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Galactagogue Effect of Banana (*Musa x paradisiaca*) Blossom Beverage on Breast Milk Production Among Mothers Undergoing Cesarean Section

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ABSTRACT

There is limited evidence to support the effectiveness of banana blossom in promoting breast milk supply among mothers undergoing cesarean section. To investigate the clinical galactagogue effect of banana blossom on breast milk production among mothers undergoing cesarean section. A randomized controlled trial was conducted with the experimental group (n_e=30) who consumed banana (*Musa X paradisiaca*) blossom beverage and the control group (n_c=30) who consumed plain water. The results showed that mothers undergoing cesarean section in the experimental group had significantly higher milk flow levels at Day 2 (p=0.017), Day 3 (p=0.005) and milk volume at Day 2 (p=0.005), and Day 3 (p=<0.001) than those of control group. This study had proven the galactagogue effect of banana blossom beverage to promote breast milk production, without any notable adverse effect. It could be used to be the alternative daily menu for postpartum mothers and a solution for midwives to deal with those who have inadequate production of breast milk.

Keywords: banana blossom; galactagogue; breastfeeding; breast milk production; mothers; cesarean section

INTRODUCTION

Breastfeeding has been linked to many positive health outcomes for both mothers and infants, and its widespread adoption as the primary mode of providing nutrition to infants. World Health Organization [WHO] & the United Nations Children's Fund [UNICEF] (2020) has recommended mothers worldwide exclusively breastfeed their infants for the first six months to achieve optimal growth, development, and health since it is the best way of a preventive intervention of mortality among children below the age of five years. However, the prevalence of global early initiation breastfeeding within the first hour of life was 42% (UNICEF & WHO, 2018), and was only 44% exclusive breastfeeding at six months (WHO, 2021). In Thailand, as the national Multiple Indicator Cluster Survey (MICS) in 2019, the early initiation breastfeeding rate was 34% and only 14% of mothers continued exclusively breastfeeding for up to 6 months (NSO & UNICEF, 2019).

The mode of delivery is one of the factors that affect breastfeeding practices. Cesarean section (c-section) is considered major abdominal surgery to deliver a baby. WHO has recommended that the appropriate c-section rate is between 10-15% (WHO, 2015). However, the c-section rate in Thailand has become increasing to 35% in 2019 (NSO & UNICEF 2019). These greatly rising trends of c-section become more unfavorable to breastfeeding. Several studies have reported the negative consequences of c-section on breastfeeding initiation (Hobbs et al., 2016; Prado et al., 2018), and duration (Chen et al., 2018; Hobbs et al., 2014). Lower breastfeeding initiation and increased difficulties with breastfeeding in mothers undergoing c-sections may be related to a physiologic influence on lactogenesis (Hobbs et al., 2014). Within a few hours after a c-section, mothers are expected to initiate breastfeeding their newborns while simultaneously coping with the problems associated with the post-operation, including prolonged recovery period, pain, fatigue, improper position for breastfeeding, and limited mobilization to carry out activities because of catheterization and intravenous lines (Beake et al., 2017; Chen et al., 2018; Sinsuksai et al., 2017). Moreover, there is also potential for physical separation from mothers, given a higher risk of infant admission to neonatal intensive care because of respiratory disorders (Beake et al., 2017). The infants are more often distressed and in need of specific feeding practices (Chen et al., 2018). These maternal physical and emotional responses to surgery as well as infant health and behavior can affect breastfeeding practice. Post-surgical procedures for mothers and newborns can delay breastfeeding initiation

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(Sinsuksai et al., 2017), and face difficulties in breastfeeding (Hobbs et al., 2016). Consequently, these mothers perceived inadequate milk supply and started formula supplementation in response to these effects (Sinsuksai et al., 2017). Many interventions have been assessed to improve breastfeeding among these mothers including immediate or early skin-to-skin contact after a cesarean birth, education and breastfeeding support in the early postnatal period, the use of sidecar bassinets during inpatient rooming-in, and use of breast pumping breastfeeding (Beake et al., 2017) as well as the use of galactagogues (Foong et al., 2020; Kwan and Abdul-Rahman, 2021).

Pharmaceutical and herbal galactagogues are substances that are believed to assist in the initiation, continuation, or augmentation of breast milk production (Bazzano et al., 2016; Foong et al., 2020; Kwan and Abdul-Rahman, 2021). They could be considered for additional support in breast milk production, especially in the presence of optimized pumping strategies or frequent and effective milk removal at regular intervals. In Europe and USA, licensed drugs with galactagogue effect, as pharmaceutical galactagogues such as domperidone, metoclopramide, chlorpromazine, sulpiride, thyrotropin-releasing hormone) are widely used. Since they increase serum prolactin by counteracting the inhibitory influence of dopamine on prolactin secretion (Foong et al., 2020). Several high-quality studies have found the effectiveness of domperidone on breast milk production, specifically among mothers of preterm infants. However, the use of domperidone in lactation has been the subject of controversy due to an increased risk of ventricular arrhythmia and sudden cardiac death (Grzeskowiak and Amir, 2015). At present, Health Canada (2018) and the European Medicines Agency (2014) recommended caution in the use of domperidone and have provided dosing recommendations.

Most mothers who prefer natural sources tend to consume natural galactagogues as passed on by the previous generations. Since foods and herbs have been consumed to ensure health and wellness in many traditional communities. In a recent scoping review on plant galactagogue worldwide in promoting women's lactation (Kwan and Abdul-Rahman 2021), the plants that are known to be consumed traditionally have been tested in clinical studies to verify their effectiveness in promoting mothers' milk production including fenugreek (*Trigonella foenumgraecum*), goat's Rue (*Galega officinalis*), milk thistle (*Silybun marianum*), plumeless thistle (*Carduus*), stinging nettle (*Urtica dioica*), melissa (*Melissa officinalis*), caraway (*Carum carvi L.*), anise (*Pimpinella anisum*), fennel seed (*Foeniculum vulgare*), lemon grass (*Cymbopogon citratus*), banana blossom (*Musa sapientum Linn*), ginger (*Zingiber officinale Roscoe*), malunggay (*Moringa oleifera*) and shatavai (*Asparagus racemosus*). Many galactagogue plant species were reported to have estrogenic properties that may stimulate mammary alveolar growth, increased serum prolactin level, cortisol level, total protein, and glycogen content (Sahoo et al., 2016), and stimulate the blood flow to mammary glands, thus enriching milk flow (Patel et al., 2013). The presence of hormone-like action of steroidal saponin was associated with a lactogenic effect whereby the chemical structure is alike to endogenous estrogen and fixed to estrogen receptors (Ghasemi et al., 2015).

Many cultures believe that certain foods increase human milk production. They vary from region to region according to the cultural belief. Banana is a popular and cheapest plant throughout the tropical and sub-tropical regions of the world. In Asian cultures (Wahyuningsih et al., 2017; Nordin et al., 2020), the banana blossom is one of the most popular and convenient plant galactagogues to promote lactation among Thai mothers (Buntuchai et al., 2017; Luecha, & Umehara, 2013; Author, 2018). In a previous study, banana (*M. x paradisiaca*) blossom was extracted using various solvents, and these crude extracts contain alkaloids, saponins, glycosides, tannins, flavonoids, and steroids. The extracts also showed antioxidant activity, which can contribute to healthy lactation (Mahmood et al., 2011; Joseph et al., 2014). Some assumptions increasing milk flow is due to the action of plant galactagogue mechanism in a biological pathway. Some herbal or plant galactagogues contain steroidal saponins in which chemical structures are alike endogenous estrogen, thus fix to estrogen receptors (Ghasemi et al., 2015). In a Malaysian study, aqueous extracts of banana blossom were demonstrated to act as a significant galactagogue in female lactating rats (Mahmood et al., 2012). Moreover, there was a significant effect of banana blossom (*Musa balbisiana Colla*) extract on breast milk production and prolactin level in Indonesian mothers from the 5th day to 12th day of postpartum (Wahyuningsih et al., 2017). Furthermore, the biscuits formulated with banana (*Musa x paradisiaca*) significantly increased breast milk production among Malaysian working mothers of term and healthy infants aged 2 to 6 months (Nordin et al., 2020). However, there is limited evidence that its milk booster may improve milk production in early postpartum among mothers undergoing cesarean section. It is also uncertain about any side effects of banana blossom. Even though banana blossom was proven a galactagogue, only a few lactating women can accept the astringent taste of the blossom. To overcome the problem, banana blossoms should be prepared in a simple form, tasty, and ready to eat. Moreover, considering the busy lifestyle of mothers and the production of tea and beverage of herbal galactagogues were popular and common use for lactating mothers in Thailand. Commercially available banana (*Musa x paradisiaca*) blossom beverage was used in this study. A randomized controlled trial (RCT) study was conducted to examine the Galactagogue effect of banana blossom beverage on breast milk production among mothers undergoing cesarean section. It is expected that this

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research could scientifically prove the traditional belief that banana blossom could be consumed as a milk booster for mothers undergoing cesarean section.

METHOD

The randomized controlled trial study was conducted on mothers undergoing c-section at postpartum ward at a postpartum unit in a community hospital, Phrae, Thailand during April - June 2019. The research protocol was approved by the Research Ethics Review Committee of Faculty of Nursing, Chiang Mai University, Thailand (No. 002/2019) and the Research Ethics Review Committee of Phrae Hospital (No. 5/2562 BE). Written informed consent was obtained before the enrollment of the participants in the study. The participants of the study were

Inclusion criteria: The mothers are healthy mothers undergoing c-section aged 18 years and above without any maternal abnormalities of breasts and nipples and without contraindication or allergic to banana blossom who deliver aterm healthy baby (≥ 37-42 weeks gestation) with Apgar scores ≥ 7. The mothers have been willing to exclusively breastfeed their baby for at least 6 months, but they have not breast milk within 3 hours after birth.

Exclusion criteria: Mothers with serious chronic disease and medical conditions decreased breast milk production (such as heart disease, diabetes, postpartum hemorrhage, postpartum sepsis), or have a contraindication to breastfeeding such as HIV infection were not involved in the study. Mothers who had any other herbal and pharmaceutical galactagogues or were allergic to banana blossom were excluded from the study. Mothers who had newborns with congenital anomalies and acute problems (such as pneumonia, sepsis, necrotizing enterocolitis) were excluded from the study.

Sample size: The sample size was estimated according to the effect of a galactagogue herbal tea on breast milk production of mothers with preterm in the study performed by Nordin and colleagues (2020). Given an a-error of 5%, power of 80%, and effect size = 0.80, a sample size of 27 was required in each group.

Material and data collection: Commercially available banana blossom beverage contains 14 mg. of banana blossom in a bottle of 100 ml., produced by a small business. It is registered with the Thai Food and Drug Administration (TFDA). This banana blossom beverage was extracted to analyze the bioactive compounds and antioxidant activity by the Center of Excellence in Agricultural Innovation for Graduate Entrepreneurs, Maejo University. In a high-polarity solvent, the extract demonstrated high total phenolic compounds and flavonoids, which are responsible for the antioxidant activity. Therefore, the aqueous extract was selected and produced in a beverage. This beverage, which contained the aqueous extract of banana blossom, demonstrated the presence of phenolic compounds and antioxidant activity, which would be expected to benefit lactating mothers (Amornlerdpison et al., 2021).

Postpartum nurse-midwives (except the head nurse) were trained by a lactation consultant nurse, as a gold standard, on how to express and record breast milk. The mothers were expressed breast milk and recorded milk flow level and milk volume by trained nurse-midwives at 3 hours of postpartum, Day 1 (24±2 hours after birth) Day 2 (48±2 hours after birth), and Day 3 (72±2 hours after birth. Milk volume from each expression was measured by using a sterile syringe was used to measure the volume accurately.

Randomization was done using a computer-generated list with a block of four methods. The participants were allocated to either one of the two equal-sized groups. After the allocation sequence was generated, the researcher packed the bottles of banana blossom beverage or plain water in the sequentially numbered seal boxes. These boxes were kept with the head nurse who opened each box when a new participant was recruited with the criteria at three hours of postpartum. All mothers received the enclosed bottles at the dosage of one bottle (100 ml.) three times after meals for three days (72 hours) postpartum. Neither the head nurse and postpartum nurse staff nor the mother was aware of the experimental group. The group allocation list was kept confidential and only revealed after the completion of the data collection process.

A total of 95 eligible mothers undergoing c-sections received the same diets and healthcare services including advice and support on breastfeeding from the same healthcare professional team in a public postpartum ward. Mothers with complications (3 high blood pressure, 3 severe fever) and mothers of acute neonatal problems (4 sepsis, 6 severe jaundices, and 4 pneumonia) as well as infants were separated from mothers and received formula (n = 8), were not involved in the study. Mothers refused to participate in this study (n=7). Sixty mothers were randomly assigned to either one of the two equal-sized groups. The mothers of the experimental group consumed a banana blossom beverage of 100 ml. (containing 14 mg. of banana blossom) three times a day for the first three days postpartum. The control group mothers received plain water without banana blossom beverages (Figure 1). Milk flow level and milk volume were recorded on Day 1 (24±2 hours after birth), Day 2 (48±2 hours after birth), and Day 3 (72±2 hours after birth) by trained nurse-midwives. Every mother was also asked and recorded about the characteristics of mothers (age, education, occupation, monthly family income, and parity), and infants (sex, and birth weight). By the end of the trial, mothers in the

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experimental group were asked about their satisfaction and any adverse effects (such as gastrointestinal discomfort, allergic reactions, urticaria, pruritus, edema, decreased urine volume, and other complications) related to the use of this banana blossom beverage.

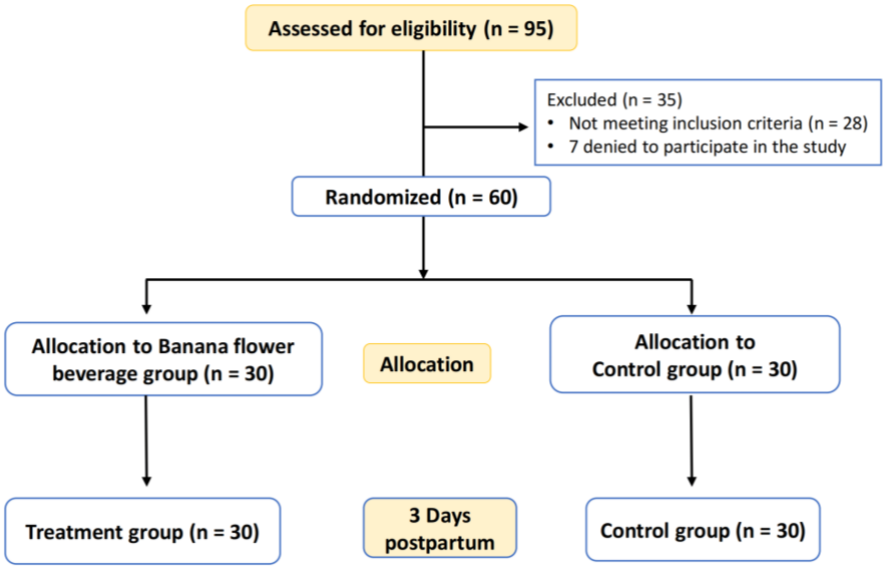

Figure 1. CONSORT Flow Diagram of Participants through the Study

Data analysis: The characteristics between the two groups and milk flow level were compared using Student's t-test and Chi-square tests. Milk volumes between two groups were compared using Mann–Whitney U test after checking the distribution of data was not normal distribution by using the Shapiro-Wilks test. A p-value of less than 0.05 was considered statistically significant.

RESULT

Participant's Characteristics

The total participants were 60 lactating mothers undergoing c-section in this study, Characteristics of these mothers and infants are summarized (Table 1). There were no differences between mothers of the experimental and control groups in maternal age, education, occupation, monthly family income, parity, birth weight, and sex of infant ($p>0.05$).

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Table 1. Comparison of Characteristics of Mothers and Infants between the Control Group (n_c=30) and Experimental Group (n_e=30)

Characteristics	Control (n_c=30)	Experimental (n_e=30)	t-test /Chi-square (p-value)
Age (year)			
Mean	30.53	29.77	0.62
SD	6.29	5.20	(0.54)
Educational Status, n (%)			
Secondary	10 (33.3)	12 (40.0)	0.29
Graduate	20 (66.7)	18 (60.0)	(0.96)
Occupation, n (%)			
Public sector	7 (23.3)	2 (06.7)	5.95
Private sector	9 (30.0)	16 (53.4)	(0.31)
Self-employed	4 (03.4)	2 (06.7)	
Housewife	10 (33.3)	10 (33.3)	
Monthly family income, n (%)			
< 30,000 Baht	19 (63.3)	21 (70.0)	0.30
≥ 30,000 Baht	11 (36.7)	9 (31.0)	(0.58)
Parity, n (%)			
Primiparous	12 (40)	12 (40)	0.00
Multiparous	18 (60)	18 (60)	(1.00)
Sex of infant, n (%)			
Male	13 (43.3)	13 (43.3)	0.00
Female	17 (56.7)	17 (56.7)	(1.00)
Birth weight (grams)			
Mean	3075	3132	0.67
SD	294	360	(0.51)

Comparison of Breast Milk Production between Two Groups

The milk production data in the two groups were summarized in Table 2 and Table 3. Compared with the control group, mothers in the experimental group, who consumed banana blossom beverages, had significantly higher milk flow levels on Day 2 (p=0.017) and Day 3 (p=0.005) postpartum (Table 2), and had significantly higher milk volume at Day 2 (p=0.005) and Day 3 (p<0.001) of postpartum (Table 3). Among mothers in the experimental group, all were satisfied with the banana flower beverage, with no adverse effects related to this banana blossom beverage. Moreover, most of them would like to continue using this beverage.

Table 2. Comparison of Milk Flow Level within Three Days Postpartum between the Control Group (n_c=30) and Experimental Group (N_e=30)

Milk flow level	Control (n_c=30) n (%)	Experiment (n_e=30) n (%)	Chi-square (p-value)
Day 2 (48±2 hrs.)			
1	12 (40.0)	2 (06.7)	6.597
2	18 (60.0)	25 (83.3)	(0.017)
3	0 (00.0)	3(10.0)	
Day 3 (72±2 hrs.)			
2	12 (40.0)	2 (06.7)	10.597
3	18 (60.0)	26 (86.6)	(0.005)
4	0 (00.0)	2 (06.7)	

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Table 3. Comparison of Breast Milk Volume within Three Days Postpartum Control Group (n_c=30) and Experimental Group (n_e=30)

Milk volume (ml)	Control (n_c = 30)	Experiment (n_e=30)	Mann-Whitney U test (p-value)
Day 2 (48±2 hrs.)			
Mean	10.467	18.673	260.000
S.D.	7.453	11.572	(0.005)
Mean Rank	24.17	36.83	
Day 3 (72±2 hrs.)			
Mean	25.533	42.433	117.000
S.D.	9.612	11.264	(<0.001)
Mean Rank	19.40	41.60	

DISCUSSION

In this study, mothers undergoing c-sections in experimental and control groups have similar characteristics and have no breast milk within 3 hours after birth. Compared with mothers in control groups, mothers who consumed banana blossom beverages had more breast milk production. Banana (*Musa x paradisiaca*) blossom beverage has promoted breast milk supply and has been proven for its lactogenic properties on breast milk production among mothers undergoing c-section in early postpartum. This has been approved for the effectiveness of banana blossom on lactating mothers in Indonesia (Wahyuningsih et al., 2017) and has been further reinforced in lactating working women in Malaysia (Nordin et al. 2020). It also was supported by a Thai survey that found that consumption of some traditional galactagogue including banana blossoms had a strong correlation with human milk volume (Buntuchai et al., 2017). As previously stated, the galactagogue properties of banana blossom beverage might be the result of phytochemicals constituents. The phytochemical compound identified in banana blossom beverages were alkaloids, saponins, glycosides, tannins, flavonoids, terpenoids, and phenolics (Mahmood et al., 2011; Joseph et al., 2014). Moreover, secondary metabolite materials identified as triterpenes (stigmasterol, and β-sitosterol), sesquiterpene (caryophyllene), and sesterpene (ophiobolin) revealed the role of banana blossom beverage to have an estrogenic effect on lactating rats (Mahmood et al., 2014). Furthermore, the banana blossom beverage in this study was extracted to analyze the bioactive compounds and antioxidant activity by the Center of Excellence in Agricultural Innovation for Graduate Entrepreneurs, Maejo University. It demonstrated high total phenolic compounds and flavonoids, which are responsible for antioxidant activity. The bioactive compounds of banana inflorescence contained β-sitosterol, flavonoids, saponin, and other phenolic compounds. Therefore, this beverage, which contained the aqueous extract of banana blossom, demonstrated the presence of phenolic compounds and antioxidant activity, which would have an estrogenic effect that is expected to benefit lactating mothers (Amornlerdpisan et al., 2021). Furthermore, considering the busy lifestyle of mothers and the common use of the beverage, this banana blossom beverage is a simple form, tasty, and ready to eat of herbal galactagogues as well as convenient for mothers undergoing c-sections to use, without any notable adverse effect. It could be used to be the alternative daily menu for postpartum mothers and a solution for midwives to deal with those who have inadequate production of breast milk.

CONCLUSION

The results in this study suggest that banana (*Musa x paradisiaca*) blossom beverage could promote breast milk production (both milk flow and milk volume) among mothers undergoing c-sections who practically breastfeed their infants within the first three days of postpartum as this period represents the timing of lactogenesis II. Therefore, the banana blossom beverage can be a promising natural galactagogue to improve breast milk volume among mothers undergoing c-section in the immediate postpartum period without any notable side effects. For mothers undergoing c-sections who are struggling with delayed lactogenesis II and inadequate production of breast milk, the use of banana blossom beverage can be considered for additional support in breast milk production, especially in the presence of optimized pumping strategies or frequent and effective milk removal at regular intervals. The usage of banana blossom beverages also contributes to the healthy growth and development of infants. It is also safe since the banana blossom is the natural galactagogue food and the finding reveal that there was not any adverse effect for the use of banana blossom beverage. The use of natural galactagogue would be more convenient than pharmaceutical galactagogue as prescribing a drug that is ordered by a physician and perhaps, increased the risk of side effects. Since the banana blossom is unpleasant in taste and inconvenient in its preparation. Therefore, the production of banana blossom

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beverages could resolve these problems and potentially be commercialized as lactogenic food-based support. Moreover, the findings of this study could be used to be an alternative daily menu for postpartum mothers and a solution for nurse-midwives to deal with those who have insufficient breast milk.

LIMITATIONS

This study provides scientific knowledge regarding the effectiveness of banana (*Musa x Paradisiaca*) blossom beverage on breast milk production among mothers undergoing c-section in early postpartum. It should also be noted that the assessment of breast milk volume using the expressed milk volume one time a day may not accurately indicate the actual milk supply. In addition, the pumped volume can be affected by many factors in many women such as pump fit, maternal discomfort with the pump, and time of the day. Moreover, the mechanism of how banana (*Musa x Paradisiaca*) blossom increases breast milk is not well understood, but the study result suggests that it may not be through stimulation of serum prolactin and estrogen. Further studies with larger sample sizes and more rigorous measurement of breast milk volume (such as daily collected expressed breast milk within 24 hours), as well as the measurement of serum prolactin, are needed to confirm the effect of consuming banana blossom beverage on increasing breast milk production in these mothers.

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