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Effect of consuming lactogenic biscuits formulated with banana (*Musa x paradisiaca*) flower flour on expressed breast milk (EBM) among lactating working women

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Abstract

The most common reasons given for breastfeeding discontinuation among working women is insufficient or low milk supply which related to physiological and psychological factors. In this case, natural galactagogue is suggested as an alternative for lactating women to augment expressed breast milk supply, instead of using drugs as a milk booster. This study investigated the banana flower of *Musa x paradisiaca* for its galactogenic property on lactating working women. Formulations containing banana flower flour (BFF) and wheat flour with ratio of 50:50 were consumed by randomised lactating working women. A total of 58 mother-infant pairs were assigned to two groups which were placebo group (n=29) who consumed plain biscuits (without addition of BFF) and experimental group (n=29) who consumed prototype biscuits. Expressed breast milk (EBM), anthropometric indices of mothers and infants were recorded before and after the consumption of the biscuits. The result showed that EBM volume after consuming lactogenic biscuits among experimental group was significantly higher compared to placebo groups. The index of mother's BMI change after the intervention was not statistically significantly different between the two groups ($p>0.05$). However, the BMI for age index after the intervention was significantly different among the infants ($p<0.05$), which means that lactogenic biscuit also contributes to the infants' growth status. The usage of banana flower as a galactagogue was useful to help increasing maternal milk production among lactating working women.

1. Introduction

WHO recommends mothers worldwide to exclusively breastfeed their infants for the first six months to achieve optimal growth, development and health since it is the best way of preventive intervention of mortality among children below the age of five years, especially in developing and undeveloped countries. However, globally, only 38% of infants aged 0 to 6 months were exclusively breastfed (WHO, 2013). Whereby in Malaysia, referring to National Health Morbidity Survey (NHMS) in 2016, only 46% of working women in public sectors succeed in breastfeeding exclusively up to 6 months (Institute for Public Health *et al*., 2016). The most common reasons given for breastfeeding discontinuation among women is insufficient or low milk supply which is related to physiological and psychological factors (Rozga *et al*., 2015). Therefore, to overcome the problem of low milk production among lactating women, this research focused on plant galactagogues. A survey was done by Othman *et al*. (2014), found out that most lactating women consumed plant or herbal galactogogue due to insufficient milk ejection and 80.7% of them were satisfied on the use of herbal galactagogue. Among the plant galactagogues that have been studied including *Asparagus racemosus* (Gupta and Shaw, 2011), *Nigella sativa* (Hosseinzadeh *et al*., 2013), *Pimpinella anisum* L. (Hosseinzadeh *et al*., 2014), *Cyperus rotundus* L (Badgujar and Bandivdekar, 2015), *Galega officinalis* (Salatino *et al*., 2017) and fenugreek (Khan *et al*., 2018).

The research on natural products base from plants and herbs lead to the discovery of phytochemical compounds that act as galactagogues. Based on the previous study a positive effect on milk production was

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found when female lactating rats were treated with crude extract of *Musa x paradisiaca* flower spp. (Mahmood *et al*., 2012). Many galactagogue plants species were reported to have estrogenic properties that may stimulate mammary alveolar growth, increased serum prolactin level, cortisol level, total protein and glycogen content (Badgujar and Bandivdekar, 2015; 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 lactogenic effect whereby the chemical structure is alike to endogenous estrogen and fix to estrogen receptors (Sharma and Bhatnagar, 2011; Behera *et al*., 2013; Ghasemi *et al*., 2015).

The flower extract from *Musa paradisiaca* had beneficial effects for health including anti-carcinogenic, anti-atherogenic, antiulcer, anti-thrombotic, anti-inflammatory, vasodilatory immune modulating, antimicrobial and analgesic effects (Loganayaki *et al*., 2010). In fact, banana bract was identified to contain high saponin which gave beneficial effects on cholesterol levels, bone health, cancer and immune system (Adeolu and Enesi, 2013). Banana flower of *Musa x paradisiaca* sp. also showed a significant high capability to inhibit enzymes β-glucuronidase and Angiotensin I Converting enzyme that could control non-infectious diseases (Acharya *et al.*, 2016). The presence of antioxidant properties in *Musa x paradisiaca* flower extract could prevent free radical and control cells damage (Mahmood *et al*., 2011), which capable to contribute towards healthy lactation. Nutritional data on banana flower provided by Sheng *et al*. (2010) states that it riches in dietary fibre and protein, as well as unsaturated and saturated fatty acids. There are also reported studies on Musa *sp* associated with women's health. Among them the boiled water of the leaves was used for bathing mothers after delivery, thus rejuvenate their body (Rajith *et al*., 2010) and also used to treat women's uterine fibroids by Latino healers in New York City (Balick *et al*., 2000).

Despite the fact that banana flower was proven as galactagogue, only a few lactating women can accept the astringent taste of the flower. In order to overcome the problem, banana flower should be prepared in a simple form, tasty and ready to eat. Developing a preserved product from the banana flower would eliminate such difficulties and promise benefits such as prolonged shelf life and convenience in preparation. Therefore, the production of biscuits is considered as the best choice. A study on food consumption pattern among Malaysian adults in 2003 found out that biscuits were placed in the top ten food items consumed daily by this group (Norimah *et al*., 2008). There is an increasing trend in the consumption of convenience food that is ready-made such as bread, biscuits and cakes in Malaysia. It could be inferred that biscuits were among the popular food items in Malaysia. Some of the reasons for such wide popularity are because of affordable cost compared to other processed foods, availability in different flavours, ready to eat, easy to keep and longer shelf life (Hooda and Jood, 2005). Considering the busy lifestyle of working adults in Malaysia, biscuits constitute a food that may be consumed anywhere and anytime without too much bother.

In response to public demand and awareness on healthier dietary and foodstuff, this study is aimed to produce lactogenic biscuits made from *Musa x paradisiaca* flower which would be tested on nursing mother for its effectiveness. It is hoped that this research is able to scientifically prove the belief among old folks that banana flower could be consumed as a milk booster for postpartum mothers.

2. Materials and methods

2.1 Preparation of formulated biscuit

The formulation for short dough biscuit was in accordance with the method of Serrem *et al*. (2011) with some modification. The ingredients used for the biscuit consist of banana flower flour (BFF), wheat flour, butter, brown sugar and vanilla flavor. An equal amount of banana flower flour and wheat flour were added in the formulation with ratio of 50:50. The mixture was kneaded to become dough and sheeted for a thickness of 4-6 mm and then baked in a conventional oven at 190^{o}C for 25 mins. The biscuit was then allowed to cool down at ambient temperature and finally packed in a plastic jar for further used. Meanwhile for control, the biscuit was prepared using the same procedure without any addition of BFF but alternately replaced with wheat flour.

2.2 Respondent criteria

Convenient sampling was done on 58 mothers-infant pairs which were recruited via social media and volunteers from member of Breastfeeding Mother's Support Group of Pahang (KUSSIP). They had fulfilled the criteria of 18 to 40 years of age, working within nine hours regardless in private or government service and exclusively breastfed their infants. Whilst for their infants, they were born full-term and healthy with the age of 2 to 6 months old and have not yet started weaning diet. Participants who had a history of smoking, alcohol, or any drug or herbs being used to improve breast milk production were excluded. Meanwhile baby with low birth weight, low APGAR scores, and intrauterine growth retardation, with any illnesses or congenital abnormalities were also being excluded. This

research was approved by the Ethics Committee of International Islamic University Malaysia with the code of IIUM/310/G/13/4/4-199 and ID Number: KAHS 29 on 9 February 2017.

2.3 Intervention procedure

The amount of biscuit consumed by the respondent was based on the method by Mahmood *et al*. (2012), in which the amount of crude banana flower extract applied to each rat was 500 mg/kg of the body. However, it was converted to human dosage by using formula of BSA For Dose Translation as described by Reagan-Shaw *et al*. (2007). Thus, the minimum dose requirement was 2.4 g in order to give a lactogenic effect. Accordingly, the lactogenic element or dosage contained in a piece of biscuit of BFF was 1.62 g while two pieces of it would sum up to 3.24 g that fulfilled the requirement. Hence, each respondent was required to take two pieces of the biscuit for a period of a month.

2.4 Data collection

The subjects were allocated to either one of the two equal-sized groups, which were the placebo group who were administered plain biscuits or experimental group, who received the lactogenic biscuits. Social demographic and growth parameter including height/length and weight of mothers and infants were recorded before started consuming biscuits. The height measurement equipment used for mother was Seca 213 portable and Seca 210 Baby Measuring Mat for the infant. Meanwhile for the weight measurement, Tanita HD-357 and Seca 384 Digital Baby Scale were used. The method of measurement was based on a guideline proposed by Centres for Disease Control and Prevention (2007), while the infants' growth development was referring to booklet of WHO Training Course on Child Growth Assessment (WHO, 2008). All respondents were requested to record the frequency of breast milk expression and their amount for a period of five working days before the intervention to obtain the baseline data. During consuming the biscuits in the third week, the respondents were required once again to record the frequency and amount of the breast milk expression for another period of five working days. Comparison of anthropometric indices of mothers and infants, frequency of breast milk expression and amount of breast milk between pre and post interventions in each group were also analysed. The respondents were required to use the breast pump either manually or electrically and retained the same method until the end of the experimental period. A 24 Hours Dietary Recall Record (2 weekdays and 1 weekend) was also being recorded to assess the energy intake and to ensure of not taking any food or drugs in abstinence list.

2.5 Data analysis

Statistical analysis was carried out on the experimental data of human trial. The distribution of the data was checked by using the Shapiro-Wilks test and verified. To determine the equivalent of all criteria in each group, Independent sample t-test was used before the intervention and p-value below 0.05 was considered statistically significant. In connection with that, the mean difference of average amount of expressed breast milk during time interval was assessed by ANCOVA purposely to control effects of expressed breast milk before starting the intervention which known as covariate. As secondary outcome, the mean difference of Body Mass Index (BMI) for age of infants was determined before and after interventions using dependent sample t-test. All data were analysed using SPSS Statistics Version 22 software.

3. Results and discussion

3.1 Socio-demographic

Table 1. Socio demographic background of respondents

Basic Characteristics of Respondents	Frequency (n = 58)	Percentage (%)
Respondent's Age (Years)		
Below 25	2	3.5
25-30	28	48.4
31-35	13	22.5
36-40	15	25.6
Respondent's Occupation		
Health Services	33	56.9
Education Area	11	19
Administrative	7	12.1
Technical Services	7	12.1
Parity of Respondent's		
Primid para	11	19
Multi para	47	81
Educational Status of the Respondents		
Secondary	5	8.6
Graduate	48	82.7
Post Graduate	5	8.6
Respondent BMI Status (Kg/M$^{2)}$		
Underweight	7	12.1
Normal	26	44.8
Overweight	17	29.3
Obese	8	13.8
Infant's Age (Months)		
2	1	1.7
3	13	22.4
4	19	32.8
5	10	17.2
6	15	25.9
Infant BMI for Age (Kg/M^2) Status		
Wasting	1	1.7
Normal	57	98.3

Socio-demographic background of the respondents

Table 2. Maternal and infants' characteristics by group

Characteristics	Placebo (n = 29)	Experimental (n = 29)	p
Mother's Age (Years)	31.83±4.36	31.88±4.56	0.96
Mother's Body Mass Index/ (BMI) kg/m²	24.50±5.35	24.60±4.46	0.94
Frequency of Expression Breast Milk Activity during working hours (Times)	2.96±0.73	2.90±0.72	0.77
Average of Expression Breast Milk Amount during working hours in 5 Days/ (mL)	344.38±95.36	380.02±183.12	0.36
Mothers' Food Intake (Kcal)	2141.42±803.68	2115.41±562.32	0.88
Infant's Age (month)	4.72±1.09	4.14±1.15	0.53
Infant's BMI For Age (Kg/M²)	16.17±1.66	16.68±1.42	0.21

Note: Significant difference between two groups: placebo and experimental (P<0.05) (Independent Student's t-test)

such as age, occupation, parity and educational status, respondent BMI status, infant's age and infant BMI for age were recorded as in Table 1. Almost half of the participants belong to age group of 25 to 30 years (48.4%). In terms of occupation, respondents in health sector (56.9%) were the most involved in this study. With regard to parity, most of the participants were multipara (81.0%), Majority of the respondents in this study completed high education level in which 91.3% of them possessed certificate, diploma or degree. In terms of BMI status, it was found that those who were normal almost as much as overweight which was 44.8% the former and 43.1% the latter. Meanwhile, the ages of infants involved in this study were 32.8% four months, followed by 25.9% six months and 22.4% three months. In terms of BMI for Age Status of the infants, 98.3% were normal.

3.2 Characteristics of selected maternal and infant by group

The characteristic of mothers and infants such as maternal age, Body Mass Index (BMI), frequency of breast milk expression practice, average amount of expressed breast milk collected for five working days, food intake, infants' age and BMI for age of the infants had been compared in both groups as shown in Table 2. Independent Student's t-test analysis showed that there were no significant differences (P>0.05) for each characteristic between the placebo and experimental groups. Thus, it can be concluded that both groups have similar characteristics prior to the intervention study. The mean of BMI for mothers in the two groups, placebo and experimental were within the normal range, which was 24.50±5.35 kg/m^2 and 24.60±4.46 kg/m² respectively (WHO, 2013). It was suggested that nursing mothers should not consume less than 1,500 kcal per day because it would lead to reduction in milk production (Ares Segura *et al*., 2016). Thus, this research showed that the calorie consumption of selected mothers was sufficient and fulfilled the energy required to produce breast milk. Meanwhile, the nutritional status of infants in terms of BMI for age from both groups showed that their growth was normal.

3.3 Expressed breast milk (EBM) production between placebo and experimental group

Experimentally, lactating mothers in the placebo group had EBM mean of 360.56±119.39 mL while in the experimental group the mean was 454.34±182.937 mL (Table 3). To determine whether the means were significantly different by considering the covariate effects, thus one-way ANCOVA was performed. A covariate was included to partial out the effects of the average amount of breast milk before consuming biscuits. Examinations of the Shapiro-Wilk statistics and histogram for each group indicated that the ANCOVA assumption normality was supported. Scatterplots indicated that the relationship between the covariate (average amount of EBM before start intervention) and the dependent variable (average amount of EBM after intervention) was linear. Finally, the assumptions of homogeneity of regression slopes and homogeneity of variances were supported by the absence of a significant independent variable-by-covariate interaction, $F(1, 54) = 0.23$, $p = 0.631$, and a non-significant Levene's Test, $F(1, 56) = 0.00$, $p = 0.999$ respectively. The ANCOVA indicated that, after accounting for the effects of average amount of EBM before intervention, in two groups, there was statistically significant difference between placebo and experimental groups, $F(1, 55) = 10.397$, $p = 0.002$, eta squared = 0.16. Thus, the current study revealed that consuming biscuit containing BFF by the experimental group increased the EBM volume (P<0.05). The total amount of EBM for placebo and experimental groups were recorded as presented in Table 4.

Table 3. The mean ± standard deviation of Expressed Breast Milk (EBM) in the placebo and the experimental groups

Group	N	Mean of EBM volume (mL)
Placebo	29	360.56±119.39
Experimental	29	454.34±182.94

In this research, lactogenic characteristic of *Musa x paradisiaca* flower that has been proven on lactating rats by Mahmood *et al*. (2012) has been further reinforced for its effectiveness on human. It was supported by a survey found that consumption of some traditional galactagogue including banana flower had a strong correlation with human milk volume (Buntuchai *et al*., 2017). Banana

flower in the form of its aglycone or without the glycoside materials showed the same effect of lactogenic properties on experimental rats, comparable as in the form of aqueous crude extract (Mahmood *et al*., 2017). As previously stated, the galactagogue properties of banana flower might be the result of phytochemicals constituents. The phytochemicals compound identified in banana flower were alkaloids, saponins, glycosides, tannins, flavanoids, terpenoids and phenolic (Mahmood *et al*., 2011; Joseph *et al*., 2014). Besides that, secondary metabolite materials identified as triterpenes (stigmasterol, and β-sitosterol), sesquiterpene (caryophyllene) and sesterpene (ophiobolin) revealed the role of banana flower to have estrogenic effect on lactating rats (Mahmood *et al*., 2014). Since this research involves the use of banana flower flour as a whole to make biscuits, it can be concluded that the active phytochemicals content in banana flower acted synergistically to affect the yield of milk production. The increasing amount of EBM is clearly shown as in Figure 1, where the gradient of straight line is very strong in the experimental group.

Table 4. Amount of Expressed Breast Milk (EBM) in the placebo and the experimental groups analysed using ANCOVA

Group	N	EBM volume (mL)	P<0.05
Placebo	29	377.38±13.14 [a]	0.002
Experimental	29	437.52±13.14 [a]	0.002
Mean Difference (95%		60.14*	0.002

Note: Based on estimated means
*Adjustment for multiple comparisons: Bonferroni
Covariates appearing in the model are evaluated at the following value: Pre-study EBM record = 362.20 mL

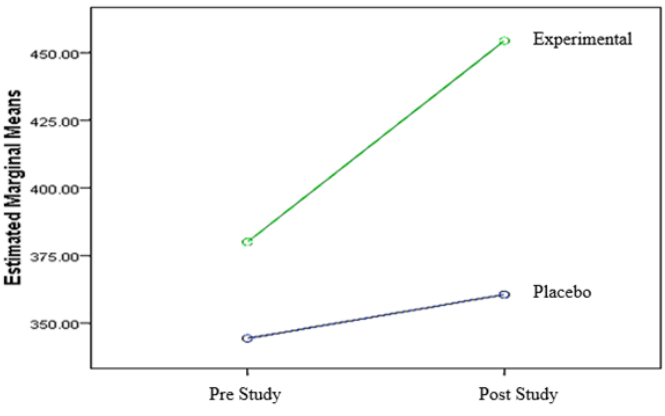

Figure 1. The difference amount of EBM before and after consuming biscuits between the placebo and the experimental groups.

As referring to Table 3, the group means were adjusted for the effect of covariate which later shows that the EBM volume means among the experimental group was significantly higher than the placebo group (P<0.05) (Table 4). In other words, if everyone in the sample had the same amount of EBM before starting any interventions, which was 362.204 mL, the amount they achieved after two weeks would be 437.52±13.13 mL for the experimental group and 377.384±13.138 mL for placebo group. The mean difference for EBM between the groups was 60.137 mL (95% CI: 377.384 - 437.521). This is clearly shown in Figure 2.

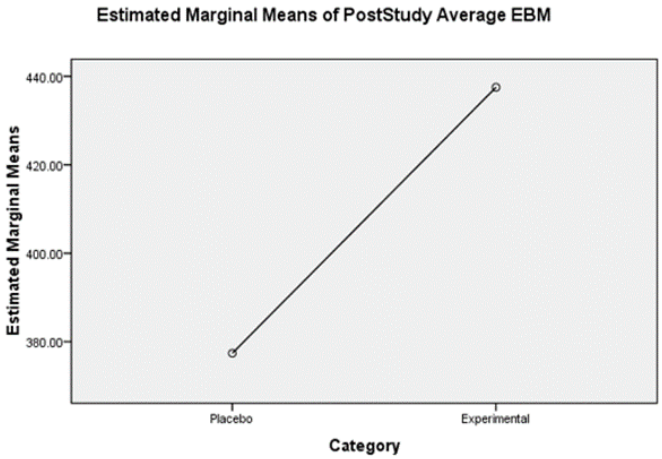

Figure 2. The Estimated Marginal Means of average EBM of post-study between the placebo and the experimental group.
Note: Covariates appearing in the model are evaluated at the following values: Pre-study average EBM record = 362.20 mL.

There are assumptions that increasing milk flow is due to the action of plant galactagogue mechanism in biological pathway. Some herbal or plant galactagogues contain, such as steroidal saponins in which their chemical structure are alike endogenous estrogen, thus fix to estrogen receptors (Ghasemi *et al*., 2015). Another hypothesis is through proliferation of mammary secretory cells and their activity, for example, shatavari can stimulate cellular division that leads to enlargement of alveolar tissues and by virtue increase the mammary gland weight (Patel *et al.,* 2013). Any increase of cells number or their rate of activity, or both, would assist to increase milk production (Mortel, 2013). Another consideration is that the dosage required to evoke maximum therapeutic effect is largely unquestioned and untested (Foong *et al*., 2015). The existence of galactagogue activities of *Musa x paradisiaca* flower could be observed by the changes in mammary glands weight, protein content and widening of the alveoli in the experimental lactating rats (Mahmood, 2014).

Positive outcomes of consuming lactogenic banana flower biscuits were also observed in the measurement of BMI for age of infant's after the intervention. A two-tailed paired samples t-test showed that the experimental infants were 0.47 points higher in their BMI for age than before the intervention. The difference was statistically significant, t(28) = 3.72, P = 0.001. Therefore, consumption of lactogenic biscuits did also contribute to the growth status of the infants in the experimental

group.

4. Conclusion

The biscuit containing banana flower flour capable to significantly increased breast milk production among career women who practically breastfeed their babies. Therefore, this study had proven the potential of the flower to promote breast milk especially for those who experience insufficient milk. Since the banana flower is unpleasant in taste and inconvenience in its preparation, thus, by producing biscuit from banana flower flour could resolve these problems and potentially to be commercialized as lactogenic food-based support. In fact, the usage of banana flower flour in the biscuits also contributes to healthy growth and development of the infants.

Conflict of Interest

Authors declare no conflict of interest.

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