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Original Research

Maternal Body Mass Index as a Determinant of Breast Milk Fat Content in Young Mothers

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ABSTRACT

Background: *Fat is a major macronutrient in breast milk, and its concentration varies according to multiple factors, including stage of lactation, time of collection, milk fraction, feeding duration, maternal diet, and maternal body mass index (BMI). Alterations in breast milk fat composition may influence infant growth patterns and long-term metabolic health. This study aimed to examine the association between maternal BMI and the fat content of expressed breast milk.*

Methods: *An analytical observational study with a cross-sectional design was conducted at the Medical Basic Chemistry Laboratory, Faculty of Medicine, Universitas Sriwijaya. Breast milk samples were obtained from 63 breastfeeding mothers in Palembang City, comprising 30 mothers with normal BMI and 33 mothers with obese BMI. Breast milk fat concentration was measured using the glycerol-3-phosphate oxidase–phenol aminophenazone (GPO-PAP) method. Data were analyzed using an independent t-test.*

Results: *The mean fat concentration of breast milk from mothers with normal BMI was 3786.7±743.2 mg/dL, whereas that from mothers with obese BMI was 4339.2±958.0 mg/dL. A statistically significant difference in fat concentration was observed between the two groups (p=0.014).*

Conclusion: *Maternal BMI is significantly associated with the fat content of expressed breast milk, with higher fat concentrations observed in mothers with obese BMI. These findings imply that maternal nutritional status should be considered in lactation counseling and infant feeding practices, particularly to optimize infant growth and metabolic outcomes.*

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INTRODUCTION

Breast milk is the secreted milk of epithelial cells in the mammary gland that has many benefits because it contains various macronutrients (carbohydrates, fats, and proteins) and micronutrients (vitamins and minerals) with a nutritional composition that suits the needs of infants (Rochmawati & Kusmintarti, 2024; Srivastava et al., 2020; Subandrate et al., 2022; Syariena et al., 2025). Milk production is influenced by various hormones whose secretion is stimulated by the baby's suction on the breast (Srivastava et al., 2020). Breast milk is the optimal source of nutrition for infants and is recommended to be given exclusively for the first six months of life (Özdemir et al., 2023; Syariena et al., 2025).

The nutritional composition of breast milk is derived from the synthetic activity of lactocytes, maternal dietary intake, and maternal nutritional reserves (Özdemir et al., 2023). In mature breast milk (after day 14 of lactation), the average macronutrient composition consists of approximately 6.8–7.8 g/dL lactose, 0.9–1.3 g/dL protein, and 3.1–3.6 g/dL fat (Özdemir et al., 2023; Subandrate et al., 2022). Breast milk can be obtained by expressing or squeezing the mother's breast. The milking method can be done by hand or pump (Sunaryo & Rahmawati, 2024). Breast milk is stored in sterile bottles that have been labeled with the date and time of milking. The storage of breastmilk is more durable at lower temperatures but the storage process can affect some of the nutrients contained in breastmilk (Gonzalez-Darias et al., 2020).

Fat contributes approximately 50% of the total caloric content of breast milk. Its concentration is relatively low in colostrum, ranging from 15–20 g/L, and increases to about 35–40 g/L in mature breast milk (Kim & Yi, 2020). Variations in breast milk fat content are closely related to the stage of lactation, with the lowest levels observed in colostrum and progressively higher concentrations in mature milk (Rochmawati & Kusmintarti, 2024; Subandrate et al., 2022; Syariena et al., 2025). The fat concentration in hindmilk (breast milk that comes out at the end of breastfeeding) is two to three times more than the fat concentration in foremilk (breast milk that comes out at the beginning of breastfeeding) (Özdemir et al., 2023).

Breast milk during the day and evening contains higher fat than morning and evening milk. The mechanism underlying the difference in fat content in hindmilk and foremilk as well as during the day and night is that fat attached to the surface of lactocyte cells changes the morphology of the alveolus so that the available surface is reduced (Samuel et al., 2020; Sun et al., 2022). This results in greater frictional forces at the end of lactation or when the breast is empty (Özdemir et al., 2023; Sun et al., 2022). Therefore, the timing and stage of breastfeeding may influence the fat concentration of breast milk and contribute to variations in its nutritional composition.

The macronutrient composition of breast milk, including fat, varies among mothers and is influenced by multiple factors such as stage of lactation, time of collection, diurnal variation, and duration of milk removal during breastfeeding or pumping (Özdemir et al., 2023; Samuel et al., 2020). Maternal characteristics also contribute to this variability. A study conducted at the University of California, Davis reported that after four months postpartum, breast milk macronutrient concentrations were associated with several maternal factors, including body mass index (BMI), dietary protein intake, parity, resumption of menstruation, and breastfeeding frequency (Özdemir et al., 2023). These findings indicate that both maternal characteristics and breastfeeding practices should be considered when interpreting variations in the nutritional composition of breast milk.

Maternal overweight and obesity have been proposed as important determinants of breast milk fat content (Ellsworth et al., 2020; Ryoo & Kang, 2022). Although the precise mechanisms remain unclear, this association is thought to be related to metabolic alterations commonly observed in overweight women, such as dyslipidemia and elevated plasma triacylglycerol (Leghi et al., 2020; Sinkiewicz-Darol et al., 2022). The fatty acid composition of breast milk is derived from endogenous synthesis in the mammary gland, mobilization of maternal fat stores accumulated during pregnancy, and maternal dietary intake during lactation (Bobiński & Bobińska, 2022). In particular, long-chain polyunsaturated fatty acids (LC-PUFAs) in breast milk are largely dependent on maternal diet because their precursors are transported from maternal plasma (Özdemir et al., 2023; Sun et al., 2022). Alterations in breast milk fat composition have been linked to increased infant adiposity and a higher risk of obesity and metabolic disorders later in life, raising concern regarding intergenerational transmission of obesity (Ellsworth et al., 2020).

Several studies have reported a positive association between maternal BMI and breast milk fat content. Research conducted in Poland, Greece, and Colorado demonstrated higher fat concentrations in breast milk from obese mothers compared with normal-weight mothers (Bzikowska-Jura et al., 2020; Isesele et al., 2022; Rocha-Pinto et al., 2025; Sims et al., 2020). A meta-analysis performed in Australia further confirmed that mature breast milk from overweight and obese mothers contains significantly higher fat levels than that of normal-weight mothers (Leghi et al., 2020).

Conversely, other studies have found no association between maternal BMI and breast milk fat content. Research from Indonesia reported no relationship between maternal BMI and breast milk fat levels (Helmizar et al., 2024), while a study in France observed no effect of maternal BMI on breast milk macronutrient and energy content, except for protein, which showed a positive association (Ryoo & Kang, 2022). Similarly, Zarzoza-Mendoza et al. reported no difference in fat concentration between mothers with normal and obese BMI (Zarzoza-Mendoza et al., 2025).

These inconsistent findings indicate that the relationship between maternal BMI and breast milk fat content remains inconclusive. Furthermore, several previous studies did not adequately control for important confounding factors, such as milk expression method, gestational age at delivery, maternal age, and standardized sampling conditions, all of which can influence breast milk composition (Bzikowska-Jura et al., 2020; Helmizar et al., 2024; Isesele et al., 2022; Özdemir et al., 2023; Rocha-Pinto et al., 2025; Ryoo & Kang, 2022; Samuel et al., 2020; Sims et al., 2020; Zarzoza-Mendoza et al., 2025). The novelty of this study lies in its use of stricter inclusion and exclusion criteria to minimize sources of variability which allows a clearer evaluation of the association between maternal BMI and breast milk fat content in a more homogeneous Indonesian population. To date, no study in Indonesia has specifically examined this association using a design that simultaneously controls for these confounding factors while focusing exclusively on young mothers in a community setting.

This research therefore contributes new scientific evidence on the role of maternal nutritional status in determining breast milk quality, which may inform nutritional counseling strategies and lactation management in primary health care settings. Therefore, this study was designed to evaluate the association between maternal BMI and the fat content of expressed breast milk in a sample of breastfeeding mothers in Palembang City. The findings are expected to provide a basis for developing more targeted breastfeeding support and maternal nutrition interventions to optimize breast milk quality.

MATERIALS AND METHOD

This study employed an analytical observational design with a cross-sectional approach and was conducted at the Medical Basic Chemistry Laboratory, Faculty of Medicine, Universitas Sriwijaya, Palembang, Indonesia. A cross-sectional design was chosen because it allows the measurement of both exposure (maternal BMI) and outcome (breast milk fat content) at a single point in time, making it efficient for assessing associations in a relatively short period. This design is appropriate for exploratory studies examining the relationship between maternal nutritional status and breast milk composition in a community setting.

Participants were recruited using a purposive sampling technique based on the fulfillment of inclusion criteria. Participants were recruited using a purposive sampling technique. The inclusion criteria were breastfeeding mothers aged 20–35 years who had infants aged >1 to 6 months, were exclusively breastfeeding, and were in good general health. Exclusion criteria included active smoking, alcohol or illicit drug consumption, multiple gestation, preterm delivery, underweight status (BMI <18.5 kg/m²), and a history of gestational diabetes mellitus or hypertension.

The minimum sample size was determined using the formula for comparison of two independent means with the following parameters: type I error (α) of 5% ($Z\alpha = 1.96$), power (1-β) of 80% ($Z\beta = 0.84$), and an estimated effect size based on previous studies. The calculation yielded a minimum sample of 25 participants per group. To account for potential dropouts, the sample size was increased to 30 participants in the normal BMI group and 33 participants in the overweight/obese BMI group, totaling 63 participants.

The independent variable was maternal body mass index (BMI), categorized into two groups: normal BMI (18.5–24.9 kg/m²) and overweight/obese BMI (≥25.0 kg/m²). Maternal weight was measured using a calibrated digital scale (GEA Medical®, accuracy 0.1 kg), and height was measured using a stadiometer (GEA Medical®, accuracy 0.1 cm). Measurements were performed by trained researchers at the time of breast milk collection. BMI was calculated as weight divided by height squared (kg/m²).

The dependent variable was breast milk fat concentration, measured as triacylglycerol levels using the glycerol-3-phosphate oxidase–phenol aminophenazone (GPO-PAP) method according to the Human® reagent kit protocol (Human Diagnostics, Wiesbaden, Germany). This enzymatic colorimetric method has been validated for the quantitative determination of triglycerides in biological samples, with intra-assay and inter-assay coefficients of variation <5%, indicating acceptable reliability.

Breast milk collection was carried out by asking the mother to express 10 mL of breast milk at 07:00 WIB. Before expressing, the mother cleaned the area around the areola and washed her hands with soap. Breast milk was expressed using the hand expression method. The expressed breast milk was collected in a sterile plastic breast milk bag and stored in a freezer at −20°C before being picked up by the researcher. Breast milk samples were transported to the laboratory using a cooler box maintained at 4–8°C between 07:30 and 09:00 WIB. Upon arrival at the laboratory, the samples were immediately analyzed for triacylglycerol levels.

Data were analyzed using SPSS version 26.0 for Windows. Normality of data distribution was assessed using the Shapiro–Wilk test, and homogeneity of variances was evaluated using Levene's test. Since the fat concentration data were normally distributed and variances were equal between groups ($p>0.05$), an independent t-test was used to compare the mean breast milk fat concentration between the normal BMI and overweight/obese BMI groups. A p-value <0.05 was considered statistically significant, and the 95% confidence interval (CI) for the mean difference was calculated. Results are presented as mean ± standard deviation (SD).

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sriwijaya (Ethical Clearance No. 170-2023). All participants provided written informed consent after receiving a full explanation of the study objectives, procedures, potential risks, and benefits. Participants were informed that they could withdraw from the study at any time without any consequences.

RESULT

The characteristics of breastfeeding mothers and infants included in this study are presented in Table 1

Table 1. Characteristic of Breastfeeding Mothers and Infants (n = 63)

Variable	Value
Sampel Quantity	63 (100%)
Breastfeeding Mothers	
Average Age (years)	28.9±4.6
Average Body Weight (kg)	60.7±11.9
Average Height (m)	1.5±0.1
Infants	
Average Age (months)	3.5±1.9
Average Birth Weight (kg)	3.1±0.4
Sex	
Female	31 (49.2%)
Male	32 (50.8%)
Fat content in breast milk	
Average fat content (mg/dL)	4076.1±899.7

A total of 63 mother–infant pairs were analyzed. The mean maternal age was 28.9±4.6 years, with an average body weight of 60.7±11.9 kg and an average height of 1.50 ± 0.10 m. The mean infant age was 3.5 ± 1.9 months, and the average birth weight was 3.1 ± 0.4 kg. The distribution of infant sex was nearly equal, with 31 females (49.2%) and 32 males (50.8%). The overall mean fat concentration of breast milk was 4076.1 ± 899.7 mg/dL.

Normality testing demonstrated that fat concentration data in both BMI groups were normally distributed ($p > 0.05$). Homogeneity testing also indicated equal variances between groups ($p > 0.05$). Therefore, an independent t-test was used to compare breast milk fat concentration between mothers with normal BMI and those with obese BMI. As shown in Table 2, breast milk fat concentration was significantly higher in mothers with obese BMI compared with mothers with normal BMI ($p = 0.014$). In this study, it was found that the average breast milk fat content of normal BMI mothers was in accordance with the normal value of breast milk fat content while the average breast milk fat content of obese and obese BMI mothers was above normal levels.

Table 2. Difference of Average Breast Milk Fat Content (n = 63)

Body mass index	n	Breast milk fat content (mean±SD)	p-value* (CI 95%)
Normal (18,5-25)	30	3786.7±743.2 mg/dL	0.014
Overweight and obese (>25)	33	4339.2±958.0 mg/dL	(122.5-982.5)

*Independent t-test

DISCUSSION

This study demonstrated a significant association between maternal BMI and the fat content of expressed breast milk, with higher fat concentrations observed in mothers with obese BMI compared with mothers with normal BMI. These findings suggest that maternal nutritional and metabolic status plays an important role in determining breast milk fat composition. The mean fat concentration of breast milk from mothers with normal BMI in this study fell within the reported physiological range of mature breast milk (approximately 3500–4000 mg/dL), whereas the mean value among mothers with obese BMI exceeded this range (Kim & Yi, 2020).

Similar patterns have been reported in studies from Poland, Greece, and Colorado, which consistently observed higher fat concentrations in breast milk from overweight and obese mothers than from normal-weight mothers (Bzikowska-Jura et al., 2020; Isesele et al., 2022; Rocha-Pinto et al., 2025; Sims et al., 2020). A meta-analysis conducted in Australia further confirmed that maternal overweight and obesity are associated with increased fat concentration in mature breast milk (Leghi et al., 2020). These findings suggest that maternal adiposity may influence the lipid composition of breast milk, potentially through alterations in maternal lipid metabolism and mammary gland lipid synthesis.

Several biological mechanisms may explain this association. Approximately 98% of breast milk fat is present as triacylglycerol, and a substantial proportion of milk fatty acids originate from maternal plasma lipids and adipose tissue stores. Overweight and obese women commonly exhibit dyslipidemia, characterized by elevated plasma triacylglycerol levels, which may increase the availability of lipid substrates for mammary uptake and milk fat synthesis (Leghi et al., 2020; Sinkiewicz-Darol et al., 2022). In addition, long-chain polyunsaturated fatty acids (LC-PUFAs) in breast milk are strongly influenced by maternal dietary intake, further linking maternal nutritional status to breast milk fat composition (Özdemir et al., 2023; Simon-Sarkadi et al., 2022; Sun et al., 2022)

In contrast, several studies have reported no association between maternal BMI and breast milk fat content. Research from Indonesia and Israel found no significant relationship between maternal BMI and milk fat concentration (Helmizar et al., 2024; Ryoo & Kang, 2022), while a French study observed no association when breast milk samples from the first month of lactation were analyzed (Zarzoza-Mendoza et al., 2025). These discrepancies may be explained by differences in lactation stage, milk sampling procedures, and population dietary patterns. Colostrum and early transitional milk contain lower fat concentrations than mature milk, which may attenuate detectable associations with maternal BMI (Hosseini et al., 2020; Kim & Yi, 2020; Ryoo & Kang, 2022). Furthermore, milk samples consisting primarily of foremilk tend to yield lower fat values than samples obtained after breast emptying or containing mixed foremilk and hindmilk (Enstad et al., 2021; Özdemir et al., 2023).

Another important factor is maternal diet. In certain populations, high habitual fat intake may elevate breast milk fat concentration regardless of BMI status, potentially masking BMI-related differences (Gusnedi et al., 2022; Helmizar et al., 2024; Pipoyan et al., 2021) These variations highlight the need for careful control of sampling conditions and participant characteristics when evaluating determinants of breast milk composition. Therefore, future studies should consider maternal dietary intake as a potential confounding factor when examining the relationship between BMI and breast milk fat concentration.

The findings of this study have several scientific and practical implications. Scientifically, this research provides empirical evidence supporting the role of maternal adiposity in modulating milk macronutrient composition, which is critical for understanding the early programming of infant metabolism. These results add to the growing body of knowledge on how maternal nutritional status influences breast milk quality, particularly in the Indonesian context where such data remain limited. Practically, these findings underscore the importance of preconception and antenatal nutritional counseling to optimize maternal BMI, which may subsequently influence breast milk quality and infant growth trajectories. Health care providers should consider maternal nutritional status when assessing breast milk adequacy and infant feeding outcomes, particularly in populations with high prevalence of overweight and obesity.

This study has several strengths. First, it employed a standardized and validated laboratory method (GPO-PAP) for quantitative measurement of breast milk fat concentration, ensuring analytical accuracy and reliability. Second, strict inclusion and exclusion criteria were applied to minimize confounding from factors such as maternal age, comorbidities, and medication use. Third, breast milk samples were collected at a standardized time (07:00 WIB) to reduce diurnal variation in fat content, which is a known source of variability in breast milk composition.

However, several limitations should be acknowledged. First, breast milk sampling did not follow the gold-standard method of collecting all milk expressed over a 24-hour period. Instead, samples were collected at a single time point in the morning, which may not fully reflect daily variation in fat concentration. Second, the sample size was modest (n=63), although it exceeded the minimum calculated requirement. Third, participants were recruited from selected sub-districts in Palembang, which may limit the generalizability of the findings to broader Indonesian populations. Fourth, maternal dietary intake was not assessed, which could have provided additional insight into factors influencing breast milk fat composition beyond BMI.

Despite these limitations, this study provides evidence supporting an association between maternal BMI and breast milk fat content in Indonesian breastfeeding mothers. Future studies employing standardized 24-hour sampling protocols, larger and more diverse sample sizes, and comprehensive assessment of maternal dietary intake and biochemical markers are warranted to further clarify this relationship and its implications for infant health. Such evidence may contribute to the development of individualized maternal nutrition recommendations and breastfeeding support strategies aimed at optimizing infant nutritional outcomes.

CONCLUSION

This study demonstrates a significant association between maternal body mass index and the fat content of expressed breast milk, with higher fat concentrations observed in overweight and obese mothers compared with mothers of normal BMI. Breast milk from mothers with normal BMI contains fat concentrations within the physiological range, indicating adequate lipid provision for infant nutritional needs. These findings underscore the importance of maintaining optimal maternal nutritional status before and during lactation and highlight maternal BMI as a relevant factor to consider in studies of breast milk composition.

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