Nurmala et al (2026)
Vol 14(1): 17904
https://doi.org/10.20884/1.api.2026.14.1.17904

Acta Pharmaciae Indonesia:
Acta Pharm Indo
E-ISSN 2621-4520

RESEARCH ARTICLE Open Access

White radish (*Raphanus sativus* L.) juice dose-dependently accelerates intestinal transit in loperamide-constipated Wistar rats

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ABSTRACT

Background: Constipation is a common functional bowel disorder. Radish leaves and seeds stimulate gut motility, but the juice of the white radish root has not been tested in a constipation model.

Objective: To evaluate the laxative activity and the most effective dose of white radish juice in loperamide-constipated male Wistar rats.

Methods: Twenty-five male Wistar rats were constipated with oral loperamide and randomly allocated to five groups (n = 5): 0.5% Na-CMC (negative control), castor oil 0.4 mL/200 g body weight (BW) (positive control), and dried white radish juice at 250, 500, or 750 mg/200 g BW. The intestinal transit ratio was calculated as the distance travelled by a Norit marker divided by the intestinal length × 100. Data were analysed by one-way ANOVA and Duncan's multiple range test ($p < 0.05$).

Results: The juice powder contained 4.59% moisture and 2.17% ash and was positive for alkaloids, flavonoids, and saponins. The transit ratio was 16.54 ± 1.35%, 28.20 ± 4.17%, and 54.82 ± 4.44% at 250, 500, and 750 mg/200 g BW, compared with 2.18 ± 0.56% in the negative control. All juice doses differed significantly from the negative control and from each other. The 750 mg/200 g BW dose did not differ significantly from castor oil (54.28 ± 6.21%).

Conclusion: White radish juice reversed the loperamide-induced delay of intestinal transit in a dose-dependent manner, and 750 mg/200 g BW was as effective as castor oil. Repeated-dose, mechanistic, and safety studies are needed before clinical use.

Keywords: constipation, intestinal transit, laxative, loperamide, *Raphanus sativus*

Introduction

Constipation is characterized by infrequent bowel movements, hard stools, straining, and a sensation of incomplete evacuation. It is among the most common disorders of gut-brain interaction worldwide and is associated with lower quality of life and more frequent medical visits [1]. Low intake of dietary fiber is consistently associated with more severe constipation symptoms [2,3]. In randomized trials, higher fiber intake softens stools, increases fecal weight, and shortens gut transit time [4].

When dietary and lifestyle measures fail, osmotic and stimulant laxatives are used. Osmotic agents such as lactulose and magnesium oxide increase small-bowel water, stimulate motility, and shorten colonic transit [5,6]. However, abdominal discomfort, electrolyte disturbance, and variable response limit their long-term use. This has encouraged the search for food-

Received: September 30, 2025; Revised: October 20, 2026
Accepted: October 20, 2026; Published: October 21, 2026

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based laxatives. Fruit juice, for example prickly pear juice, has accelerated gastrointestinal transit in both healthy and loperamide-constipated rats [7].

Radish (*Raphanus sativus* L.) is a widely consumed root vegetable that is traditionally used for indigestion and constipation. A crude extract of radish leaves contracted guinea-pig ileum through histaminergic receptors and enhanced charcoal transit in mice [8]. Radish seeds improved intestinal motility in rats fed a high-calorie diet by restoring gastrointestinal motility hormones [9]. A herb pair containing radish seeds relieved senile constipation in mice through the gut microbiota, short-chain fatty acids, and serotonin (5-HT) signalling [10]. Glucoraphenin, a glucosinolate of radish roots and seeds, and its microbial metabolite also enhanced intestinal peristalsis in zebrafish [11].

These studies examined leaves, seeds, a herbal combination, or an isolated compound. Evidence for the juice of the white radish root, the form most often consumed as food, in a drug-induced constipation model is lacking. Its effective dose range and its potency relative to a standard stimulant laxative are therefore unknown. This study aimed to evaluate the laxative activity of white radish juice in loperamide-induced constipated male Wistar rats. It also compared the juice with castor oil and identified the most effective dose.

Methods

Study design and ethical approval

This was a randomized experimental study with a posttest-only control group design. Constipated rats were allocated to a negative control, a positive control, and three white radish juice doses. The primary outcome was the intestinal transit ratio of a Norit marker, a standard screening endpoint for laxative activity [12]. The protocol was approved by the Animal Research Ethics Committee, Faculty of Mathematics and Natural Sciences, Pakuan University (No. 039/KEPHP-UNPAK/10-2022). The individual animal was the unit of analysis.

Preparation of white radish juice powder

Fresh white radish roots were washed and juiced. The juice (5 L) was dried in a vacuum dryer to obtain a powder, which was stored in a closed container until use. All doses in this study refer to this dried juice powder, suspended in 0.5% sodium carboxymethylcellulose (Na-CMC).

Moisture and ash content

Moisture content was determined gravimetrically [13]. A 2 g sample was weighed into a pre-dried porcelain dish and dried at 105 °C for 5 h. It was then cooled in a desiccator, weighed, and dried further at 1 h intervals until two consecutive weighings differed by no more than 0.25%. Total ash was determined by igniting 2 g of sample in a pre-ignited, tared silica crucible at 600 °C until free of carbon. The crucible was cooled in a desiccator and weighed [13]. Both results were expressed as percent w/w.

Phytochemical screening

Alkaloids, flavonoids, tannins, and saponins were screened qualitatively using standard tube tests [14]. For alkaloids, 0.5 g of powder was heated with 1 mL of 2 N hydrochloric acid and 9 mL of distilled water and filtered. The filtrate was tested with Mayer's and Dragendorff's reagents. For flavonoids, 0.5 g of powder was mixed with 96% ethanol, magnesium powder, and concentrated hydrochloric acid. A yellow to red colour indicated a positive result. Tannins were tested in an aqueous filtrate with 1% ferric chloride and with 1% gelatin; a blue-black colour or a precipitate indicated a positive result. For saponins, 10 mL of aqueous filtrate was shaken vigorously. Foam that remained stable for at least 10 min and persisted after adding 2 N hydrochloric acid indicated a positive result.

Animals

Twenty-five male Wistar rats aged 8 to 12 weeks and weighing 150 to 200 g were used. They were acclimatized for 7 days under standard laboratory conditions with standard feed and water *ad libitum*. General condition was observed daily, and body weight was recorded at regular intervals. Homogeneity of body weight was accepted when the coefficient of variation (CV) was below 15%. The rats were then randomly allocated to five groups of five rats each.

Induction of constipation

Ten loperamide tablets were weighed and crushed, and the powder was suspended gradually in 0.5% Na-CMC until homogeneous. Each rat received loperamide orally at 0.036 mg/200 g BW in a volume of 2 mL. Rats were considered constipated when no defecation occurred for 2 days. Constipated rats were then fasted for 16 h with free access to water.

Table 1. Treatment groups and doses

Group	Treatment	Dose (oral)
Negative control	0.5% Na-CMC	2 mL/200 g BW
Positive control	Castor oil (oleum ricini)	0.4 mL/200 g BW
Dose 1	White radish juice powder	250 mg/200 g BW
Dose 2	White radish juice powder	500 mg/200 g BW
Dose 3	White radish juice powder	750 mg/200 g BW

All rats (n = 5 per group) were constipated with loperamide before treatment. Juice powder doses correspond to 1.25, 2.5, and 3.75 g/kg BW and were suspended in 0.5% Na-CMC. BW, body weight; Na-CMC, sodium carboxymethylcellulose.

Table 2. Qualitative phytochemical screening of white radish juice powder

Compound class	Test	Observation	Result
Alkaloids	Mayer's reagent	White to yellowish precipitate	+
	Dragendorff's reagent	White precipitate in red solution	+
Flavonoids	Mg powder + HCl	Yellow colour	+
Tannins	$FeCl_3$ 1%; gelatin 1%	Yellow solution, no precipitate	−
Saponins	Foam test + 2 N HCl	Stable foam ≥10 min	+

+, detected; −, not detected. $FeCl_3$, ferric chloride; HCl, hydrochloric acid; Mg, magnesium.

Treatment and intestinal transit test

Each group received a single oral dose of its assigned treatment (Table 1). Castor oil (oleum ricini) was used as the positive control because its active metabolite, ricinoleic acid, stimulates intestinal smooth muscle [12,15]. One hour after treatment, each rat received 1 mL/200 g BW of 0.5% Norit suspended in 0.5% Na-CMC by oral gavage. Twenty minutes later, the rats were euthanized by CO_2 inhalation in accordance with the approved protocol. The intestine was excised from the pylorus to the rectum and laid straight without stretching. The total intestinal length and the distance travelled by the Norit front from the pylorus were measured with a ruler. The intestinal transit ratio was calculated as follows [16]:

Intestinal transit ratio (%) = (distance travelled by Norit (cm) / total intestinal length (cm)) × 100

Statistical analysis

Data are presented as mean ± standard deviation (SD) of five rats per group. The intestinal transit ratio was compared among the five groups by one-way analysis of variance (ANOVA). When ANOVA was significant, Duncan's multiple range test was used to compare groups. Statistical significance was set at $p < 0.05$.

Results

Yield and quality of white radish juice powder

Drying 5 L of white radish juice produced 415 g of brown powder with a distinctive aroma, equivalent to 8.3 g of powder per 100 mL of juice. The moisture content was 4.59% and the ash content was 2.17%. Both values were below the acceptance limits used in this study, 10% for moisture and 5% for ash. Low moisture limits microbial growth and chemical degradation during storage.

Phytochemical profile

The juice powder was positive for alkaloids, flavonoids, and saponins and negative for tannins (Table 2). Alkaloids produced a white to yellowish precipitate with Mayer's reagent and a white precipitate in a red solution with Dragendorff's reagent. Flavonoids gave a yellow colour after the magnesium and hydrochloric acid reaction. Tannin tests with ferric chloride and gelatin gave yellow solutions without precipitate.

Animal homogeneity

After acclimatization, the CV of body weight was 6.36%, below the 15% limit. Body weight increased during acclimatization, and no rat died during the study.

Table 3. Intestinal transit of a Norit marker in loperamide-constipated male Wistar rats by treatment group

Group	Total intestinal length (cm)	Distance travelled by marker (cm)	Intestinal transit ratio (%)
Negative control (0.5% Na-CMC)	112.4 ± 4.3	2.5 ± 0.6	2.18 ± 0.56[a]
Positive control (castor oil 0.4 mL/200 g BW)	118.8 ± 6.8	64.6 ± 10.2	54.28 ± 6.21[d]
White radish juice 250 mg/200 g BW	115.6 ± 8.2	19.2 ± 3.2	16.54 ± 1.35[b]
White radish juice 500 mg/200 g BW	116.2 ± 5.9	32.6 ± 3.6	28.20 ± 4.17[c]
White radish juice 750 mg/200 g BW	117.4 ± 6.5	64.2 ± 3.4	54.82 ± 4.44[d]

Values are mean ± SD; n = 5 rats per group; the unit of analysis is the individual rat. Intestinal length was measured from the pylorus to the rectum. Intestinal transit ratio = distance travelled by marker / total intestinal length × 100, calculated for each rat and then averaged. Different superscript letters indicate significant differences between groups (one-way ANOVA followed by Duncan's multiple range test, $p < 0.05$). BW, body weight; Na-CMC, sodium carboxymethylcellulose; SD, standard deviation.

Intestinal transit

Total intestinal length was similar across groups (112.4 to 118.8 cm), so differences in transit ratio reflected marker travel (Table 3). Transit was strongly suppressed in the negative control group (2.18 ± 0.56%). Castor oil increased the transit ratio to 54.28 ± 6.21%. White radish juice increased the transit ratio in a dose-dependent manner. The ratios were 16.54 ± 1.35%, 28.20 ± 4.17%, and 54.82 ± 4.44% at 250, 500, and 750 mg/200 g BW, respectively. ANOVA showed a significant difference among groups ($p < 0.05$).

Duncan's test placed every juice dose above the negative control, and the three doses differed significantly from each other (Table 3). The ratio rose 1.7-fold from 250 to 500 mg/200 g BW and 1.9-fold from 500 to 750 mg/200 g BW. The 750 mg/200 g BW group did not differ significantly from the castor oil group.

Discussion

This study produced three main findings. White radish juice reversed the loperamide-induced delay of intestinal transit at every dose tested. The effect increased with dose, and the largest gain occurred between 500 and 750 mg/200 g BW. At 750 mg/200 g BW, the transit ratio was statistically indistinguishable from that produced by castor oil.

The model behaved as expected. Loperamide is the most widely used inducer of experimental constipation because it inhibits peristalsis and increases intestinal fluid absorption [12]. Transit in the vehicle-treated negative control group was only 2.18%, consistent with marked suppression and no laxative effect of the vehicle. Castor oil acts through ricinoleic acid, which activates prostanoid EP3 receptors on intestinal smooth muscle [15]. Its strong effect here confirms that the model was sensitive to a prokinetic stimulus.

The dose-dependent response agrees with other plant preparations tested in loperamide models. Aqueous extracts of *Globularia alypum*, *Malva sylvestris*, beetroot leaves, and *Crataegus azarolus* leaves improved gastrointestinal transit in constipated rats [17–20]. Fermented barley extract and fermented soybean powder also restored charcoal transit in a dose-dependent manner [16,21]. Similar laxative effects have been reported for *Morella serrata* root and *Taraxacum officinale* aerial parts [22,23]. Radish leaf extract was active in mice at 30 to 100 mg/kg [8], whereas the juice in this study required 1.25 to 3.75 g/kg. This difference is consistent with the lower concentration of active constituents in a whole-juice powder than in a leaf extract. Differences in species and test protocol may also contribute.

The constituents responsible for the effect were not identified, but the screening results suggest candidates. Flavonoids such as quercetin and hesperidin enhanced motility in loperamide-constipated rats through muscarinic and 5-HT_4 receptor signalling [24,25]. Radish glucosinolates and their metabolites enhanced intestinal peristalsis [11], and radish leaves contain a histaminergic gut stimulant [8]. Fermentable fiber can also accelerate transit by raising short-chain fatty acid production, as shown for a pectin-rich cactus extract and a radish-containing herb pair [10,26]. However, the transit test lasted only 80 min after a single dose. This is too short for meaningful colonic fermentation, so an acute action on intestinal smooth muscle or enteric receptors is more plausible. Juicing also removes most insoluble fiber, so bulk-forming effects are unlikely to explain the acute response. Minerals such as magnesium can act osmotically [6],

but magnesium was not measured, and the total ash content was low (2.17%).

The equivalence with castor oil at 750 mg/200 g BW is notable because castor oil is a potent stimulant laxative. However, equal transit in a single acute test does not imply equal clinical efficacy. Using body surface area conversion [27], 3.75 g/kg in rats corresponds to about 0.61 g/kg in humans. This equals about 36 g of dried juice powder for a 60 kg adult. Based on the yield in this study, this equals roughly 440 mL of fresh juice, an amount that is feasible as food.

This study has several limitations that affect interpretation. No non-constipated control group was included, so the degree of loperamide suppression and the extent of recovery toward normal transit cannot be quantified. Fecal number, weight, and water content, the core endpoints of constipation models, were not measured. Transit was also assessed at a single time point after one dose. The loperamide dose was lower than the 3 to 5 mg/kg commonly used in rat studies [16,17]. Each group contained only five rats, and blinding of outcome assessment was not reported. Phytochemical screening was qualitative, and fiber, glucosinolate, and magnesium contents were not quantified. Future studies should use repeated dosing with a normal control group, fecal endpoints, and colonic histology. They should also quantify the main constituents, test receptor antagonists such as pyrilamine and atropine, and evaluate subchronic toxicity.

Conclusion

White radish juice reversed the loperamide-induced suppression of intestinal transit in male Wistar rats in a dose-dependent manner. At 750 mg/200 g BW, the transit ratio (54.82 ± 4.44%) did not differ significantly from that of castor oil (54.28 ± 6.21%). White radish juice is therefore a promising food-based laxative candidate. Repeated-dose studies with fecal endpoints, mechanistic work, and safety evaluation are needed before clinical testing.

Acknowledgment

The authors thank the Faculty of Mathematics and Natural Sciences, Pakuan University, for research facilities, and the laboratory and animal care staff for their technical assistance.

Conflict of interest

The authors declare no conflict of interest.

Author contributions

SN: Conceptualization, Methodology, Investigation, Project administration, Writing – original draft. NA: Data curation, Formal analysis, Investigation, Writing – review & editing. NH: Investigation, Resources, Validation, Writing – review & editing. EH: Investigation, Supervision, Visualization, Writing – review & editing. All authors read and approved the final manuscript.

Funding

This research received no external funding.

Declaration of generative AI use

During manuscript preparation, ChatGPT (OpenAI) was used to assist in locating literature. The authors and editors reviewed all content and take full responsibility for the published article.

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