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# Effect of Red Watermelon Juice on Upper-Body Musculoskeletal Pain and Work-Related Fatigue Among Food Handlers in Jambi City: A Quasi-Experimental Study

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***Abstract***
***Introduction:*** *Food handlers are at risk of work-related fatigue and upper-body pain due to repetitive physical activities and prolonged standing. L-citrulline in red watermelon (Citrullus lanatus) may improve blood flow through nitric oxide (NO)-mediated vasodilation.* ***Objective:*** *This study aimed to analyze the effect of L-citrulline administration through red watermelon juice on upper-body pain and work-related fatigue among food handlers.* ***Method:*** *This quasi-experimental study used a non-randomized control group pretest-posttest design involving 100 food handlers, divided into experimental and control groups (50 participants each). The experimental group received 250 mL of red watermelon juice prepared from 400 g of watermelon flesh, without additional ingredients, once daily for five days, one hour before work. Upper-body pain was measured using the Visual Analogue Scale (VAS), while fatigue was assessed using reaction time. Confounding variables were also analyzed for homogeneity.* ***Results and Discussion:*** *The experimental group showed a significant reduction in upper-body pain, with mean VAS scores decreasing from 6.58 to 3.27 ($p = 0.000$), and an improvement in reaction time from 489.64 ms to 407.21 ms ($p = 0.000$). No significant improvement was observed in the control group. Confounding variables were homogeneous ($p > 0.05$) and were not significantly associated with changes in pain or fatigue. These findings suggest that L-citrulline-rich watermelon juice may improve circulation through NO-mediated vasodilation.* ***Conclusion:*** *Red watermelon juice supplementation was effective in reducing upper-body pain and work-related fatigue among food handlers.*

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## Introduction

Physical activity requires muscular endurance; however, prolonged and excessive workloads can lead to occupational fatigue. Food handlers in Nutritional Support Service Units (SPPG) face substantial physical demands that may affect productivity, occupational health, and food safety (Tarwaka, 2022). Fatigue occurs when prolonged muscle activity disrupts energy metabolism, reduces muscular performance, and contributes to musculoskeletal discomfort (Tarwaka, 2022); (Hall, J. E., & Hall, 2021).

According to the Decree of the Head of the National Nutrition Agency Number 401.1 of 2025, SPPG operations require food preparation and cooking to begin at midnight to ensure timely distribution under the Free Nutritious Meal (MBG) Program. These activities involve several ergonomic risk factors, including repetitive movements during chopping and packaging, awkward postures while preparing ingredients, static muscle loading during prolonged standing, and manual handling of heavy cooking equipment and food containers. Such exposures may increase musculoskeletal strain, particularly in the shoulders, arms, neck, and lower back (Badan Gizi Nasional, 2025). Preliminary observations in the Putri Ayu Community Health Center service area identified two SPPG units employing approximately 100 food handlers, who perform repetitive tasks for eight hours per shift (Badan Gizi Nasional, 2025).

Occupational fatigue among food handlers may be aggravated by prolonged working hours, inadequate nutritional intake, and continuous exposure to ergonomic stressors (Farihatin, 2022). Preliminary interviews revealed complaints of lethargy, drowsiness, reduced work capacity, and musculoskeletal pain, particularly in the upper body. These symptoms may be associated with repetitive muscle contractions, sustained postures, and insufficient recovery periods. Some workers reported consuming energy drinks to maintain stamina, although excessive consumption may pose health risks related to high caffeine intake (Herawanto, 2022).

Citrulline is a non-essential amino acid that supports nitric oxide production, promoting vasodilation and potentially improving muscle blood flow during physical activity (Setiowati, 2023). Red watermelon (Citrullus lanatus) is a natural source of L-citrulline, containing approximately 1.1–4.7 mg/g of fresh weight. Its high-water content, potassium, carbohydrates, and antioxidant compounds may support hydration, muscle metabolism, and post-exertion recovery. Therefore, administering 250 mL of fresh watermelon juice prepared from approximately 400 g of watermelon flesh may represent a practical nutritional intervention for workers experiencing physical fatigue and muscle discomfort.

Previous research suggests that citrulline-rich watermelon consumption may reduce muscle soreness and support recovery following strenuous physical activity (Souza, 2022). However, evidence regarding its effectiveness among food handlers exposed to repetitive movements, awkward postures, static loading, and manual material handling remains limited. Furthermore, nutritional interventions may support physical recovery but do not eliminate the underlying ergonomic hazards. Therefore, this study aimed to examine differences in upper-body pain and occupational fatigue following citrulline administration among food handlers at SPPG units within the Putri Ayu Community Health Center service area in 2026.

## Method

This study employed a quasi-experimental design with a non-equivalent control group pretest-posttest structure. The study was conducted in August 2026 at the Nutrition Fulfillment Service Units (SPPG) within the service area of the Putri Ayu Community Health Center, Jambi City. The study population comprised 100 food handlers from two SPPGs. Total sampling was applied, with 50 participants assigned to the experimental group and 50 to the control group, proportionally distributed across both SPPGs. Individuals who were absent, experienced health problems, consumed energy drinks or medications during the study, or declined participation were excluded.

The experimental group received 250 mL of fresh red watermelon juice prepared from 400 g of watermelon flesh without added sugar or water. The intervention was administered under researcher supervision for five consecutive days, one hour before work. Meanwhile, the control group continued their usual work activities without receiving watermelon juice. Measurements were conducted before and after the intervention. Upper-body pain involving the arms, shoulders, and upper back was assessed using the Visual Analog Scale (VAS), ranging from 0 to 10. Occupational fatigue was measured using a smartphone-based reaction time test performed five times, with the average reaction time recorded in milliseconds. Participant characteristics, including age, nutritional status, exercise habits, smoking habits, and sleep duration, were collected through interviews and anthropometric measurements.

Data analysis included the Kolmogorov-Smirnov normality test and a homogeneity test. Within-group differences between pretest and posttest measurements were analyzed using the paired t-test or Wilcoxon test, depending on data distribution. Between-group differences in changes were assessed using the independent t-test or Mann-Whitney test. Statistical significance was established at $p < 0.05$

## Result and Discussion

### The Influence of Respondent Characteristics on Upper Body Pain and Fatigue

This study involved 100 food handlers divided into an experimental group and a control group, with 50 respondents in each. The respondent characteristics observed included age, nutritional status, exercise habits, smoking habits, and sleep duration. These variables were considered because they are potential factors influencing upper body pain and work-related fatigue.

**Table 1**
Respondent Characteristics and Comparability

| Variable | Control (n=50) | Experimental (n=50) | p-value |
|---|---|---|---|
| **Age** | 36.38 ± 8.62 | 36.06 ± 8.65 | 0.695 |
| **Nutritional Status** | 25.22 ± 4.56 | 25.31 ± 4.66 | 0.928 |
| **Exercise Habits** | | | 0.670 |
| **Smoking Habits** | | | 0.464 |
| **Sleep Duration** | | | 0.713 |
| **Pain before intervention** | 6.12 ± 1.31 | 6.58 ± 1.14 | 0.086 |
| **Fatigue before intervention** | 482.36 ± 61.84 | 489.64 ± 54.74 | 0.551 |

The study results indicate that the majority of respondents were aged ≥30 years (73%), had abnormal nutritional status (61%), did not exercise regularly (68%), were non-smokers (79%), and had insufficient sleep duration (58%). Based on equivalence test

results, there were no significant differences between the control and experimental groups regarding age (p=0.695), nutritional status (p=0.928), exercise habits (p=0.670), smoking habits (p=0.464), and sleep duration (p=0.713). Baseline levels of pain and fatigue also did not differ significantly between the two groups (p=0.086 and p=0.551, respectively). These findings demonstrate that the two groups possessed relatively comparable baseline characteristics prior to the intervention. Baseline equivalence is crucial because the study employed a quasi-experimental non-equivalent control group design; therefore, post-intervention changes needed to be assessed while accounting for the potential influence of respondent characteristics.

**Table 2**
Relationship between Respondent Characteristics and Pain and Fatigue

| Characteristic | Pain (P-Value) | Fatigue (P-Value) |
|---|---|---|
| **Age** | 0.063 | 0.058 |
| **Nutritional Status** | 0.544 | 0.556 |
| **Exercise Habits** | 0.709 | 0.167 |
| **Smoking Habits** | 0.695 | 0.183 |
| **Sleep Duration** | 0.286 | 0.400 |

The analysis results indicate that age, nutritional status, exercise habits, smoking habits, and sleep duration showed no significant association with pain or fatigue, as all p-values exceeded 0.05. Consequently, these variables did not demonstrate a statistically significant influence on changes in pain and work-related fatigue within this study.The absence of a significant association may be attributed to the relatively uniform job characteristics of the respondents. All respondents worked as food handlers, performing tasks that involved prolonged standing, chopping ingredients, processing food in large quantities, portioning, lifting or moving equipment, and repetitive washing of utensils. This shared occupational exposure suggests that the physical workload may be a more dominant factor than individual characteristics. Nevertheless, these findings do not imply that age, nutritional status, physical activity, smoking, and sleep are unrelated to fatigue or musculoskeletal complaints in general. The results merely indicate that, within this specific population and study context, such associations were not statistically proven. Therefore, respondent characteristics should still be taken into account in intervention studies concerning pain and work-related fatigue.

## The Effect of L-Citrulline (Red Watermelon Juice) Administration on Upper Body Pain

**Table 3**
Changes in Upper Body Pain Before and After the Intervention

| Group | n | Pre-Test | Post-Test | Difference | P-Value |
|---|---|---|---|---|---|
| **Control** | 50 | 6.12 ± 1.31 | 6.32 ± 1.27 | +0.20 | 0.000 |
| **Experimental** | 50 | 6.58 ± 1.14 | 3.27 ± 1.42 | -3.31 | 0.000 |

Based on Table 3, the mean upper-body pain score in the experimental group decreased from 6.58 before the intervention to 3.27 after the administration of red watermelon juice for five days a reduction of 3.31 points. In contrast, the control group experienced an increase in pain scores from 6.12 to 6.32, an increase of 0.20 points. Wilcoxon test results indicated a significant difference between pre- and post-intervention scores in the experimental group (p=0.000). The Mann-Whitney test on post-intervention scores also revealed a significant difference between the experimental and control groups

(p=0.000). The mean rank for pain scores in the experimental group was 27.91, which was lower than that of the control group (73.09). These results demonstrate that the group receiving red watermelon juice experienced lower levels of pain after the intervention compared to the control group.

These findings align with the study by (Nandyantami et al., 2024) which compared the effects of watermelon juice and pure L-citrulline on delayed-onset muscle soreness (DOMS). That study showed that both watermelon juice and L-citrulline significantly reduced DOMS at 12 and 24 hours post-exercise. Although the previous study involved individuals performing physical exercise while the current study involved food handlers, both studies show a similar pattern: the consumption of watermelon which contains L-citrulline has the potential to help alleviate muscle pain complaints following physical activity. Physiologically, L-citrulline is a precursor to L-arginine, which subsequently plays a role in the formation of nitric oxide (NO). Increased L-arginine availability can support NO production, which is involved in regulating vascular function and vasodilation. A meta-analysis by (Smeets et al., 2022) demonstrated that L-citrulline supplementation or watermelon consumption is associated with increased L-arginine availability and NO synthesis, and may influence vascular function. (PubMed) This mechanism may be linked to the work activities of food handlers, which heavily involve the muscles of the shoulders, arms, and upper back. Repetitive tasks such as chopping, stirring, lifting equipment, portioning food, and washing utensils can place a physical load on these muscle groups. Enhanced tissue perfusion, supported by the L-citrulline–L-arginine–NO pathway, could theoretically help supply oxygen and metabolic substrates to active tissues, thereby supporting muscle recovery.

However, research findings regarding L-citrulline are not always consistent. A meta-analysis by González et al. (2022) showed that the effects of citrulline supplementation on various aerobic performance parameters remain variable. Similarly, a study by Schierbauer et al. (2025) involving 10 days of L-citrulline supplementation found no significant improvement in time to exhaustion compared to a placebo. (MDPI) These differing results may stem from variations in dosage, duration of administration, type of intervention, participant characteristics, and the nature of the physical activity. The present study involved the administration of 250 mL of red watermelon juice over five days to workers engaged in daily occupational activities. Therefore, the findings are best interpreted as evidence that consuming red watermelon juice has the potential to help reduce upper-body pain among food handlers, rather than as proof that L-citrulline alone is the sole cause of this pain reduction. In addition to L-citrulline, watermelon juice contains water and other nutritional components that may contribute to hydration status and physical recovery. A recent 2026 integrative review indicates that watermelon is a primary source of L-citrulline and has the potential to influence performance and muscle recovery, although evidence regarding the overall food matrix effect is still evolving. (Journal of Sports) Thus, the 3.31-point reduction in pain in the experimental group and the 0.20-point increase in the control group demonstrate that a five-day regimen of red watermelon juice resulted in a more favorable outcome regarding upper-body pain compared to the group that received no intervention.

An important consideration in interpreting these findings is the potential placebo effect associated with the intervention. Because the control group did not receive a placebo beverage and participants were aware of their treatment allocation, expectations regarding the benefits of watermelon juice may have influenced self-reported pain scores. The Visual Analog Scale (VAS) measures subjective pain perception, which can be

affected by psychological expectations, motivation, and individual differences in pain tolerance. Therefore, the observed reduction in upper-body pain cannot be attributed exclusively to the physiological effects of L-citrulline. Additionally, differences in daily physical workload, ergonomic exposure, and recovery time may have contributed to changes in pain intensity. Although the experimental group demonstrated a substantial reduction in pain compared with the control group, the absence of placebo control and participant blinding limits causal interpretation. Future studies should incorporate placebo-controlled designs, standardized workload assessments, and blinded outcome evaluation to better distinguish physiological effects from expectation-related responses.

**The Effect of L-Citrulline Administration (Red Watermelon Juice) on Work-Related Fatigue**

**Table 4**
Changes in Work Fatigue Before and After the Intervention

| Group | n | Pre-Test | Post-Test | Difference | P-Value |
|---|---|---|---|---|---|
| Control | 50 | 482.36 ± 61.84 | 490.91 ± 64.24 | + 8.55 | 0.001 |
| Experimental | 50 | 489.64 ± 54.74 | 407.21 ± 59.06 | -82.43 | 0.000 |

*Note: Wilcoxon test. The Mann-Whitney test on post-test scores between groups yielded a p-value of 0.000.

Fatigue measurements using the reaction time test revealed differing changes between the two groups. In the experimental group, the mean reaction time decreased from 489.64 ms pre-intervention to 407.21 ms post-intervention, representing a reduction of 82.43 ms. Conversely, the control group experienced an increase in reaction time from 482.36 ms to 490.91 ms, an increase of 8.55 ms. The Wilcoxon test indicated a significant change in the experimental group (p=0.000). A significant change was also observed in the control group (p=0.001), but the direction differed, manifesting as an increase in reaction time. Furthermore, the Mann-Whitney test showed a significant difference in post-intervention measurements between the experimental and control groups (p=0.000), with a mean rank of 34.45 for the experimental group and 66.55 for the control group.

The reduction in reaction time within the experimental group indicates improved responsiveness following the consumption of red watermelon juice. In this study, reaction time served as an objective indicator of fatigue; thus, a lower post-intervention reaction time signifies a faster response compared to pre-intervention conditions. Fatigue among food handlers may be linked to the high physical demands of their work. Repetitive tasks, prolonged standing, processing large quantities of food, and the manual handling of materials and equipment can all heighten physical demands. Such conditions can affect the ability to maintain physical and sensorimotor responses while working.

L-citrulline supplementation has the potential to support physiological responses to physical activity via the L-citrulline–L-arginine–NO pathway. L-citrulline can increase the availability of L-arginine, a substrate for nitric oxide (NO) production. NO plays a role in vascular function and can thus physiologically support tissue perfusion. Evidence from 2022 also indicates a link between L-citrulline supplementation, arginine availability, and NO synthesis, although the magnitude of the effect on physical performance varies. (PubMed) Previous research on individuals performing resistance training also suggests that L-citrulline has the potential to influence muscle oxygenation and the perception of fatigue, even though results regarding physical performance have

not always been consistent. These studies position L-citrulline as an NO precursor capable of enhancing blood flow and muscle oxygenation (Gonzalez et al., 2023).

The findings of this study must be interpreted with caution, as the intervention involved red watermelon juice rather than pure L-citrulline. Consequently, the observed effects on reaction time cannot be attributed solely to L-citrulline; the water and natural carbohydrate content of watermelon may also contribute to hydration status and energy availability during activity. A 2026 review on watermelon consumption concluded that watermelon holds potential for muscle recovery and physiological responses to physical activity, though evidence regarding the underlying mechanisms and the overall effects of the fruit as a food matrix requires further strengthening(Éric et al., 2026).

The study by (Schierbauer et al., 2025) also serves as an important point of comparison, as it found no significant increase in time to exhaustion following 10 days of L-citrulline supplementation. Discrepancies between that study and the current one likely stem from differences in participant characteristics, dosage, intervention duration, mode of administration, and the specific outcomes measured. While the current study assessed changes in reaction time among food handlers, Schierbauer et al. evaluated time to exhaustion and cardiorespiratory responses during high-intensity cycling. (Frontiers) Taking all these results into account, the administration of red watermelon juice over a five-day period demonstrated more favorable changes in fatigue indicators compared to the control group. The experimental group experienced a reduction in reaction time of 82.43 ms, whereas the control group showed an increase of 8.55 ms. These findings suggest that red watermelon juice has potential as a food-based approach to support the physical recovery and readiness of food handlers, although further research is required to ascertain the specific contribution of L-citrulline to these effects.

Overall, the study results indicate that the consumption of red watermelon juice for five days significantly influenced the reduction of upper-body pain and the improvement of reaction times key indicators of occupational fatigue. However, these effects must be understood within the context of consuming watermelon juice as a whole food, meaning the specific contributions of individual components cannot be entirely isolated from the contribution of other nutritional components found in watermelon.

The interpretation of reaction-time improvements should also consider potential learning effects and measurement errors. Because participants completed the same smartphone-based reaction-time assessment before and after the intervention, repeated exposure may have increased familiarity with the testing procedure, improved response coordination, and reduced reaction times independently of physiological recovery. Although both groups underwent repeated testing, differences in individual learning rates cannot be excluded. Furthermore, smartphone-based measurements may be influenced by touchscreen responsiveness, device processing delays, environmental distractions, participant concentration, and variations in testing conditions. Averaging five repeated measurements may reduce random variability but does not eliminate systematic measurement errors. Consequently, the 82.43 ms reduction observed in the experimental group should not be interpreted solely as evidence of reduced occupational fatigue. Standardized testing environments, familiarization sessions, consistent devices, and validated reaction-time instruments are recommended to minimize practice effects and improve measurement reliability in future investigations

Overall, the study results indicate that consuming red watermelon juice for five days was associated with reduced upper-body pain and improved reaction-time performance

among food handlers. However, these findings should be interpreted cautiously because the non-placebo-controlled design, potential participant expectations, repeated-testing learning effects, and possible measurement errors may have influenced the observed outcomes. Furthermore, the intervention involved whole watermelon juice, making it difficult to isolate the specific contribution of L-citrulline from other nutritional components. Therefore, although the findings suggest potential benefits, further placebo-controlled studies using standardized and validated measurement procedures are necessary to establish the intervention's effectiveness

**Study Limitations**

This study has several limitations. First, the quasi-experimental design without randomization or placebo control may introduce selection and expectation biases. Participants were aware of receiving watermelon juice, potentially influencing subjective pain assessments. Furthermore, the intervention lasted only five days, limiting conclusions regarding long-term effectiveness. Second, repeated smartphone-based reaction-time testing may produce learning effects, as participants become familiar with test procedures and respond faster independently of physiological improvements. Measurement errors related to device responsiveness, environmental distractions, participant concentration, and inconsistent testing conditions may also affect reliability. Averaging five measurements reduces random variability but cannot eliminate systematic errors. Third, variations in ergonomic workload, sleep quality, hydration, and nutritional intake were not comprehensively controlled. Additionally, watermelon juice contains multiple nutrients, preventing attribution of observed benefits exclusively to L-citrulline. Future studies should employ randomized placebo-controlled designs, longer follow-up periods, standardized ergonomic assessments, and validated fatigue measurements to strengthen causal interpretation and clinical applicability

**Conclusion**

All confounding variables (age, nutritional status, exercise habits, smoking habits, and sleep duration) were found to be homogeneous between the experimental and control groups ($p > 0.05$), rendering the two groups comparable for analysis. The administration of L-citrulline (red watermelon juice) had a significant effect on reducing upper-body pain levels among food handlers in the experimental group compared to the control group ($p = 0.000$). Similarly, the administration of L-citrulline (red watermelon juice) significantly reduced work-related fatigue (measured by reaction time) in the experimental group compared to the control group ($p = 0.000$). Extraneous variables such as age, nutritional status, exercise habits, smoking, and sleep durationdid not show a statistically significant relationship with the respondents' pain levels or work-related fatigue.

**Declaration of AI Assistance**

The authors used generative artificial intelligence (AI) tools solely to improve language clarity, grammatical accuracy, sentence structure, and paraphrasing during manuscript preparation. AI was not used for data collection, analysis, interpretation, or the generation of research findings. All AI-assisted content was carefully reviewed, verified, and revised by the authors, who take full responsibility for the accuracy, originality, and integrity of the manuscript

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