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The Association Between Saturated Fatty Acids (SFAs) Level in Dietary and Blood During Pregnancy and SFAs Level in Breast Milk of Postpartum Mothers

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Abstract

Saturated fatty acids (SFAs) in breast milk are essential for infant's metabolism as a major metabolic fuel and a low level of SFAs in breast milk might be detrimental for infants' growth. SFAs in breast milk is determined by maternal SFAs intake and blood levels. Several studies on maternal SFAs have been conducted on breastfeeding mothers but rarely conducted in pregnant women, meanwhile there is an increased SFAs in intake and blood levels in pregnant women on their third trimester due to fat mobilization. This study aims to analyze the relationship between SFAs level in dietary and blood during pregnancy to their levels in breast milk. This research was a longitudinal study and some research data were derived from the BSEA and IPB main research in May-December 2018 at two Bogor City Health Centers, Indonesia. Ninety-eight pregnant women were selected through *consecutive* sampling method. The data analysis was using *Spearman test* and *Multiple logistic regression*. There is no significant relation between SFAs level in dietary with SFAs level in blood. However, dietary intake of lauric acid and total SFAs were significantly associated with lauric acid and total SFAs in breast milk ($p<0.05$), but not significantly correlated with other types of SFAs ($p>0.05$). The level of capric, myristate, palmitic, behenic, and lignoceric acids in blood is associated with corresponding SFAs ($p<0.05$).

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As a conclusion, SFAs intake in third semester of pregnancy is allowed since increased SFAs in breast milk is important for infants' early growth.

Keywords: Saturated Fatty Acids; Pregnancy; Blood; Dietary; Breast Milk.

1. Introduction

Breast milk is the best nutrition source for nearly all infants [1]. The fatty acids concentration in breast milk play an essential role for the development and growth of the infants, such as palmitic acid for major metabolic fuel and docohexaenoic acid (DHA) to increase cognitive and encourage brain development [2,3,4]. The Saturated Fatty Acid (SFAs) which beneficial for tissue repair becomes the largest proportion of breast milk fatty acids (47%). A low level of SFA content in breast milk also not suggested, for it could be detrimental as impaired tissue regeneration and induce uncontrollable inflammation in newborns [5]. As the only source of infants' SFA intake and the importance of SFA for infant growth, the SFA in the breast milk requires some attentions. Maternal SFA intake is a determinant of the SFA breast milk [6]. Consuming SFA and lauric acid food sources will increase total SFA and lauric acid concentration in breast milk. According to a prior research, it is reported that consumption of formula contains 40 gram of palm oil or equal to 4 tablespoons significantly can increase the lauric acid content in breast milk from 3.9% to 9.2% [7]. Dietary SFA was positively associated with total cholesterol in early pregnancy although was not associated in late pregnancy [8]. As described in the previous research, different types of SFA have varying effects on arrays of processes and pathways; however, research on the various types of SFA seems to be rare. Moreover, not only the increased of SFA intake but an elevated blood levels of SFA also followed by high SFA content in breast milk. Mothers with higher blood long-chain fatty acid (LCFA) level also have high level of breast milk-related LCFA [9]. There are several studies conducted in Indonesia whose employed the total SFA rather than particular type SFA-detailed. One study found a relationship between total fat intake of breastfeeding mother and total fat content in breast milk [10]. Most of researches took respondents of breastfeeding mother as their research subject because the pregnant women in third trimester were so scarce, meanwhile there was a unique condition related to late gestation such as increased SFA intake and fat metabolism changes that affected in to increased blood SFA level. These conditions might be associated with increased SFA in breast milk which benefits to infants' growth [11,12]. Therefore, the present study aimed to analyse the association of SFA level in dietary and blood during pregnancy to SFA level in breast milk. In particular, this research intend to analyse the association between the level of SFA in dietary with SFA in blood, the association between the level of SFA in dietary with SFA in breast milk and the association between SFA level in blood with SFA level in breast milk including the type of SFA that present in this research.

2. Materials and Methods

2.1. Study Design, Time and Samples

This research was a longitudinal-study conducted in May-December 2018 at two Bogor City Health Centers, Indonesia. There were 98 pregnant women who participated in the main study about maternal PUFAs and infant health study by IPB University and BSEA (BASF South East Asia). The women were selected by *consecutive*

sampling method at North Bogor Health Center and Tanah Sareal Health Center.

2.2. Data Collection

The subjects of this research were selected by inclusion criterias of mothers in single pregnancy with the age of 15-40 years old. The subject also considered by exclusion criterias, including subject that have been detected with congenital abnormality and experiencing or undergoing therapy for specific diseases (diabetes, cancer, hyperlipidemia, and drug use such as corticosteroids). The data research were include characteristics of subject, SFA intake, SFA levels in blood and SFA levels in human milk, while data of subject characteristics were mother's age, pregnancy age, mother's education, mother's occupation, family income, pre-pregnancy body mass index (Pre-pregnancy BMI), Gestational Weight Gain (GWG) which derived from the main study, and the SFA intake data was collected through 2 x 24-hour food recall questionnaire which completed only in one day (and not continued in the following day) to minimalize data bias during the SFA intake collection. The blood samples were taken from *cubital veins* as much as 5 cc during 36-40 weeks pregnancy and extracted to get the fatty acids content by *Folch* method [13], afterwards, it was put into analysis by employing a *gas chromatography flame ionization detector* (GC-FID) method. Meanwhile, the breast milk samples were taken by manual method in 5-8 days postpartum as much as 2-5 cc, then put into analysis to measure the fatty acids content by a *gas chromatography flame ionization detector* (GC-FID) method. SFA content in blood and human milk data is presented as gram SFA per 100 gram of total fat for each data. The SFA content in diet, blood, and human milk that employed in this research were caproic acid (6:0), caprylic acid (8:0), capric acid (10:0), lauric acid (12:0), myrisric acid (14:0), palmitic acid (16:0), stearic acid (18:0), arachidic acid (20:0), behenic acid (22:0), and lignoceric acid (24:0) meanwhile the total SFA content is the summation quantity of caproic acid (6:0), caprylic acid (8:0), capric acid (10:0), lauric acid (12:0), myrisric acid (14:0), palmitic acid (16:0), stearic acid (18:0), arachidic acid (20:0), behenic acid (22:0), and lignoceric acid (24:0). Data of food SFA content was obtained from the Indonesian Food Fatty Acid Content Database [14], Australia Food Nutrition Database [15] and Standard Table of Food Composition in Japan 2015 [16]. The database was successfully converted 116 food types from the Indonesian database, 84 food types from the Australian database, and 8 food types from the Japanese database where 12 food types (6%) could not be converted. Most of the data can be converted correctly. In addition, the nutritional status data is obtained from the medical records of research subjects from the local health center.

2.3. Statistical Analysis

The data research was processed by applying Microsoft Excel 2019 and SPSS version 25.0. Then, bivariate analysis for this research was conducted by *Spearman Correlation Test* to investigate any correlations presence between the SFA levels from dietary, blood and human milk.

2.4. Ethical Approval

The Ethical clearance was obtained and approved by permit number: 041/IT3. KEPMSM-IPB/SK/2018 from Institute of Research and Community Service at Institut Pertanian Bogor for Human Subject.

3. Result and Discussion

3.1. Subject Characteristics

The subjects in this study were 98 pregnant women who performed a complete data from the baseline (pregnancy-related data) until the end of the main study (breast milk data). Maternal characteristics data are distributed according to age, gestational age, education level, employment position, and family income, as well as nutritional status; including pre-pregnancy BMI and GWG.

Table 1: The Distribution of Respondent Characteristics.

Characteristics	n	%
Maternal age (years)		
< 20	1	1
20-35	73	74.5
>35	24	24.5
Age pregnancy (weeks)		
< 37	2	2
> 37	96	98
Mother education		
Elementary school	27	27.6
Junior high school	22	22.4
Senior High School or equivalent	42	42.9
Higher Education or equivalent	7	7.1
Mother occupation		
Housewife	74	75.5
Non housewife	24	24.5
Family income		
Lower-income standard*	80	81.6
Upper-income standard*	18	18.4
Pre-pregnancy Body Mass Index		
Underweight	7	7.1
Normal	53	54.1
Overweight	24	24.5
Obesity	14	14.3
Gestational Weight Gain		
Less than recommendation	42	42.9
Normal	32	32.7
More than recommendation	24	24.5

**Regional minimum wage of Bogor City 2020 = Rp. 3.557.146*

According to Table 1, the average age of pregnant women is 29.5 years where 96 mothers (98%) delivered babies with a gestational age of more than 37 weeks and only two mothers (2%) delivered babies with a gestational age of 36 weeks. This is an indication that the majority of individual did not face an elevated risk [17]. Majority of respondents held a high school diploma / vocational diploma / similar degrees and have completed at least one topic of diploma / bachelor / equivalent education. There are several studies have linked the poorer economic status to increased breast milk SFA [18] .The nutritional status also is presented in Table 1 which includes BMI before to pregnancy and GWG. The average BMI before to pregnancy in this study was 22.85 3.91 kg/m2 which is within the normal range (54%). The pregnant women classified as overweight or obese (24.5%), obese (14.3%) and underweight at 7.1%. The majority subject have a normal BMI which lead to

no risk of altered fatty acid metabolism, meanwhile in obese mothers, an increased SFA level of lauric acid, mystatic acid, palmitic acid, and total SFA was reported [19]. The majority respondents (42.9%) had less GWG categories than recommendations, 32.7% respondents have adequate GWG categories, and the remaining respondents (24.5%) have more GWG than recommendations categories.

3.2. The SFA composition in dietary, blood and human milk

Most types of SFA in dietary (77%), blood (86%) and breast milk (52%) are long-chain fatty acids (LCFA) when compared to MCFA (medium-chain fatty acids). Some types of MCFA are reported to be volatile and have low level of attachment to albumin (a protein that binds fat to circulation) so MCFA levels found lower in the blood when compared to LCFA, although MCFA intake is more easily absorbed in the intestines toward circulation [20]. SFA blood and intake is described in Table 3 where it shows palmitic acid as the most dominant type of SFA (because palmitic acid is the most common type of SFA found in animal and human tissues). Palmitic acid also has a high binding power in albumin and pool in breast milk is higher than other types of SFA [21]. The high palmitic acid level in breast milk is also useful for the formation of infant lipid membranes [5].

Table 2: The SFA composition of dietary, blood in the third trimester and human milk.

Saturated Fatty Acids	**Dietary**[a]		**Blood**[b]		**Human Milk**[c]	
	Mean ± SD	**%**	**Mean ± SD**	**%**	**Mean ± SD**	**%**
Medium-chain Fatty Acids	4.76±4.66	23	4,23±8,09	14	14,34±20,38	48
6:0	0,06 ± 0,08	0,29	2,96 ± 5,67	10,14	0,12 ± 0,17	0,39
8:0	0,43 ± 0,47	2,08	0,13 ± 0,32	0,45	0,04 ± 0,11	0,13
10:0	0,35 ± 0,33	1,69	0,38 ± 0,85	1,30	0,75 ± 1,92	2,44
12:0	2,45 ± 2,62	11,86	0,44 ± 1,01	1,51	2,63 ± 3,58	8,57
14:0	1,47 ± 1,16	7,12	0,32 ± 0,24	1,10	11,30 ± 14,60	36,82
Long-chain Fatty Acids	15.92±6.72	77	24,96±15,65	86	15,90±19,91	52
16:0	13,21 ± 5,44	63,94	23,89 ± 13,02	81,84	15,29 ± 18,40	49,82
18:0	2,41 ± 0,98	11,67	0,29 ± 0,66	0,99	0,10 ± 0,08	0,33
20:0	0,15 ± 0,08	0,73	0,23 ± 0,59	0,79	0,27 ± 0,94	0,88
22:0	0,10 ± 0,14	0,48	0,40 ± 0,90	1,37	0,16 ± 0,21	0,52
24:0	0,05 ± 0,08	0,24	0,15 ± 0,48	0,51	0,08 ± 0,28	0,26
Total Saturated Fatty Acids	20,66 ± 8,00	100	29,19 ± 14,83	100	30,69 ± 21,87	100

[a] *g/day.* [b] *g/100 g total blood lipid.* [c] *g/100 g total human milk lipid.*

3.3. The Relationship of SFA dietary and blood levels of SFA

As shown in the Table 4, there is no correlation between SFA intake and SFA in the blood although some studies said there is a link between SFA intake and SFA levels in the blood. However this study uses SFA intake during breastfeeding, therefore there was no significant association present from this study because the SFA and blood intake data were taken at the same time in the third trimester of pregnancy (weeks 36-40).

Table 3: The relationship of SFA level in dietary and SFA level in blood.

Saturated Fatty Acids	**R**	***p****
6:0	0.002	0.981
8:0	-0.035	0.733
10:0	-0.045	0.663
12:0	0.072	0.479
14:0	0.129	0.204
16:0	-0.014	0.899
18:0	0.017	0.866
20:0	-0.049	0.635
22:0	-0.066	0.518
24:0	0.052	0.609
Total Saturated Fatty Acids	-0.009	0.933

**Spearman test. * p-value* <0,05

3.4. The Relationship between SFA of dietary and blood with SFA content in human milk

Table 4 shows a significant correlation found between total SFA and lauric acid consumption also in total SFA of breast milk ($p<0.05$) but no significant correlation found in other types of SFA ($p>0.05$). The result of this study consistent with the previous study which found a positive correlation between total SFA intake and total SFA concentration in breast milk [22]. An increase in lauric acid content in breast milk is attributed to the increase in lauric acid consumption during pregnancy throughout the third trimester. The level of capric, myristic, palmitic, stearic, behenic, and lignoceric fatty acids ($p<0.05$) in blood are correlated to the corresponding SFA content in breast milk. Only blood levels of capric acid has a negative correlation to capric acid content in breast milk, whereas other fatty acids (myristic, palmitic, stearic, behenic, and lignoceric) displayed a positive correlation. In general, the type of SFA in the blood is closely related to the type of SFA in breast milk than the SFA type of dietary. When the SFA is considered in total number, the total intake of SFA has a higher correlation value than total SFA of the blood.

Table 4: The Relationship between level of SFA from dietary and blood with SFA content in the breast milk.

Saturated Fatty Acids	**Dietary**		**Blood**	
	R	***p-value***	**R**	***p-value***
6:0	0,094	0,360	0,090	0,378
8:0	0,038	0,709	0,014	0,890
10:0	0,029	0,776	-0,242	0,016*
12:0	0,247	0,014*	-0,045	0,662
14:0	0,029	0,775	0,274	0,006*
16:0	0,071	0,488	0,271	0,007*
18:0	0,077	0,452	0,446	0,000*
20:0	0.034	0,739	-0,106	0,298
22:0	0,085	0,403	0,388	0,000*
24:0	-0,103	0,314	0,207	0,041*
Total SFA	0,224	0,027*	0,144	0,156

[a]*Spearman test. * p-value* <0,05

Different fatty acid configurations seem to have various effects on series of metabolic and physiological

processes when consumed. The caproic and caprylic acids present in human milk as well as in bovine milk. Studies found that caprylic acid has biological activity as microbacterial agent. It lowers salmonella infection rate in chickens by giving anti infection activity which will be beneficial to sensitive infant intestine [23]. There is no association shown between maternal intake from caproic and caprylic acids to caproic and caprylic acids in breast milk, probably due to their small levels in the breast milk of Asian race mothers and the highly volatile of caproic acid in breast milk [24]. The capric acid level in the blood was associated with capric acid in breast milk but not with the intake of capric acid. Similar to caprylic acid and caproic acid, the intake of capric acid that enters the blood found in relatively small level. According to a study, the minor level is also due to its somewhat volatile chemical component of capric acid in the blood [25]. Capric acid belongs to MCFA which is synthesized in the mamae gland [20]. Low level in the blood might stimulate the mamary glands to level up the production of capric acid level in breast milk.

Lauric acid naturally found in various animal and plants but mostly found in coconut oil and palm oil [26]. The maternal intake of lauric acid has a positive association to lauric acid in breast milk but not related to lauric acid level in the blood. This result is in line with previous research[7] that stated there is an increasing lauric acid content in breast milk after the consumption of food sources containing lauric acid. Consumption of 40 g (4 tbsp) of coconut oil can increase the lauric acid content in breast milk from 3.9% to 9.6% of total fatty acids in breast milk. In the body, digested-lauric acid with an affinity similar to others but the weak bonded from albumin made the level found to be low in the blood [27]. According to these findings, increased lauric acid intake throughout the third trimester is beneficial since it followed by an increased content of lauric acid in breast milk. Prior research mentiones that lauric acid content in breast milk had a beneficial effect on the newborn. Studies found that lauric acid posseses antibacterial and antiviral properties [28,29]. Monolaurin from milk has been proposed to have anti-protozoal potential [30]. Since a rising of lauric acid content followed by lauric acid consumption is present, then the increasing lauric acid intake makes sense to improve milk antimicrobial activity.

In contrast to lauric acid, the intake of myristic acid did not show a significant association, but the level of myristic acid in the blood is associated to myristic acid content in breast milk. The majority of myristic acid content in the breast milk was derived from adipose breakdown [31]. This result was confirmed by a study which stated that blood myristic acid comes mainly from the liver rather than from the intake of miristat acid that enters the blood [32]. The unique positional chain of myristic acid in milk is responsible for a tendency of HDL-cholesterol increase rather than LDL-cholesterol [33].

LCFA intake including palmitic, stearic, arachidic, behenate, and lignoceric acids showed no significant results with LCFA breast milk. However, there are significant association tests were shown in blood LCFA with corresponding fatty acids in breast milk. Regardless, there is no relationship between LCFA intake and LCFA breast milk because not only intake factor but also the intake of LCFA that enter the body do not directly flow into the bloodstream but go to the lymph system and stored for subsequent use [33]. LCFA breast milk is obtained exogenously from circulating fatty acids. Researchers mentioned there is lactogenesis mechanism present [35] and most LCFA in blood level come from adipose tissue rather than from intake that go into the bloodstream [36].

In this study, total SFA intake is significantly correlated with total SFA in breast milk, a positive correlation was obtained and showed a linear proportional relationship. There is an increase follows a rising in total SFA intake in SFA breast milk. These results are in line with previous research [37,38]. The increased SFA breast milk is beneficial for newborn because SFA in breast milk in a form like palmitic acid has the unusual stereospesific distribution that brings important biological implication, such as palmitic acid which extensively esterified at sn-2 position of the triglyceride. The human milk contain of esterified palmitic acid predominanty to the sn-2 position had improved intestinal infant absorption for calcium and palmitic acid itself. An unusual stereospesic palmitic acid stimulated the expression of the transcription of PGC-1b coactivator and enhanced transcriptional regulation of lipoprotein in the liver. This finding implies that palmitic acid has essential role in infant lipoprotein metabolism [39].

Since SFA breast milk has several advantages for the newborn, pregnant women in the third trimester are permitted to consume SFA. According to some researches, SFA consumption has an effect on cholesterol level. However, a prior study mentioned that SFA consumption during pregnancy is associated with an increase in total cholesterol level, but reported only in the first trimester and not in the third trimester [40]. In comparison to pregnant women in their third trimester, SFA consumption during the third trimester is positively associated with the baby's birth weight which promotes the infant growth [41]. Despite this research is a long-term study, there are limitation of this study. Food intake data was collected only using 2x24 hour recall data during pregnancy, therefore it reflects the daily intake of pregnant women. Furthermore, this study only collected data on transitional breast milk samples, potential for bias in the content of breast milk so cannot be compared with SFA content in other stages.

4. Conclusion

The SFA intake in the third semester of pregnancy is allowed since increased SFA in breast milk essential to infants' early growth. Despite its benefit, this intake is not suggested for long-term use since SFA may be retained in the body and brings unfavorable effect on the mother. This study gives an overview about the pregnant women profile in urban areas of developing countries such as Indonesia, and it can be used as a reference for further research with similar geographical settings. Further research is required, particularly cohort methods from pregnancy through lactation to determine the maximum period of SFA source food intake (only during the third trimester or until breastfeeding time).

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5. Conflict of Interest

The authors declare no potential conflict of interest concerning the research, authorship, and/or publication of

this article.

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