



Potential of *Physalis angulata* fruit extract in improving nutritional status in protein-energy malnutrition: An experimental animal study

Potensi ekstrak buah Ciplukan (*Physalis angulata*) dalam meningkatkan status gizi pada malnutrisi energi protein: Studi eksperimental pada hewan coba

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Abstract

Malnutrition remains a major concern in Indonesia, with Aceh Province ranking among the top five provinces for stunting prevalence in 2022 (31.2%). *Physalis angulata*, known for its antioxidant and nutritional content, has not been extensively studied for its role in improving protein-energy malnutrition (PEM). This study aimed to assess the nutritional effects of a *Physalis angulata* fruit extract on PEM. A quantitative research method with a true experimental post-test only control group design was used on 25 Wistar strain aged 5-6 weeks with a weight of 100-150 g. PEM was induced through a low-protein diet for 56 days, followed by intervention with *Physalis angulata* extract at 250, 500, and 1000 mg/kgBW for 30 days. The study was performed at the Physiology Laboratory, Faculty of Medicine, Brawijaya University, from May 25 to October 1, 2024. The results showed no significant effect on body length ($p = 0.087$) but a significant increase in body weight ($p = 0.000$). In conclusion, the extract can improve weight gain in PEM, although it does not promote linear growth. Further research with varied doses, longer interventions, and time-series measurements is recommended.

Keywords: *Physalis Angulata*, Protein-energy malnutrition, Experimental rats, Body growth, Nutritional intervention.

Abstrak

Masalah kurang gizi merupakan permasalahan gizi yang menjadi perhatian utama di Indonesia. Propinsi Aceh pada 2022 menempati 5 besar jumlah propinsi dengan angka stunting terbanyak yaitu 31.2%. Salah satu tanaman yang digunakan secara empiris sebagai sumber nutrisi adalah Ciplukan. Ciplukan mengandung antioksidan dan sumber nutrisi dan belum banyak diteliti secara ilmiah dalam meningkatkan status gizi pada kurang energi protein (KEP). Penelitian dilakukan untuk mengetahui efek nutrisi buah ciplukan pada KEP. Metode penelitian kuantitatif dengan rancangan *true experimental posttest only control group design* pada ratus norvegicus strain Wistar 5-6 minggu dengan berat 100-150 g sebanyak 25 ekor. Pembuatan tikus KEP dilakukan dengan diet rendah protein diberikan selama 56 hari dan dilanjutkan dengan intervensi ekstrak ciplukan 250mg, 500mg, dan 1000mg perkg.BB selama 30 hari. Penelitian dilakukan di laboratorium Fisiologi FKUB dari tanggal 25 Mei s/d 1 Oktober 2024. Tidak ada pengaruh ekstrak ciplukan terhadap panjang badan ($p= 0,087$) dan ada pengaruh yang signifikan terhadap berat badan ($p= 0,000$). Kesimpulan, ekstrak ciplukan mampu meningkatkan berat badan, namun hasil berbeda ditunjukkan terhadap panjang badan. Hasil ini merekomendasikan bahwa ciplukan dapat dijadikan sebagai sumber nutrisi pada KEP. Perlu penelitian lanjutan dengan lama intervensi dan dosis yang berbeda serta dilakukan dengan pengukuran *time series* secara berkala.

Kata Kunci: *Physialis Angulata*, Kurang energi protein, Eksperimen pada tikus, Pertumbuhan, Intervensi nutrisi

Introduction

The trends in stunting are indicative of broader global health dynamics and are influenced by an interplay of multiple determinants, including maternal health, nutritional practices, sanitation, and socio-economic factors (Soliman et al., 2024). Although child stunting has been declining in recent years, 148.1 million children worldwide are stunted (UNICEF, 2023). *Stunting is a disorder of growth and development in children due to chronic malnutrition and recurrent infections.* Ministry of Health data for 2014 was 37%, but in 2022, it dropped to 21.6%. Although this figure has decreased, 21.6% is high compared to other countries. President Jokowi has targeted 14% by 2024. In 2022, Aceh Province ranked among the top five provinces with the highest prevalence of stunting at 31.2%, following East Nusa Tenggara (35.3%), West Sulawesi (35.0%), Papua (34.6%), and West Nusa Tenggara (32.7%). Based on the 2021 stunting data, Langsa City reported a stunting prevalence of 25.5% (Annur, 2023; Kemenkes RI, 2023).

The short-term impacts of stunting include impaired physical growth and delayed cognitive development (Aurora et al., 2021). In the long term, stunting predisposes individuals to a higher risk of chronic conditions, including diabetes mellitus, obesity, cardiovascular diseases, cancer, stroke, and age-related disabilities (Agushyvana et al., 2022), and is closely related to the overall quality of a nation's human capital (Beal et al., 2018; The Ministry of Finance of the Republic of Indonesia, 2022). Addressing childhood stunting necessitates a global commitment to integrated, evidence-based strategies focusing on nutritional, health, and socioeconomic determinants to ensure the well-being and growth of children worldwide (Schneider, 2025; Soliman et al., 2024).

Children affected by stunting are more likely to exhibit lower intelligence quotient (IQ) scores, increased daytime sleepiness, and diminished engagement in learning activities (Aurora et al., 2021). Early childhood represents a critical "golden age" for growth and development, during which children acquire information from their environment that profoundly influences their future cognitive and behavioral patterns. Accordingly, adequate nutritional intake and appropriate developmental stimulation are essential during this stage (Mediani, 2020; Yadika et al., 2019).

The occurrence of stunting is determined by factors such as low birth weight, inadequate consumption of energy and protein, and low socioeconomic status of the household. A significant association has been observed between reduced height-for-age and insufficient dietary intake (Ariani, 2020; Komalasari et al., 2020). Proteins are essential for growth and tissue repair and serve as an energy source (Azmy & Mundiastuti, 2018). It plays a fundamental role in building and maintaining body cells and tissues. Protein deficiency can impair the growth of tissues and organs, body weight and height, and head circumference (Dewi & Adhi, 2014).

The findings of a 2017 study identified the main causes of stunting as low energy intake (93.5%), infectious diseases (80.6%), male sex (64.5%), low maternal education (48.4%), low protein intake (45.2%), absence of exclusive breastfeeding (32.3%), low paternal education (32.3%), and maternal employment (29%) (Mugianti et al., 2018). In Aceh Province, the primary determinants of stunting are the low rate of exclusive breastfeeding among toddlers and the high unemployment rate, which hinders the fulfillment of nutritional needs (Ramadhan & Ramadhan, 2018).

One of the national strategies for accelerating stunting reduction, as stated in Presidential Regulation No. 72 of 2021, is to ensure adequate nutritional fulfillment (Presidential Regulation of the Republic of Indonesia No. 72 of 2021 on the Acceleration of Stunting Reduction, 2021). The interventions implemented for stunting management, once a diagnosis has been established, include initiating early therapy through the provision of nutritious and balanced meals, supplementation with vitamin A, zinc, iron, calcium, and iodine, and family education (The Ministry of Finance of the Republic of Indonesia, 2022).

Several plants have been empirically used to promote height growth, including processed Moringa leaves (Kurniawati & Komalyna, 2021; Muliawati et al., 2019; Muliawati & Sulistyawati, 2019), *Centella asiatica* (Zahara et al., 2018), *Physalis angulata*, and *Morus Alba*. However, the effects of *Physalis angulata* and *Morus Alba* have not yet been scientifically proven.

Physalis angulata is a medicinal plant that is relatively unknown to the public and contains vitamins A, B, C, β -carotene, phosphorus, and iron

(Pujiasmanto et al., 2022). Other constituents include fiber (4.8%), protein (0.3%), phosphorus (55%), alkaloids, anthocyanins, betacyanins, cardioglycosides, coumarins, flavonoids, steroidal glycosides, terpenoids, tannins, phenolics, and saponins (Helmi et al., 2021; Pujiasmanto et al., 2022).

This study was conducted to determine the potential of *Physalis angulata* in stunting prevention. Composition of *Physalis angulata* improves physical growth in a protein-energy malnutrition model. This study is important because *Physalis angulata* is a family medicinal plant that is easily obtainable and is local wisdom, and its benefits need to be known as a source of nutrition in cases of protein energy deficiency.

Methods

The true experimental design used a post-test-only control group design approach, where observations were made after treatment with *Physalis angulata* fruit extract. The stages of this research consisted of creating a PEM rat model and intervention of 250 mg, 500 mg, and 1000 mg of *Physalis angulata* fruit per kg of body weight. This study was conducted in the Physiology Laboratory of the Faculty of Medicine, Universitas Brawijaya. The study was conducted in the Physiology Laboratory of the Faculty of Medicine, Brawijaya University, from May 25 to October 1, 2024.

This study employed a true experimental design with a *post-test-only control group* approach, in which observations were conducted following the administration of *Physalis angulata* fruit extract. The research stages included the development of a protein-energy malnutrition rat model and the administration of *Physalis angulata* fruit extract at doses of 250, 500, and 1,000 mg/kg body weight (Astuti et al., 2020; Parisa, 2019).

A total of 30 male Wistar rats aged 5–6 weeks and weighing 100–150 g were used. During the adaptation period, the rats were fed diets according to their respective groups. A low-protein diet was administered for 56 days (until a 20% reduction in body weight from the baseline was achieved). Initial body weights were recorded, and the rats were housed individually under a 12-hour light cycle. Once malnutrition was induced, cape gooseberry extract was administered to the intervention groups for 30

days (Astuti et al., 2020; Luthfiah & Widjajanto, 2013; National Research Council, 1995).

All statistical analyses were performed using IBM SPSS Statistics. Data normality was assessed using the Shapiro–Wilk test, which indicated that body length and body weight were normally distributed ($p > 0.05$). Differences among the five experimental groups were analyzed using one-way analysis of variance (ANOVA) with a significance level set at $\alpha = 0.05$. When statistically significant differences were identified, post hoc multiple comparisons were conducted using the Least Significant Difference (LSD) test to determine pairwise group differences. Data are presented as mean \pm standard deviation (SD).

The experimental animals were divided into five groups: negative/normal control (healthy control rats fed a standard diet), positive control (PEM rats without cape gooseberry extract), PEM rats receiving cape gooseberry extract at a dose of 250 mg/kg body weight, PEM rats receiving 500 mg/kg body weight, and PEM rats receiving 1,000 mg/kg BW. Ethical approval for this study was granted by the Health Research Ethics Committee (KEPK) of the Health Polytechnic, Ministry of Health, Aceh, under reference number DP.04.03/12.7/080/2024.

Result and Discussion

The following are the results of the examination of the research parameters/variables in this study. Data for the body length and body weight variables were normally distributed based on the Shapiro–Wilk test with a p-value > 0.05 . Based on the results of the one-way ANOVA on body length data, no significant differences were observed in the mean body length among the five experimental groups, as indicated by a p-value of $0.087 > \alpha$. Furthermore, the results of the multiple comparison analysis using the Least Significant Difference (LSD) test were obtained and are presented in detail in the table below:

Table 1. Comparison of mean body length in experimental animals

Observation group	Mean \pm stand. dev (cm)	p-value
Negative control	22,32 \pm 0,81 ^a	
Positive control (PEM)	20,17 \pm 3,77 ^a	0,087 $> \alpha$

PEM and Physialis Angulata extract 250 mg/Kg.BW	24,07±2,10 ^{ab}
PEM and Physialis Angulata extract 500 mg/Kg.BW	19,16±5,09 ^a
PEM and Physialis Angulata extract 1.000 mg/Kg.BW	21,33±1,46 ^a

Description : The mean±sd, if it contains different letters, it means there is a significant difference (p -value<0.05) and if it contains the same letters, it means there is no significant difference (p -value>0.05)

The table above presents the results of the LSD test, indicating no significant difference in mean body length between the group (22.32 ± 0.81^a) and the positive control or PEM model groups (20.17 ± 3.77^a). Based on the mean values, the mean body length in the positive control group was lower than that in the negative control group; however, this difference was not significant.

The table above also shows a significant difference in mean body length between the positive control group (20.17 ± 3.77^a) and the treatment group of PEM model rats receiving cape gooseberry extract at a dose of 250 mg/kg body weight (24.07 ± 2.10^{ab}). The mean body length in the 250 mg/kg body weight treatment group was higher than that in the positive control (PEM) group, indicating a statistically significant increase in body length after cape gooseberry extract administration. However, a different outcome was observed with the administration of 500 mg/kg body weight cape gooseberry extract (19.16 ± 5.09^a), which showed a decrease in body length compared to both the 250 mg/kg body weight treatment group and the positive control group. Subsequently, body length increased again in the group receiving 1,000 mg/kg body weight cape gooseberry extract (21.33 ± 1.46^a).

Furthermore, there was no significant difference in mean body length between the PEM treatment group receiving cape gooseberry extract at a dose of 500 mg/kg body weight (19.16 ± 5.09^a) and the PEM treatment group receiving 1,000 mg/kg body weight (21.33 ± 1.46^a). Although the mean body length in the 500 mg/kg body weight group was lower than that in the 1,000 mg/kg group, both doses demonstrated a similar capacity to increase body length.

Based on the above findings, it can be concluded that the administration of cape

gooseberry extract had no statistically significant effect on rat body length. Furthermore, post-hoc analysis revealed an increase in body length in the group receiving 250 mg/kg body weight of cape gooseberry extract, and this dose was considered the most effective in increasing the body length of rats in the PEM model.

The results of this study indicated a mean difference between the negative and positive control groups. Furthermore, differences in the mean values were observed between the positive control and treatment groups 1, 2, and 3. However, the statistical analysis revealed that these differences were not significant. The difference in mean body length between the PEM-model rats and those administered cape gooseberry extract is presumably attributable to the bioactive constituents within the extract. Cape gooseberry extract contains vitamin C, which functions as an antioxidant and enhances the body's absorption of calcium (Hapzah & Supriandi, 2018; Hidayah, 2023).

Stunting is a nutritional problem in which affected individuals are more susceptible to infections, which can also be a contributing cause of stunting. Infections may present with symptoms or be asymptomatic. This condition increases the risk of contracting diseases that can lead to morbidity and mortality from infectious illnesses. Infections result in nutrient loss, reduced absorption, and increased energy requirements, ultimately leading to malnutrition (Mulyani et al., 2022; Gizaw et al., 2022). Numerous studies have examined the relationship between infection and the development of stunting. One such study in Zimbabwe reported that individuals with stunting experienced intestinal parasitic infections, impaired growth, underweight, and wasting. The most common intestinal parasitic species identified were *Ascaris lumbricoides* and *Giardia lamblia* (Yoseph & Beyene, 2020).

Physalis angulata has anti-inflammatory properties (Novitasari et al., 2024). It reduces oxidative stress and accelerates wound healing in 3T3-L1 cells while inhibiting the expression of HIF-1 α and IL-6 in TGF- β -induced fibrotic cell models. These activities suppress fibrotic cell migration, which may benefit skin repair in patients through their antioxidant and anti-inflammatory effects (Wiraswati et al., 2024).

The potential anti-inflammatory bioactive compounds in cape gooseberries include

phytosterols and non-steroidal compounds. The phytosterols present are physalins and withanolides, while the non-steroidal bioactive compounds include quercetin, ursolic acid, lupeol, and emodin. The anti-inflammatory mechanism operates by inhibiting the activation of macrophages, nuclear factor-kappa B (NF- κ B), myeloperoxidase, cyclooxygenase, inducible nitric oxide synthase, pro-inflammatory cytokines, monocyte chemoattractant protein-1, and anti-inflammatory cytokines (Timotius et al., 2021).

Table 2. Comparison of mean body weight in rats

Observation group	Mean \pm stand. dev (cm)	<i>p</i> -value
Observation group	187,53 \pm 6,83 ^a	
Negative control	81,06 \pm 14,56 ^b	
Positive control (PEM)	188,78 \pm 16,48 ^a	
PEM and Physalis Angulata extract 250 mg/Kg.BW	174,33 \pm 16,09 ^a	0,000 $<$ α
PEM and Physalis Angulata extract 500 mg/Kg.BW	181,56 \pm 10,06 ^a	

Description : The mean \pm sd, if it contains different letters, it means there is a significant difference (*p*-value $<$ 0.05) and if it contains the same letters, it means there is no significant difference (*p*-value $>$ 0.05)

The results of the body weight parameter analysis in rats showed a mean decrease in body weight in the positive control group or the PEM model group (81.06 \pm 14.56) compared with the normal/negative control group (187.53 \pm 6.83). Subsequently, an increase in body weight was observed in PEM rats receiving cape gooseberry extract at doses of 250 mg/kg body weight (188.78 \pm 16.48), in the group receiving 500 mg/kg body weight (174.33 \pm 16.09), and in the group receiving 1,000 mg/kg body weight (181.56 \pm 10.06). One-way ANOVA demonstrated a statistically significant effect among groups on body weight gain, with a significance value of 0.000. Body weight loss was observed in the PEM model rats; however, administration of cape gooseberry extract at a dose of 250 mg/kg body weight resulted in the fastest weight gain. Increases in body weight were also observed at doses of 500 mg/kg and 1,000 mg/kg, although the 250 mg/kg dose was the most effective in promoting weight gain in PEM model rats.

The results of this study indicate a significant effect of cape gooseberry extract administration on weight gain in rats, with the most effective dose being 250 mg/kg body weight.

There was a decrease in the weight of PEM model rats after being administered a dose of 250 mg/kg. BW of *Physalis angulata* extract intervention group. However, the dose used was 500 mg/kg. BW and 1,000 mg/Kg. BW of *Physalis angulata* extract, there was also an increase in body weight. The fastest dose for increasing body weight in the PEM model rats after administration of *Physalis angulata* extract was 250 mg/Kg. BW. The results of this study indicated a significant effect of administering *Physalis angulata* extract on weight gain in rats, but the most effective dose was 250 mg/Kg. BW.

Weight gain results from multiple interrelated internal and external factors. Nutrients within the body function synergistically and are interconnected with an increase in the height and body weight of an individual. Research findings indicate that the *Physalis angulata* extract exhibits high antioxidant activity. The ripe fruit of *Physalis angulata* contains high levels of phenolic acids, which are a valuable source of nutrition (de Oliveira et al., 2020). The antioxidants in *Physalis angulata* are responsible for its antioxidant activity, which protects the body against oxidative stress, known to contribute to the development of several chronic diseases (Nguyen et al., 2021).

Physalis angulata fruits contain lipids, proteins, carbohydrates, and high levels of vitamin C (Iwansyah et al., 2020). One of the functions of lipids is to serve as an energy source. Weight gain in adolescents is accompanied by an increase in blood lipid profiles within this age group (Nurhidayati et al., 2022). Protein is also a commonly used intervention for stunted children. Studies have shown that a 90-day intervention with high-protein milk can significantly increase energy and protein intake, as well as body weight and nutritional status (BMI-for-age) in undernourished adolescents aged 14–17 years (Fauziah et al., 2022). Research findings in cattle fed a low-protein diet showed a decrease in energy absorption, ultimately resulting in weight loss (Liu et al., 2021).

One of the causes of inadequate weight gain is insufficient nutritional intake, including protein, carbohydrate, fat, vitamin, and mineral

intake. This condition can lead to underweight and malnutrition. Malnutrition increases the susceptibility to infection in children with stunting (Al Rahmad, 2023; Rusliani et al., 2022). The results indicate that *Physalis angulata* fruit extract contains potential bioactive compounds, such as flavonoids, alkaloids, tannins, and polyphenols. From this perspective, the extract acts as an antimicrobial agent capable of combating pathogens that are resistant to common antibiotics (Hananto et al., 2021).

Physalis angulata fruit contains carbohydrates as a dietary component that serves as the primary energy source for the body. Upon consumption, carbohydrates are broken down into glucose, which is the main energy source for cells, tissues, and organs. Carbohydrates and body weight are closely related; while excessive carbohydrate intake can lead to weight gain, adequate and balanced consumption is essential for maintaining overall health and can support weight reduction when consumed appropriately (Rarastiti, 2023; Wan et al., 2023).

This study had a limitation in terms of anthropometric measurements. The height and weight of the rats should have been measured daily throughout the intervention period to capture more detailed and accurate information on the growth patterns of the participants. However, in this study, measurements were only taken at specific intervals, which may not fully reflect daily fluctuations and incremental growth changes.

Conclusion

Physalis angulata fruit extract increased the body weight of experimental animals; however, a different outcome was observed for body length. These findings suggest that *Physalis angulata* fruit may serve as a nutritional source in cases of protein-energy malnutrition. Further studies are warranted with varying intervention durations and doses of *Physalis angulata* fruit extract, as well as periodic growth measurements using a time-series approach.

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