2024, Retos, 60, 40-49

Premenstrual symptoms, mood responses and level of serotonin: study on banana drinks enriched by egg albumin in the luteal phase of collegiate female athletes

Síntomas premenstruales, respuestas del estado de ánimo y nivel de serotonina: estudio sobre bebidas de plátano enriquecidas con albúmina de huevo en la fase lútea de atletas universitarias

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Abstract. This research aims to analyze the effect acute intervention of banana drink enriched with egg white to premenstrual symptoms, mood and levels of serotonin in collegiate female athletes with Premenstrual Dysphoric Disorder (PMDD). This experimental study was randomized, double blind, and used a pre and post placebo-control group design. Purposive sampling technique was used to select the research sample. Purposive sampling technique was used to select research samples and divided into two groups, namely the placebo drink group and the banana drink group. Each participant was in the late luteal phase at the time of data collection. efore the test, records were made regarding the characteristics of the research subjects, menstrual cycle calculations, cervical fluid observations and basal body temperature measurements. The PSST-A is used to diagnose moderate/severe PMDD, mood respons were assessed using 24 BRUMS Research items with the Brunel Mood Scale. Serotonin analysis was carried out using the Elisa Kit Human Serotonin. Before and after intervention (pre-post-test) both groups were given a push up test for 60 seconds. Intervention was given 3 hours before completing the PSST-A, BRUMS questionnaires and push up test. Statistical tests of research data were carried out using SPSS version 23. Based on the results of the PSST-A analysis, it was reported that banana drink was able to significantly reduce (*$p<0.05$) anxiety, difficulty concentrating, fatigue/lack of energy decreased interest in social activity, insomnia, physical symptoms and home responsibility. Likewise, in the results of the BRUMS scale analysis, a lowering was shown in depression, anger, fatigue, confusion compared to the group given a placebo drink. Statistical analysis of serotonin levels did not show a significant increase in both the placebo and banana drink groups. Further research needs to consider digestive health and the gut microbiome in producing serotonin and analyzing the antioxidant properties of bananas on psychosomatic and behavioural symptoms.
Keywords: Premenstrual dissorder, menstrual cycle, banana, egg albumin, mood response, serotonin

Resumen. Esta investigación tiene como objetivo analizar el efecto de la intervención aguda de la bebida de plátano enriquecida con clara de huevo sobre los síntomas premenstruales, el estado de ánimo y los niveles de serotonina en deportistas universitarias con trastorno disfórico premenstrual (TDPM). Este estudio experimental fue aleatorizado, doble ciego y utilizó un diseño de grupo control antes y después del placebo. Se utilizó la técnica de muestreo intencional para seleccionar la muestra de investigación. Se utilizó una técnica de muestreo intencional para seleccionar muestras de investigación y se dividieron en dos grupos, a saber, el grupo de bebida placebo y el grupo de bebida de plátano. Cada participante se encontraba en la fase lútea tardía en el momento de la recopilación de datos. Antes de la prueba, se realizaron registros sobre las características de los sujetos de investigación, cálculos del ciclo menstrual, observaciones del líquido cervical y mediciones de la temperatura corporal basal. El PSST-A se utiliza para diagnosticar el TDPM moderado/grave; las respuestas del estado de ánimo se evaluaron utilizando 24 elementos de investigación de BRUMS con la escala de estado de ánimo de Brunel. El análisis de serotonina se realizó utilizando el kit Elisa Human Serotonin. Antes y después de la intervención (pre-post-test), a ambos grupos se les realizó una prueba de flexiones durante 60 segundos. La intervención se realizó 3 horas antes de completar los cuestionarios PSST-A, BRUMS y la prueba de flexiones. Las pruebas estadísticas de los datos de la investigación se llevaron a cabo utilizando SPSS versión 23. Según los resultados del análisis PSST-A, se informó que la bebida de plátano pudo reducir significativamente (*$p<0,05$) la ansiedad, la dificultad para concentrarse, la fatiga/falta de energía disminución del interés en la actividad social, insomnio, síntomas físicos y responsabilidad en el hogar. Asimismo, en los resultados del análisis de la escala BRUMS se demostró una disminución de la depresión, la ira, la fatiga y la confusión en comparación con el grupo que recibió una bebida placebo. El análisis estadístico de los niveles de serotonina no mostró un aumento significativo ni en el grupo de placebo ni en el de bebida de plátano. Es necesario realizar más investigaciones para considerar la salud digestiva y el microbioma intestinal en la producción de serotonina y analizar las propiedades antioxidantes de los plátanos sobre los síntomas psicosomáticos y de comportamiento.
Palabras clave: Trastorno premenstrual, ciclo menstrual, plátano, albúmina de huevo, respuesta del estado de ánimo, serotonina

Fecha recepción: 19-04-24. Fecha de aceptación: 03-08-24
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Introduction

Premenstrual Syndrome (PMS) is a condition in which a woman undergo with at least one psychological, behavioural or physical symptom that arise during the luteal phase of which can cause dysfunction, academic, social and/or work performance (Beiranvand et al., 2016; Sanchez et al., 2023). Symptoms of PMS consist of: headaches, stomach ache, low back pain, back pain, nausea, changes in appetite, mood changes, irritability, restlessness, anger, crying, tiredness, swelling, breast pain, weight gain and constipation. These symptoms can occur at a severe, moderate or mild level (Saglam & Orsal, 2020). PMDD is a much more severe from PMS in terms of symptom intensity, predominance of mood symptoms, and significant functional impairment. The most common symptoms are depression, tension, anxiety, irritability, sleep changes, mood swings, hostility, breast tenderness, and flatulence (Firoozi et al., 2012).

The prevalence of PMS is known to be high among

female university students (Gudipally & Sharma, 2024). It can be increases with the duration and intensity of exercise in female athletes (Wismanadi et al., 2024). This condition is also reinforced by the age of first menstruation in young women (menarche), training intensity, length of sports career, older age and competitive sports (Czajkowska et al., 2015). The chronicity and severity of PMS can clout to the academic performance, impairment of studies, activities, quality of life, and it can also affect relationships (Al-Shahrani et al., 2021). Meanwhile on female athletes, it shows significant results in lowering competitive performance, reduction in training loads and rearrangement in training schedules especially before and during menstruation (Prado et al., 2022).

PMS symptoms are associated with hormonal fluctuations particularly during the late luteal phase in the menstrual cycle where there is a hormonal disproportion in oestrogen and progesterone (Sanchez et al., 2023). Biological theories suggest causes of this syndrome include the effects of progesterone on neurotransmitters such as serotonin, catecholamines, opioids and GABA, insulin resistance, increased prolactin levels or increased sensitivity to the effects of prolactin, abnormal hypothalamic-pituitary-adrenal axis function, sensitivity to endogenous hormones and deficiencies nutrients such as Magnesium, Calcium, B6 (Firoozi et al., 2012). Studies show that women with PMS have lower levels in serotonin on whole-blood, platelet and serotonin metabolites in the mid and late luteal phase. Serotonin is liable for many physiologic, emotional, psychologic, and behavioural responses (Carmichael et al., 2021). Serotonin synthesis is highly dependent on plasma Tryptophan (TRP) levels. The availability of the essential amino acid TRP as a precursor of serotonin in the brain can be increased through dietary interventions (Mitchell et al., 2011).

Bananas are known to be a good source of catecholamines and serotonin. The amounts of each in banana pulp are dopamine, 7.9 μg/g, norepinephrine, 1.9 μg/g and serotonin, 28 μg/g. Bananas contain many bioactive compounds such as phenolics, carotenoids, flavonoids, vitamin C and vitamin E which have antioxidant activity which is good for health (Hartoto et al., 2024). Based on a review of the phytochemical and pharmacological components of bananas, using banana pulp as functional foods and medicines is highly recommended (Sidhu & Zafar, 2018). Consuming TRP in bananas is beneficial because its content together with carbohydrates will make it easier for TRP to cross the blood-brain barrier and can be used as a basic ingredient for the formation of serotonin (Wurtman et al., 2003). Moreover, bananas are a source of bioactive components that form serotonin, including vitamins B6, B12 and magnesium, which play a role in serotonin synthesis (Emaga et al., 2007).

TRP ride into the brain via the L-type amino acid transporter. However, TRP be in the running with other large neutral amino acids (LNAA; namely tyrosine, isoleucine, leucine, valine and phenylalanine) for transport by L-type amino acid transporters (Mitchell et al., 2011). Studies on α-lactalbumin, a whey-derived protein with a high TRP content and on egg protein hydrolysate showed an increase in TRP: LNAA to a ratio that has meaningful effects to behavioural and cognitive (Mitchell et al., 2011). TRP is a highly lipophilic amino acid, its transport in the blood requires plasma albumin (Palego et al., 2016). TRP that is not bound to albumin will compete with branched chain amino acids (BCAA) to enter the brain (Yamamoto et al., 1997). Albumins are a class of water-soluble proteins found in egg white (Sharif et al., 2018).

The relationship of premenstrual symptoms and negative mood to certain foods has not been widely studied. Gaining an understanding of the interactions of functional ingredients that can be utilized to reduce the severity of premenstrual symptoms in female athletes and improve their mood and performance is necessary. This research was carried out with the aim of specifying the effect of acute intervention banana drinks enriched by egg white for premenstrual symptoms, mood regulation and level of serotonin in collegiate female athletes.

Material and Methods

Study Design

This study was a randomized, double-blind, placebo-controlled study. Twenty eight female athletes with dysmenorrhea, premenstrual syndrome and mood swings from various volleyball clubs in East Java who studies at Universitas Negeri Surabaya were involved and selected using a purposive sampling technique. Participants must meet the following criteria: age 20 ± 2 years, 3 years as an experienced athlete, at least more than 3 hours/week training sessions, unmarried or never had sexual relations, BMI 21 ± 3 kg/m2, waist circumference less than 90 cm, regular menstruation for the last 5 months, no serious illness, no use of hormonal contraceptives or other medications, no clinical diagnosis of eating disorders, hypothyroidism, not smoker and having PMDD. Aims and methods of the study were fully explained to the participants and written informed consent was received from all participants. All study protocol was ethically clear by Ethical Board of the Health Research Ethics Committee Faculty of Public Health Airlangga University No: 55/EA/KEPK/2021.

Treatment Procedure

Research participants were randomly divided into two groups: placebo drink (n=14) and banana drink (n=14). Participants were in a fasting state (6 hours), did not consume coffee, energy drinks, or other substances containing high levels of tryptophan that could affect the results 24 hours before the start of the trial. The pre-post-test before and after the intervention for both groups was given a push up test for 60 seconds. On the first day (pre-test), participants in both groups were given 360 ml of mineral water as a control, while on the second day (post-test), experimental participants were given a warm banana drink (104^0F) made from banana powder enriched with 80 gr/360 ml of egg

white, while the placebo was given 12 gr/360 ml of warm sugar water (104^0F). All drinks were placed in paper cups with opaque lids without identification of the contents and were given 3 hours before completing the PSST-A, BRUMS questionnaires and push up test. Participants were given two drink interventions between the time after the pre-test before the six-hour post-test time, at 12 noon, and 6 pm, 360 ml banana drink or 360 ml sugar water according to each group. Banana powder is made through a foam mat drying process using egg whites based on research by Noordia et.al (2020). The use of 12 g of glucose as a placebo was adjusted to the glucose content same as one ripe banana. Drinks were given randomly by other researchers.

Instrument and Data collection

Each participant was in the late luteal phase at the time of data collection based on LH peak calculations and Luteinizing Hormone (LH) test results as well as measurements of basal body temperature and cervical fluid characteristics. The Steiner Premenstrual Symptom Screening Tool (PSST-A) is used to diagnose PMS and moderate/severe PMDD in women with symptoms who will receive treatment. This instrument includes all premenstrual symptoms and their impairment measures according to DSM-IV-TR criteria and translates them into a dimensional rating scale to assess severity (Steiner et al., 2011). Information regarding the surge in luteinizing hormone (LH) is obtained using urine ovulation predictor tests (LH Ovulation test strips). This data is collected to predict the time of ovulation. The rise in LH in the urine is known to occur near the time when ovulation takes place during the menstrual cycle (Leiva et al., 2017). Mood responses were assessed using 24 BRUMS Research items with the Brunel Mood Scale application (http://www.moodprofiling.com/testRP-Ss.php) by answering the statement "How do you feel right now?", the condition that best represents the participant's situation at that time. Selection of a numerical rating scale from zero to four (very = 4; a lot = 3; quite = 2; a little = 1; or not at all = 0) (Brandt et al., 2016). The serotonin test is used to measure serotonin levels in the blood (serum). Serotonin (5-hydroxy-tryptamine) is a monoamine derived from the essential amino acid tryptophan. Serotonin analysis was carried out using the Elisa Kit Human Serotonin ST-BT Labs Kit. Venous blood that had been taken from each participant (3 ml;3 hours after push up test,), was collected in a vacutainer without anticoagulant to separate the serum (2 ml). Serum is separated by centrifugation. Serotonin analysis was carried out by high pressure liquid chromatography. The reference value used for studio data interpretation was 90–240 μg/L (Moroianu et al., 2022).

Statistical analysis

The data were analyzed to determine the mean value and differences before and after treatment. SPSS version 23 with a significance level of $p < 0.05$ was used for statistical analysis. Normality data using Shapiro-Wilk test. To compare changes from the pre-test and post-test of the same group, the Wilcoxon Signed Rank Tests and Paired Sample T-Test were used, while between groups (banana drink and placebo groups) the Mann Whitney and Independent Sample T-Test were used.

Results

Physical characteristics of research subjects are shown in Table 1.

Table 1.
Physical characteristic of research subjects

x	Group Placebo	Group Banana Drink	p value
Age (years)	20.23 ± 1.17	20.46 ± 0.66	0.56
Height (cm)	160.54 ± 4.50	161.00 ± 5.92	0.59
Weight (kg)	56.38 ± 5.50	54.77 ± 7.26	0.40
BMI (kg/m^2)	21.33 ± 1.74	21.59 ± 1.84	0.17
Waist (cm)	74.69 ± 8.04	74.76 ± 6.00	0.94
Heart rate	78.65 ± 12.88	77.00 ± 9.09	0.18
Systole (mmHg)	108.42 ± 5.78	104.69 ± 6.48	0.61
Diastole (mmHg)	76.35 ± 5.43	70.84 ± 5.95	0.46
Temperature (°C)	35.91 ± 0.46	34.82 ± 4.43	0.75
Training volume (hours/week)	5.00 ± 0.91	4.77 ± 0.44	0.37
Training experience (years)	8.15 ± 2.60	6.38 ± 2.02	0.88

Data given as mean ± SD. No significant difference in the characteristic of each groups (p>0.05).

There were no significant differences in the physical characteristics of the research subjects based on p>0.05, so physical characteristics will not influence the differences in results at the end of the intervention. The acute effect of banana drink on premenstrual symptoms, mood regulation and level of serotonin reveal on Table 2, Table 3 and Table 4.

Table 2.
Descriptive statistics and intragroup analysis of the Premenstrual Symptoms

Symptoms	Group	Mean ± SD	Shapiro-Wilk		Wilcoxon signed rank test (p)	Mann-Whitney U (delta B and P) (p)
			n	p		
Anger/irritability						
Pre	PD1	1.85±0.80	13	0.012	0.007*	0.009**
Post	PD2	1.15±0.69		0.000		
Pre	BD1	1.62±0.51	13	0.000	0.001*	
Post	BD2	0.38±0.65		0.000		
Anxiety						
Pre	PD1	1.08±0.95	13	0.066	0.129	0.687
Post	PD2	0.69±0.48		0.000		
Pre	BD1	1.15±0.90	13	0.003	0.020*	
Post	BD2	0.62±0.65		0.003		
Tearful/increase sensitivity to rejection						0.920
Pre						

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Descriptive statistics and intragroup analysis of the Premenstrual Symptoms

Symptoms	Group	Mean ± SD	Shapiro-Wilk		Wilcoxon signed rank test (p)	Mann-Whitney U (delta B and P) (p)
			n	p		
Post	PD1	1.08±0.86	13	0.029	0.014*	
Pre	PD2	0.38±0.65		0.000		
Post	BD1	1.23±0.93	13	0.110	0.014*	
	BD2	0.46±0.78		0.000		
Depressed mood /hopelessness						
Pre						
Post	PD1	1.00±0.707	13	0.012	0.033*	0.216
Pre	PD2	0.38±0.65		0.000		
Post	BD1	1.23±1.01	13	0.041	0.004*	
	BD2	0.15±0.38		0.000		
Decreased interest in work activities						
Pre						
Post	PD1	1.69±0.75	13	0.005	0.020*	0.244
Pre	PD2	1.15±0.56		0.001		
Post	BD1	1.69±0.94	13	0.087	0.010*	
	BD2	0.77±0.83		0.001		
Decreased interest in home activities						
Pre						
Post	PD1	1.69±0.63	13	0.004	0.038*	0.050
Pre	PD2	1.15±0.56		0.001		
Post	BD1	1.31±0.86	13	0.002	0.021*	
	BD2	0.62±0.51		0.000		
Decreased interest in social activities						
Pre						
Post	PD1	0.77±0.83	13	0.001	0.527	0.650
Pre	PD2	0.54±0.66		0.002		
Post	BD1	1.38±1.04	13	0.116	0.010*	
	BD2	0.46±0.77		0.000		
Difficulty concentrating						
Pre	PD1	1.15±0.69	13	0.009	0.058	0.545
Post	PD2	0.69±0.63		0.004		
Pre	BD1	1.31±1.11	13	0.059	0.015*	
Post	BD2	0.54±0.66		0.002		
Fatigue of lack energy						
Pre	PD1	1.31±0.63	13	0.004	0.257	0.264
Post	PD2	1.08±0.49		0.000		
Pre	BD1	1.62±0.96	13	0.078	0.008*	
Post	BD2	0.77±0.73		0.009		
Overeating/food cravings						
Pre	PD1	2.00±0.58	13	0.002	0.059	0.243
Post	PD2	1.62±0.65		0.000		
Pre	BD1	1.46±1.05	13	0.001	0.317	
Post	BD2	1.23±0.93		0.110		
Insomnia						
Pre	PD1	1.15±1.14	13	0.027	0.161	0.186
Post	PD2	0.69±0.63		0.004		
Pre	BD1	1.38±1.33	13	0.007	0.034*	
Post	BD2	0.38±0.77		0.011		
Hypersomnia (needing more sleep)						
Pre						
Post	PD1	1.31±0.75	13	0.011	0.248	0.920
Pre	PD2	1.00±0.82		0.012		
Post	BD1	1.54±1.05	13	0.036	0.083	
	BD2	1.00±0.92		0.034		
Feeling overwhelmed or out of control						
Pre						
Post	PD1	0.92±0.64	13	0.006	0.058	
Pre	PD2	0.46±0.66		0.001		
Post	BD1	1.08±1.04	13	0.029	0.234	0.579
	BD2	0.77±0.01		0.004		
Physical symptoms (including breast tenderness, headache, joint muscle pain, bloating and weight gain)					0.083	
Pre						
Post	PD1	1.69±0.95	13	0.025		
Pre	PD2	1.15±0.98		0.070		
Post	BD1	1.77±0.93	13	0.005	0.004*	0.081
	BD2	0.46±0.78		0.000		
School work efficiency/productivity						
Pre						
Post	PD1	0.92±0.76	13	0.014	0.059	
Pre	PD2	0.54±0.66		0.002		1.000
Post	BD1	0.92±0.76	13	0.014	0.096	

Table 2.
Descriptive statistics and intragroup analysis of the Premenstrual Symptoms

Symptoms	Group	Mean ± SD	Shapiro-Wilk		Wilcoxon signed rank test (p)	Mann-Whitney U (delta B and P) (p)
			n	p		
	BD2	0.54±0.66		0.002		
Relationships with friend/classmates						
Pre	PD1	0.54±0.776	13	0.001	0.157	
Post	PD2	0.23±0.44		0.000		
Pre	BD1	0.54±0.776	13	0.001	0.059	0.762
Post	BD2	0.15±0.37		0.000		
Relationships with family						
Pre	PD1	0.62±0.51	13	0.000	0.083	
Post	PD2	0.38±0.50		0.000		
Pre	BD1	0.54±0.88	13	0.000	0.059	0.336
Post	BD2	0.15±0.37		0.000		
Social live activity						
Pre	PD1	0.62±0.51	13	0.000	0.564	
Post	PD2	0.34±0.52		0.000		
Pre	BD1	0.77±0.73	13	0.009	0.059	0.511
Post	BD2	0.38±0.51		0.000		
Home responsibility						
Pre	PD1	0.69±0.75	13	0.005	0.480	
Post	PD2	0.54±0.77		0.001		
Pre	BD1	0.77±0.93	13	0.005	0.024*	0.169
Post	BD2	0.08±0.28		0.000		

Note: BD: Banana drink group; PD: Placebo drink group
*There was a significant difference in the Wilcoxon signed test ($p < 0.05$)
** There is a significant difference in the Mann-Whitney U ($p < 0.05$)
Both interventions between pre and post, Banana drink (BD) and Placebo drink (PD) significantly ($p < 0.05$) reduce symptoms of: anger/ irritability ($p = 0.001$ for BD and 0.007 for PD), tearfulness/sensitivity to rejection ($p = 0.014$ both), depressed mood/hopelessness (BD: $p = 0.004$ and PD: $p=0.033$), and decreased interest in work activity (BD: $p = 0.021$ and PD: $p = 0.038$). However, only banana drink intervention was able to diminish symptoms of: anxiety ($p=0.020$), decreased interest in social activity ($p=0.010$), difficulty concentrating ($p=0.015$), fatigue/lack of energy (0.008), insomnia ($p=0.034$), physical symptoms ($p=0.004$), home responsibility ($p=0.024$). The difference in effect between the banana drink group and the placebo drink was only shown on anger symptoms ($p=0.009$).

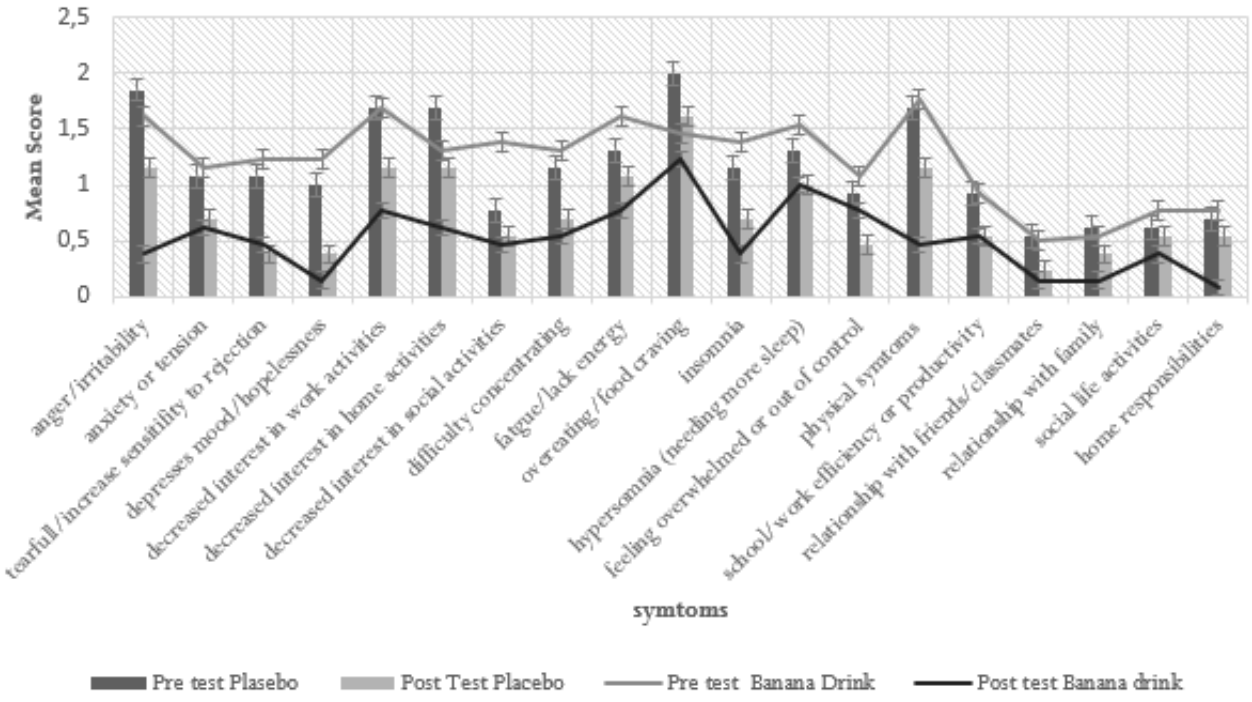

Figure 1. The acute effect of banana drink and placebo intervention on premenstrual symtoms

Table 3.
Descriptive Statistics and Intragroup Analysis of the Mood Regulation

Brunel Mood Scales	Group	Mean±SD	Shapiro-Wilk n	Shapiro-Wilk p	Wilcoxon signed rank test (p)	Paired Samples T-test (p)	Mann- Whitney U (p)	Independent T-Test (p)
Depression								
Pre	PD1	47.62 ± 8.26	13	0.023	0.182			
Post	PD2	45.23 ± 4.92		0.130				
Pre	BD1	56.15 ± 11.14	13	0.010	0.003*		0.309	
Post	BD2	48.85 ± 9.16		0.000				
Anger								
Pre	PD1	53.54 ± 7.25	13	0.163	0.478			
Post	PD2	53.54 ± 10.99		0.001				
Pre	BD1	55.69 ± 10.81	13	0.004	0.003*		0.129	
Post	BD2	49.00 ± 6.38		0.001				
Fatigue								
Pre	PD1	51.85 ± 6.65	13	0.551		0.941		
Post	PD2	51.69 ± 5.10		0.317				
Pre	BD1	51.69 ± 6.13	13	0.087		0.004**		0.647
Post	BD2	47.00 ± 4.97		0.052				
Confusion								
Pre	PD1	52.62 ± 7.78		0.026		0.848		
Post	PD2	53.15 ± 9.49	13	0.119				
Pre	BD1	55.08 ± 12.09	13	0.048		0.022**		0.647
Post	BD2	48.23 ± 6.31		0.006				
Vigour								
Pre	PD1	46.15 ± 5.35	13	0.091		0.385		
Post	PD2	44.61 ± 6.95		0.449				
Pre	BD1	48.38 ± 5.73	13	0.380		1.000		0.587
Post	BD2	48.85 ± 6.15		0.550				

Note: BD: Banana Drink group; PD: Placebo Drink group
*There was a significant difference in the Wilcoxon signed test (p <0.05)
** There is a significant difference in the Paired Sample T-Test (p <0.05)

Banana drink group showed a significant decrease in scale of depression (p=0.003), anger (p= 0.003), fatigue (p=0.004), confusion (p=0.022) at pre-test and post-test, but not in vigour. Meanwhile, comparison between groups (banana and placebo) showed no difference in effect.

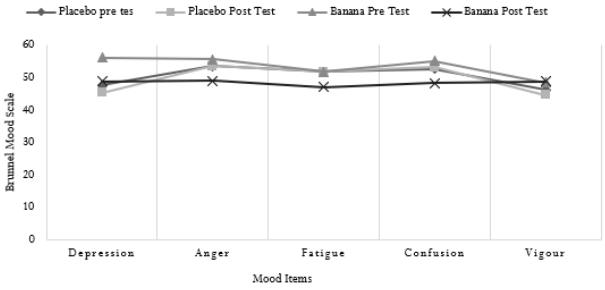

Figure 2. The acute effect of banana drink and placebo intervention on mood regulations

Table 4.
Descriptive Statistics and Intragroup Analysis of the Serotonin

Serotonin (µg/L)	Group	Mean ± SD	Shapiro-Wilk n	Shapiro-Wilk p	Wilcoxon signed rank test (p)	Paired Sample T-Test (p)
Pre	PD1	36.86 ± 17.77	13	0.063	0.903	
Post	PD2	35.83 ± 13.65		0.159		
re	D1	5.96 ± 19.46	13	0.071	0.270	0.085
Post	BD2	31.60 ± 16.63		0.003		

PD: Placebo Drink Group; BD: Banana Drink Group
Differences statistically significant at p < 0.05. No significant difference on both groups.

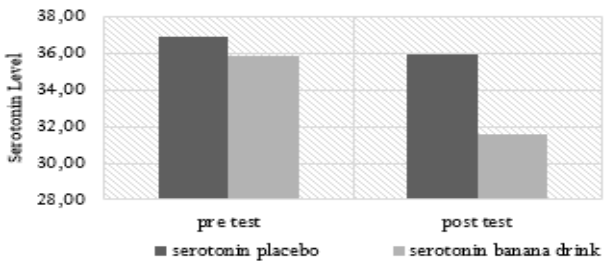

Figure 3. The acute effect of banana drink and placebo intervention on serotonin

Discussion

This research was conducted to figure out the effect of acute intervention of banana drink enriched with egg white as a supplement drink to relieve premenstrual symptoms, regulate mood and its effect on serotonin levels in collegiate female athletes suffering PMDD. The occurrence of pre-menstrual syndrome in women is multifactorial. Hormonal imbalances in the menstrual cycle such as progesterone de-ficiency and excess estrogen which cause various

interactions and biochemical changes are one possible causal factor. Additionally, serotonin, oxidative stress, inflammation and gamma-aminobutyric acid (GABA) levels also play a role in premenstrual symptoms (Sultana et al., 2022).

The results of the PSST-A analysis show that giving banana drinks significantly reduces premenstrual symptoms in anger/irritability, crying easily/sensitive to rejection, depressed/hopeless mood, anxiety, fatigue/lack of energy, insomnia, decreased interest in work activities and social activities, difficulty concentrating, and physical symptoms. Likewise, in the results of the BRUMS scale analysis, an alleviation was shown in depression, anger, fatigue, confusion but not in vigor. Meanwhile, the placebo (glucose drink) showed a reduction in symptoms of anger/irritability, easy crying/sensitivity to rejection, depressed/hopeless mood, and decreased interest in work activities only meanwhile the BRUMS analysis shows no differences.

Bananas have great antioxidant potential. The content of lycopene and lutein, catecholamines, phenolic compounds, catechin, epicatechin, lignin and tannin, as well as anthocyanins, biogenic amines, flavonoids, phytosterols and other phytochemicals in bananas have an important antioxidant capacity, while carotenoids in bananas such as α- β-carotene and β-cryptoxanthin has significant provitamin-A activity (Kritsi et al., 2023). Russell et al. (2009) have detected ferulic, sinapic, salicylic, syringic, gallic, vanillic, p-hydroxybenzoic, gentisic, and p-coumaric acids as the main components in bananas. However, the concentration of ferulic acid is the highest among other phenolics. The biological effects of phenolics as natural antioxidants are anti-inflammatory, antiallergenic, antibacterial, antiviral, vasodilation and antithrombotic functions (Sholikhah et al., 2018). The flavonoid content in bananas which act as free radical collectors includes myricetin, cyanidin, quercetin and kaempferol (Kevers et al., 2007).

Bananas have several vitamins and minerals that are useful for nervous system function. Nutritional values of diets consumed by women suffering unipolar depression such as magnesium (Mg), iron (Fe), potassium (K), and B vitamins which has been shown to reduce depressive symptoms (Stefańska et al., 2014) A study showed that a decreasing trend in total magnesium levels was associated with an increase in estrogen (Grossi et al., 2017). Magnesium in bananas can reduce oestrogen levels in women (Bourre, 2006). The role of magnesium (Mg^{2+}) in brain function and mood is for nerve transmission and the formation of phospholipid membranes (Botturi et al., 2020). Bananas are rich in vitamin B6, and can provide up to 33% of the daily value for one medium banana. Retallick-Brown et al. revealed that vitamin B6 and the use of multiple micronutrients are effective in reducing severe PMS symptoms. Strasser et al. (2016) state that not only foods rich in tryptophan but also foods rich in antioxidants can have a positive impact on mood and cognition. A low sodium, high potassium diet has an overall positive effect on general mood (Torres et al., 2008).

In this research, banana drink product was processed using the addition of egg white with the aim that apart from being a foaming agent in the microencapsulation process and the various biological activities, it can also be used as a TRP supplement for serotonin synthesis and helping the process of transporting it in the blood. One medium banana contains 11 mg of TRP (Richard et al., 2009), while egg white (also known as albumin) has a TRP content of 0.16 g/100 g of material (Belitz et al., 2009). The main components of albumen protein are ovalbumin (54%), ovotransferrin (12%–13%), ovomucoid (11%), lysozymes (3,5%), ovoglobulins (2,0%), and ovomucin (1,5%-3%). Ovalbumin has been known to have various biological activities such as antioxidant, anticancer, antihypertensive, antimicrobial and immune modulation (Sharif et al., 2018). Lysozyme exhibits potent antimicrobial activity against bacterial, fungal and viral pathogens serving in addition to strengthening the immune system, protecting against infections and acting as a natural antibiotic. (Nawaz et al., 2022). Ovotransferrin occurs to be a multi-functional protein with iron binding, iron delivery, antiviral, bactericidal, bacteriostatic and immunomodulating properties (Juul-Madsen et al., 2014)

The insignificance of the increase in blood serum serotonin levels after 3 hours of giving banana drinks could possibly be caused by the following things. As stated by Palego et al (2016), serotonin synthesis is influenced not only by the amount of TRP in food and the concentration of TRP in plasma but also its absorption into tissues and the brain, as well as the role of the gut microbiome as a link between nutrition, intestinal absorption, TRP goals, and a person's health (Hartoto et al., 2024). Richard et al. (2009) revealed that Positron Emission Tomography (PET) scans of the human brain showed significant changes in serotonin synthesis occurring 5 hours after amino acid consumption, depending on the size of the drink (e.g. 50 g or 100 g) and the plasma dose used (e.g. total tryptophan or free tryptophan which competes with amino acids). The synthesis of serotonin (5-hydroxytryptamine [5-HT]) depends on the supply of the essential amino acid, L-tryptophan (TRP), which cannot be biosynthesized by humans and must be obtained from food sources (Gibson, 2018). TRP is a substrate for serotonin (5-hydroxytryptpamine, 5-HT) synthesis in the brain and intestines. The essential amino acid TRP is a precursor of the monoaminergic neurotransmitter serotonin (5-hydroxytryptamine, 5-HT) (Höglund et al., 2019). Insulin and large neutral amino acids such as , Valine (Val), Leucine (Leu), Isoleucine (Ileu), Tyrosine (Tyr), and Phenylalanine (Phe), play a major role in the mechanism of TRP absorption. LNAAs compete with each other for the same transporter system in crossing the brain blood barrier (BBB), under the control of insulin. This explains why protein-rich foods increase plasma TRP levels but are not absorbed into the brain. Dietary composition and low protein foods all contribute to the absorption of TRP across the BBB supporting 5-HT synthesis. Protein-rich foods actually contain TRP, but at lower levels than other LNAAs, which overall induces more inhibition of TRP uptake in the brain. Thus, a

protein-rich diet increases the availability of amino acids and TRP, but the presence of LNAA competition for transport to the brain reduces TRP entering the brain compared with the amount that crosses the BBB after a low-protein diet (Palego et al., 2016). Increasing the ratio of plasma TRP over LNAA (i.e. TRP: LNAA) does more than just increase TRP levels alone but will also facilitate the entry of TRP into the brain. Increasing in TRP: LNAA between 40% and 150% above baseline indicate changes in cognition such as memory, mood, attention, and cognitive benefits (Mitchell et al., 2011).

The limitation of this study was small sample size so it cannot generalizes the findings. However, our study showed that banana drink could decrease negative mood responses in female athletes. Further investigations at the molecular and cellular levels need to be carried out to explore the mechanism of TRP in bananas with the addition of albumin on serotonin levels and PMS symptoms in female athletes suffering from PMS/PMDD by paying attention to the concentration of TRP entering the body, the period of serotonin synthesis, the health of digestive function and the role of the gut microbiome in producing serotonin. More analysis of the antioxidant properties of banana as a beneficial nutritional supplement in premenstrual psychosomatic and behavioural symptoms is necessary to guide further.

Conclusion

The results obtained in this study show that giving banana drinks can reduce negative mood responses such as depression, anger, fatigue, confusion and minimize the severity of PMDD including anxiety, difficulty concentrating, fatigue/lack of energy, decreased interest in social activity, insomnia, physical symptoms and home responsibility. However, it has not been able to increase serotonin levels in women suffering from PMDD.

Acknowledgements

We would like to thank the support from the Faculty of Sport and Health Sciences, Universitas Negeri Surabaya in this project. The author also thanks profusely to all those who have helped in the completion of this project.

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