3 months and 6 months of age was analyzed with Spearman's test The Medical Ethics Review Committee of Faculty of Medicine, Diponegoro University / Dr Kariadi Hospital has approved this study, and informed consent was obtained from all participants.

Results

This study recruited 41 mother-infant pairs who met the inclusion criteria and agreed to join this study, 9 subjects dropped out because they could not exclusively breastfeeding. Therefore, we analyzed 32 infants consisted of 12 boys and 20 girls. The median of birth weight was 3100 (2510–3995) gram, with a birth length of 49 (47.2–53) cm, and 27 (17–39) year old for median age of the mother.

Table 1 described the difference between maternal intake, breastmilk composition, and infant growth. There was a significant difference found between maternal intake, but no significant difference found between breastmilk composition at 2 week, 3 month, and 6 month old infants. The WAZ and HAZ score were also significant increased.

Recommended Dietary Allowances (RDAs) are the levels of intake of essential nutrients that, on the basis of scientific knowledge, are judged by the Food and Nutrition Board to be adequate to meet the known nutrient needs of practically all healthy persons. According to Indonesian RDAs, women aged 19–29 years requires 2250 kcal of energy, 60 g of protein, and 65 g of fat per day. Women aged 30–49 years requires 2150 kcal of energy, 60 g of protein, and 60 g of fat per day. Breastfeeding mother requires an additional 330 kcal of energy, 20 g of protein, and 11 g of fat per day (Ministry of Health Republic of Indonesia, 2019).

Based on Table 1, we found that the average of maternal intake during breastfeeding was lower compared to Indonesian RDA. Average energy intake at 2 week, 3 month and 6 month old group were 74.4%, 76.7% and 65% respectively, 80.5%, 86.3% and 69% for protein, and 99.2%, 109.9%, 83.5% for fat. There was a negative correlation between protein dietary intake of the mother and protein composition in breastmilk at 3 month old infants. There was a linear relationship between the decrease in maternal intake and the growth status (Table 2).

Figure 1 and 2 showed the comparison between protein and fat average intake in the mothers with the protein and fat average composition in breastmilk.

Table 3 and Figure 3 showed the correlation between infant growth assessed by WHZ, WAZ, and HAZ score with the maternal dietary intake and the breastmilk composition. There was a negative correlation between maternal fat intake and HAZ score in 2 week old infants. There was also a negative correlation between maternal protein intake and HAZ score in 3 month old infants. A catch up growth was found through the first six month of life, represented by the increase WAZ and HAZ score.

Discussion

Breastfeeding mothers need an additional 500 kcal of calories and 25 g of protein per day, which is needed to produce breast milk as much as 780 ml / day (range 450–1200 ml/day) (Kominiarek and Rajan, 2016). According to the Indonesian RDA, breastfeeding mothers need an additional 20 grams of protein per day, so that the total protein needed is 80 grams per day (Ministry of Health Republic of Indonesia, 2019). In this study, the highest maternal protein intake was found when the baby was 3 month old, which was 69.02 ± 19.27 grams/day, around 80% of the requirement. Not all breastfeeding mothers need the same amount of protein, it varies depending on age, weight, activity and health status (Kominiarek and Rajan, 2016). However one study revealed that protein intake less than

Table 1. Differences in maternal intake, the composition of breast milk, and growth of infants aged 2 weeks, 3 months, and 6 months.

Variables	2 weeks old mean ± SD	3 months old mean ± SD	6 months old mean ± SD	*p*
Maternal intake per day				
Energy (kcal)	1920.2 ± 514.80	1978.4 ± 426.75	1676.5 ± 411.53	<0.001§*
Protein (gram)	64.39 ± 21.51	69.02 ± 19.27	55.18 ± 17.29	0.004‡*
Fat (gram)	70.4 ± 32.79	78.1 ± 23.25	59.3 ± 24.15	<0.001§*
Breast milk composition / dL				
Energy (kcal)	51.9 ± 25.89	76.5 ± 53.43	44.6 ± 27.89	0.195‡
Protein (gram)	1.9 ± 2.06	4.1 ± 4.64	2.6 ± 3.43	0.228‡
Fat (gram)	2.4 ± 1.38	2.4 ± 1.55	2.5 ± 1.83	0.974‡
Growth				
WHZ (SD)	−0.08 ± 0.94	−0.13 ± 1.35	−0.12 ± 0.98	0.427§
WAZ (SD)	−1.25 ± 0.95	−0.84 ± 0.97	−0.57 ± 0.89	<0.001§*
HAZ (SD)	−1.45 ± 1.21	−1.25 ± 0.98	−0.68 ± 1.00	<0.001§*

§Repeated ANOVA; ‡ Friedman; * Significant ($p < 0.05$).

Table 2. Correlation between maternal intake and composition of breast milk at various ages.

		Breast milk composition/dl					
		Energy		Protein		Fat	
Age	Maternal dietary intake/d	*r*	p	*r*	p	*r*	p
2 weeks	Energy	−0.012	0.942¥				
	Protein			−0.086	0.597¥		
	Fat					0.022	0.891¥
3 months	Energy	−0.179	0.264¥				
	Protein			−0.320	0.042¥*		
	Fat					−0.036	0.823¥
6 months	Energy	0.110	0.488¥				
	Protein			0.005	0.974¥		
	Fat					0.100	0.528¥

¥Spearman's correlation * Significant ($p < 0.05$)

75 grams per day is associated with lower birth weight and low birth length (Clark, 2018).

Mature breast milk contains 6.7 to 7.8 g/dl of lactose, 3.2 to 3.6 g/dl of fat and 0.9 to 1.2 g/dl of protein (Ballard and Morrow, 2013). A study in Poland revealed that the median macronutrient composition of breast milk at the first month of lactation is 1.1 g for protein, 3.5 g for fat, and 66.0 kcal for calories per 100 ml of breast milk (Bzikowska et al., 2018). Our study found that the average composition of the samples breast milk were 51.9 kcal/dl of energy and 1.9 g/dl of protein in the 2 week old group; 76.5 kcal/dl/dl of energy and 4.1 g of protein in the 3 month old group and 44.6 kcal/dl of energy and 2.6 g/dl of protein in the 6 month old group. The fat composition is almost the same, namely 2.4 to 2.5 g/dl in three groups. There was no significant difference in the three groups, despite the 3 month old group having the highest calorie and protein composition. Our study also found that there was a negative correlation between protein dietary intake of the mother and protein composition in breastmilk in the 3 month old group.

A study in Sweden reported that there was a correlation between maternal dietary intake of protein with the protein at the breast milk, but most other studies found inconsistent results. Likewise, there was also no differences found between protein composition of breast milk from vegetarian and non-vegetarian mothers (Bravi et al., 2016). There was a study on Chinese lactating mothers which divided the mothers into four groups based on their diet, which was diet based on animal sources, eggs, plant, or fruit. The study found that the colostrum of animal and plant-based diet groups had positive correlation with higher fat and lower protein in breast milk. However, it was found that the mature breast milk of mothers in animal-based diet group had a positive correlation with the calorie composition in breast milk, from birth until the age of 2 months. On the other hand, the plant-based diet group had a negative correlation with the fat composition in breast milk (Hu et al., 2021). A study found that mothers who delivered preterm babies had a lower protein composition of breast milk due to the duration of lactation (Kreissl et al., 2016). One study from Indonesia found that maternal fat intake seemed weakly correlated with the fat composition in breast milk, although the result was not statistically significant (Kurniati et al., 2016). Another study in Iran found that fat composition in breast milk was positively correlated to maternal carbohydrate intake (Nikniaz *et al*., 2009). We found that maternal protein intake and protein composition in breast milk from 3 month old group was negatively correlated, and there was no correlation between maternal fat intake and fat composition in breast milk.

Several studies have also linked the macronutrient content of breast milk to maternal dietary intake, for example, a study on lactating women in Latvia showed that there was no relationship between maternal dietary intake and macronutrients in breast milk (Aumeistere et al., 2019). However, human milk fatty acids, especially SFAs and MUFAs contained in breast milk are affected by the of mothers' eating habits, although the mechanism is still unclear (Innis, 2014; Quyen et al., 2020). The content of several vitamins and minerals in breast milk is also affected by the maternal diet. Thiamin, Riboflavin, vitamin B6 and vitamin B12 as well as minerals, Iodine and Selenium, are affected by maternal dietary intake. Similarly, the levels of several amino acids and fatty acids in breast milk are also affected by maternal food intake (Dror and Allen, 2018). Ratio of Calcium / Phosphate (Ca/P) was affected by the mother's BMI. Mothers with higher BMI who gave birth to girls have a higher Ca/P ratio, while mothers who gave birth to boys have higher phosphate. In addition, it was found that the Ca and Ca/P ratio decreased with the duration of lactation (Sanchez et al., 2020).

We found that the growth of infants, especially the length, is increasing rapidly in the first 6 month, thus it seemed that exclusive breastfeeding can increased infant's growth, especially WAZ and HAZ (Table 1). Contradictorily, we found that maternal fat intake was negatively correlated with 2 week old infants' HAZ score. Maternal protein intake was also negatively correlated with 3 month old infants' HAZ score, but these results were inconsistent for each measurement. One study in

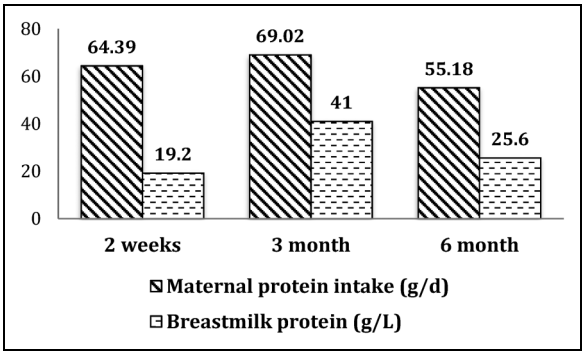

Figure 1. The average of maternal protein intake (gram/day) and average protein composition in breastmilk (gram/L) at various ages.

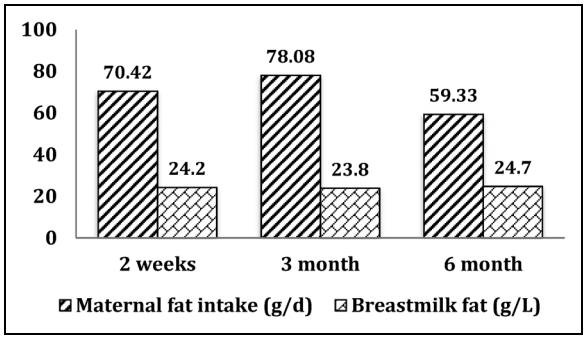

Figure 2. The average of maternal fat intake (gram/day) and average fat composition in breastmilk (gram/L) at various ages.

Table 3. Correlation between maternal dietary intake and composition of breast milk with infant growth.

	WHZ		WAZ		HAZ	
Variables	*r*	*p*	*r*	*p*	*r*	*p*
Maternal intake at 2 weeks						
Energy	−0.086	0.635€	−0.036	0.844€	−0.029	0.871€
Protein	−0.203	0.257¥	−0.302	0.088¥	−0.106	0.556¥
Fat	0.187	0.297€	−0.216	0.227€	−0.339	0.048€*
Breast milk composition at 2 weeks						
Energy	0.098	0.588€	−0.079	0.661€	−0.153	0.396€
Protein	0.073	0.688¥	0.189	0.292¥	0.124	0.492¥
Fat	−0.129	0.473¥	0.075	0.680¥	0.054	0.765¥
Maternal intake at 3 months						
Energy	0.172	0.347€	−0.088	0.632€	−0.269	0.136€
Protein	0.205	0.260¥	−0.242	0.181¥	−0.341	0.049¥*
Fat	0.099	0.590€	−0.130	0.478€	−0.252	0.164€
Breast milk composition at 3 months						
Energy	−0.021	0.911¥	0.141	0.440¥	0.020	0.915¥
Protein	−0.220	0.226¥	−0.174	0.341¥	0.122	0.505¥
Fat	−0.058	0.754¥	−0.136	0.457¥	−0.121	0.508¥
Maternal intake at 6 months						
Energy	0.115	0.530€	−0.023	0.902€	−0.130	0.477€
Protein	0.176	0.335€	0.008	0.966€	−0.200	0.273€
Fat	0.002	0.990€	0.026	0.886€	0.062	0.738€
Breast milk composition at 6 months						
Energy	0.001	0.995¥	−0.166	0.364¥	−0.215	0.237¥
Protein	0.063	0.731¥	0.094	0.610¥	0.106	0.563¥
Fat	−0.034	0.852¥	−0.106	0.564¥	−0.172	0.347¥

€Pearson correlation; ¥Spearman correlation; *Significant ($p < 0.05$)

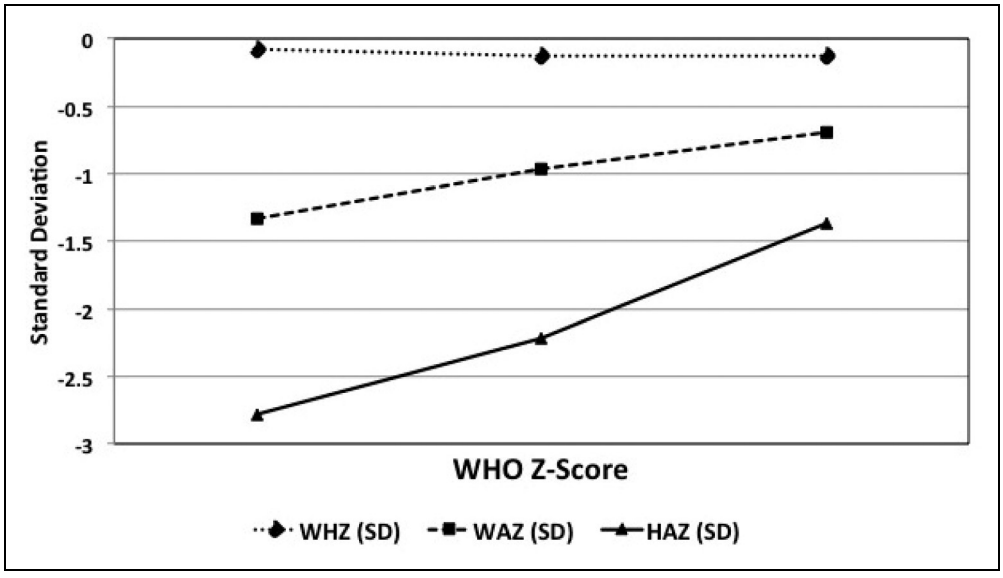

Figure 3. Infant growth z-score at 2 week, 3 month, and 6 month old.

Iran found that breast milk with a fat composition more than 3 g/dl correlated with higher WAZ (Nikniaz *et al*., 2009). Other study did not find a correlation between breast milk composition and infant growth, although there was a positive correlation between maternal body fat with breast milk fat composition, and between maternal total body water with maternal muscle mass (Kurniati et al., 2016). Research on Polish lactating mothers whose breast milk composition were evaluated at 1 month, 3 month and 6 month of infants age, found that 3 months postpartum breast milk had a positive correlation with the mother's body composition, which was fat mass percentage, fat mass,

and muscle mass. The results of this study suggested that it is not maternal diet that correlated with breast milk composition, but maternal body composition (Bzikowska-Jura et al., 2018). Unfortunately, we did not measure maternal body composition in our study, thus we can not compare the result.

All of our samples were exclusively breastfed, full-term, healthy infants. There was a catch-up growth in weight and height at birth until 6 month of age. Infant growth was not only affected by macronutrients in breast milk, but also affected by the frequency of breastfeeding and the volume of breast milk (Ballard and Morrow, 2013; de Fluiter et al., 2021), we can conclude that maternal dietary intake, especially protein and fat intake, is not directly related to infant growth. The limitation of the study is that our equipment can not specifically assess variations in the amino acid and fatty acid composition of maternal dietary intake, which may affect the infant growth.

Conclusions

Our study concluded that there was a correlation between maternal food intake with the composition of breastmilk and infant growth although the result was inconsistent between each infant age group. Energy and protein intake of the breastfeeding mother is lower than the recommended Indonesian RDA, but is still sufficient for the growth of infants aged 0–6 months who are exclusively breastfed.

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Author contribution

MM conceived and designed the study, analysed and interpreted literature data and wrote the first and final drafts of the manuscript. RYA contributed to the design of the study, analysed the data, edited references and approved the final version as submitted. RP contributed to the study design, helped with the interpretation of data, reviewed the manuscript and approved the final version as submitted. BN contribute to the interpretation of nutrition data, reviewed the manuscript and approved the final version as submitted.

Consent for publication

All authors agree with the final article and in submitting this paper to the Nutrition and Health Journal for publication.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

All procedures performed within this research which involved human participants was in accordance with the ethical standards and the ethical approval was obtained from The Board of Medical Ethics Review Committee Faculty of Medicine, Diponegoro University / Dr Kariadi Hospital has approved this study with number 18/EC/FK-RSDK/I/2017. Informed consent was obtained from all participants.

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