



ISSN : 2347 - 2243

Indo - American Journal of Life Sciences and Biotechnology



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Antiulcer Activity of *Ocimum sanctum* Leaf Extract in a Pylorus Ligation-Induced Ulcer Model

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Received: March 9, 2012 Accepted: July 6, 2012 Published: November 9, 2012

DOI: [10.62644/iajlb.2012.v9.i4.pp1-8](https://doi.org/10.62644/iajlb.2012.v9.i4.pp1-8)

ABSTRACT

Holy basil, *Ocimum sanctum*, is a staple of Ayurvedic practice, and leaf preparations of the plant are often described as gastroprotective. The pylorus ligation model in the rat is one of the standard screens on which such claims rest. This narrative review asks what that model can and cannot show about an antiulcer leaf extract, and how much weight the published literature on the plant can carry. It draws on work covering gastric mucosal defence, oxidative injury, the chemistry and reported gastric effects of *O. sanctum*, ulcer models, and the design and reporting of animal experiments, and it reports no new data. In the ligated rat, the injury is driven mainly by accumulated acid and pepsin, so the model reads out reduced secretion or neutralisation far better than it reads out strengthened mucosal defence. Reports on the plant point towards antisecretory, antioxidant and mucus-related actions, yet the extracts used differ widely, and most studies are small, rarely blinded, and seldom report how animals were allocated. The review concludes that antiulcer activity in this model is plausible but not yet well characterised, that a positive result says little about humans, and it lists what a convincing study would report.

Keywords: *Ocimum sanctum*; Holy basil; Antiulcer activity; Pylorus ligation; Shay rat model; Gastric acid; Narrative review

Citation: Papadakis, Zielinski and Pimentel [2012]. Antiulcer Activity of *Ocimum sanctum* Leaf Extract in a Pylorus Ligation-Induced Ulcer Model. *Indo-Am. J. Life Sci. Biotechnol.* 9(4):1-8. DOI: [10.62644/iajlb.2012.v9.i4.pp1-8](https://doi.org/10.62644/iajlb.2012.v9.i4.pp1-8)

Article Class: Narrative Review

1. Introduction

Peptic ulcer is among the oldest and most familiar disorders of the digestive tract, and for much of the twentieth century it was explained almost entirely by acid. That picture changed when *Helicobacter pylori* was recognised in the stomach of

patients with gastritis and ulcer (1), and it is now understood that infection and the use of non-steroidal anti-inflammatory drugs account for most cases (2, 3). Acid suppression and eradication therapy work well, yet people still look to plants, partly from habit and partly because natural



products have long been a productive source of medicines (4, 5).

Ocimum sanctum Linn., known as tulsi or holy basil, is one of the plants most often named in this context. It is grown around homes and temples across the Indian subcontinent, has a long place in Ayurvedic practice (6, 7), and has had its pharmacology summarised more than once (8). Several laboratory reports describe protection of the rat stomach by leaf preparations and by the seed oil, including in the pylorus ligation model that gives this article its title (9, 10).

The title describes a single experiment in rats, but this article does not report one: no animals were used and no new data are presented. It asks what a pylorus ligation experiment with a leaf extract can legitimately tell us, and how much of the published case for tulsi stands on firm ground. The aim is a balanced reading of what has been shown and what has merely been repeated.

2. Literature Review

2.1 How the Stomach Protects Itself

The gastric mucosa lives next to a fluid that is acidic enough to digest it, and it survives because several defences operate together. A layer of mucus and bicarbonate holds a near-neutral surface beside the epithelium (11), epithelial cells repair themselves quickly, blood flow clears leaked acid, and prostaglandins coordinate these responses (12, 13). Injury is best thought of as a loss of balance between aggressive factors, chiefly acid and pepsin whose secretion is tightly controlled (14), and these defensive ones (15). An extract could lower secretion, neutralise acid, thicken mucus or improve blood flow, and a single experiment will rarely tell these apart.

2.2 Oxidative Stress and the Gastric Mucosa

Reactive oxygen species are produced in every tissue, and their excess damages lipids, proteins and DNA (16). Whether antioxidants work as drugs is still argued over (17), but oxidant injury has real support in the stomach (18). For this reason, antiulcer papers on plant extracts regularly report tissue lipid peroxidation and antioxidant enzymes alongside acid measurements (19).

The assays behind these numbers are old and well-established: thiobarbituric acid reactive substances for lipid peroxidation (20), sulfhydryl groups for the glutathione pool (21), and spectrophotometric methods for superoxide dismutase (22) and catalase (23). They measure a stomach after injury, so a change may be a consequence of less damage and not a reason for it.

2.3 *Ocimum sanctum*: Chemistry and Reported Gastric Effects

Leaves contain phenolic compounds and a volatile oil in which eugenol is prominent, and some of the phenolics show antioxidant and cyclooxygenase-inhibiting properties in the test tube (24). Eugenol itself protected the rat stomach against indomethacin injury in one study (25). These facts concern a compound, and a crude leaf extract is a different material.

An aqueous leaf preparation was described as protective across several injury models and as promoting healing of chronic lesions (9), while the fixed oil from the seeds was reported to reduce ulcers in more than one model, with effects on secretion and mucus (10). Neither study settles what a leaf extract made with a different solvent would do.

2.4 Pylorus Ligation and Other Ulcer Models

In the pylorus ligation preparation, the outlet of the stomach is tied under



anaesthesia in a fasted rat, and gastric juice accumulates for several hours before the animal is killed and the stomach examined. Retained acid and pepsin digest the non-glandular and glandular mucosa, producing lesions that can be scored, and the juice can be measured (Table 1). The model has been used since the 1940s because it is cheap, quick and sensitive to acid-reducing drugs.

Its strength is also its limit. Since the injury is driven largely by retained secretion, the model reads out antisecretory and neutralising effects far better than it reads out changes in mucosal defence (26). Ethanol and NSAID models stress the barrier instead, and acetic acid produces a chronic lesion suited to studying healing (27). A plant that works in one may do nothing in another, which is why a claim built on a single model deserves a cautious reading.

Table 1. Common experimental ulcer models and what each mainly probes.

Model	Main injury	Best suited to
Pylorus ligation	Retained acid and pepsin, autodigestion (26)	Antisecretory or neutralising action
Ethanol	Direct damage, barrier failure (12)	Mucosal protection
NSAID (indomethacin)	Prostaglandin loss (13)	Prostaglandin-linked defence (25)
Stress (cold restraint)	Reduced blood flow, acid, oxidants (18)	Mixed mechanisms
Acetic acid	Chronic, penetrating lesion (26)	Healing, not prevention

Note: Qualitative summary; the models overlap and no single model is a stand-in for human disease.

2.5 Plant Extracts as Drug Leads

Plants have given medicine many of its most useful compounds (28), and alkaloids

alone have been reviewed for gastric and duodenal protection (29). Yet the step from traditional use to proof is longer than it looks. Ethnopharmacology has been criticised for accepting tradition as evidence and for leaning on convenient in vitro tests (30, 31), and activity against *H. pylori* in a dish, as many herbs show (32), is not an ulcer treatment.

The extract matters as much as the plant. The solvent determines which compounds are pulled out (33), and extraction and drying alter yield and composition (34). An aqueous extract, an ethanolic extract and a seed oil are three different medicines under one botanical name. This is one reason the same plant can look striking in one laboratory and unremarkable in the next.

3. Materials and Methods

3.1 Scope

The review asks two questions. First, what can a pylorus ligation experiment with a plant leaf extract show about antiulcer action? Second, how strongly does the published work on *O. sanctum* support a gastroprotective claim? Because the title reads like a single laboratory study, we state plainly that no experiment was done and no experimental data are reported.

3.2 Literature Assembly

Sources were chosen by the authors from the pharmacology, gastroenterology and experimental-design literature up to 2012, covering gastric defence, oxidative injury, the plant, ulcer models, extraction and the reporting of animal work. We did not run a formal systematic search and we do not claim one, so some relevant studies are surely missing, and the selection reflects what the authors knew and could access.

3.3 Appraisal Framework

Each report on the plant was read with a short set of questions. Was the extract



described well enough to be repeated? Were animals allocated at random and the lesions scored without knowing the group? Was the dose range wide enough to see a pattern, and was more than one model used? Reporting standards for animal work give a ready template (35). None of these steps is hard, but each is easy to skip.

4. Results

4.1 What a Pylorus Ligation Experiment Measures

Figure 1 shows the sequence of a typical experiment, and Table 2 sets out the usual endpoints. Every endpoint reflects accumulation over a fixed interval: a shorter one emphasises the early rise in acid, a longer one allows more digestion to develop, so results at different times may not match. Timing, in other words, is part of the result and not a footnote to it. Fasting before ligation matters too, since food in the stomach changes both secretion and lesion scoring.

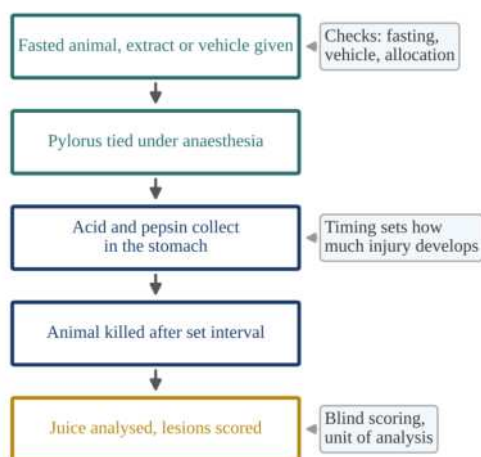


Figure 1. Sequence of a pylorus ligation experiment and the endpoints read from it (schematic, not data).

4.2 What the Reports on the Plant Support

Set against the models in Figure 2, the reports give an uneven picture. The plant has been tested most often in acid-driven

or stress-driven models, which suits a claim of antisecretory action but says little about the barrier or healing. A few studies add a healing model (9), and mechanistic work on a single constituent points towards a barrier-related action (25), but these two lines have not been joined for a crude leaf extract.

Table 2. Usual endpoints in a pylorus ligation experiment and how far each can be read.

Endpoint	What it reflects	Main caveat
Juice volume	Secretion and retention	Depends on ligation time
pH and acidity	Acid output (14)	Titration method varies
Pepsin	Aggressive factor	Assay rarely standardised
Mucus	Defensive factor (11)	Methods differ widely
Ulcer index	Visible lesion score	Observer-dependent without blinding (36)

Note: Endpoint names follow common usage; no values are given because they depend on the protocol.

	Acid and pepsin	Mucosal barrier	Oxidative injury	Healing
Pylorus ligation	Dark	Blank	Light	Blank
Ethanol	Blank	Dark	Light	Blank
NSAID	Blank	Dark	Light	Blank
Cold stress	Light	Light	Dark	Blank
Acetic acid	Blank	Light	Light	Dark

Dark = main target, light = partly, blank = little (schematic, not data)

Figure 2. Qualitative matrix of what each ulcer model mainly probes (schematic judgement, not data).

Where antioxidant markers are measured, shifts are consistent with less oxidant injury but cannot show cause, since a marker can fall simply because fewer cells were damaged (18). Comparison across papers is hard, because dose is usually given per kilogram of an extract whose



yield and composition are not fixed, and converting an animal dose to a human one is not simple scaling by body weight (37).

4.3 Quality of the Evidence

Surveys of animal research report a pattern familiar from ulcer papers: random allocation and blinding are seldom mentioned, and sample size is rarely justified (38). Experiments without such safeguards tend to report larger effects (36), and where animal studies have been compared with trials, the animal literature has sometimes overstated what later happened in patients (39, 40). Selective publication adds to the distortion (41).

These problems appear in Table 3 along with their remedies. One, the unit of analysis, deserves attention in a ligation experiment. Rats housed together share a cage, and treating each rat as an independent replicate when the treatment was applied to a cage inflates precision (42, 43). The difference between groups may be real, but the confidence placed in it is not. The point is not that any one report is poor, only that its result travels less far than its abstract suggests.

Table 3. Recurring weaknesses in animal antiulcer studies and what follows from them.

Weakness	Consequence	Remedy
Extract not characterised	Dose and identity unclear (33, 34)	Report solvent, yield, markers
No allocation concealment or blinding	Inflated effects (36, 38)	Randomise; score blind
Cage as unit	Overstated precision (42, 43)	Analyse at the right unit
Single dose or model	Mechanism unclear	Dose range; second model
Selective publication	Optimism (41)	Report null results

Note: The weaknesses are those described in the cited methodological literature, not attributed to any single study.

A small study that finds no effect has not shown that the plant is inactive, because few animals give little power to detect anything (44). The honest summary is that positive reports exist, they are mostly small and incompletely described, and the layers of evidence needed to move from a rat result to a human claim are largely absent (Figure 3). Read this way, a null result in a small experiment is not evidence of absence.

5. Discussion

5.1 Interpretation

The reading that the evidence allows is conditional. If a leaf extract protects ligated rats, the most likely explanation is that it lowers acid or pepsin output or neutralises some of it, and an effect on the barrier would need another model. For *O. sanctum* the picture is of a plant with plausible actions on several fronts, supported by studies too varied to add up. That is a modest claim, and it is the one the evidence will currently bear.

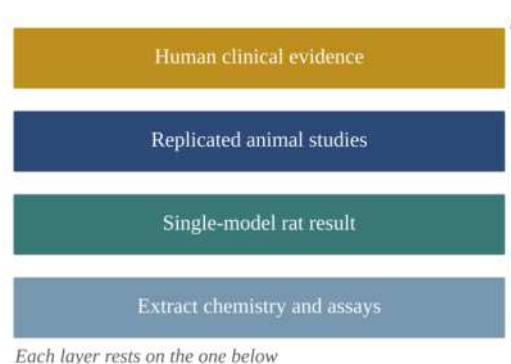


Figure 3. Layers of evidence between a rat result and a human claim (schematic, not data).

The second conditional concerns the extract: a claim made for one preparation cannot be borrowed for another. The third concerns scale: protection in a ligated rat is not prevention in a person, whose ulcers arise mainly from infection and drugs (2).



5.2 Limitations

The review is narrative and shares the weaknesses of that form: studies were selected without a registered protocol, appraisal was qualitative, and nothing was pooled. The reference list stops at 2012. Reviews are more useful when they say where the evidence stops than when they smooth it over.

5.3 Future Work

A study that could settle the question would state the extract fully, including solvent, yield and some chemical marker, would use a range of doses and a reference drug, and would add a second model that tests the barrier. Randomisation, blinding and a justified number of animals should be stated as the reporting guidelines advise (35), and the unit of analysis should match the unit treated. Only then would a clinical trial be worth asking about. It is a habit worth keeping even when the answer seems obvious.

6. Conclusion

Antiulcer activity of *Ocimum sanctum* leaf extract in the pylorus ligation model is plausible, and the published reports are broadly encouraging. The model, however, mainly reveals effects on acid and pepsin, the extracts are inconsistently described, and the studies are small and rarely protected against bias. A reader of a rat study can fairly ask whether the result would hold outside the cage in which it was obtained.

For the laboratory worker the message is practical: characterise the extract, use more than one model, blind the scoring and analyse at the correct unit. A positive rat result is a reason for better experiments, not for confidence. Such differences look small one at a time, yet they decide whether two experiments can be compared at all. These points apply with equal force to any herbal extract, not only to tulsi.

7. Acknowledgements

The authors thank colleagues who commented on earlier drafts of this review.

8. Funding

This work received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

9. Conflict of Interest

The authors declare no conflict of interest.

10. Author Contributions

I.P. conceived the review and wrote the sections on gastric physiology and ulcer models. K.Z. wrote the sections on plant extracts and the chemistry of the plant. R.P. wrote the sections on experimental design and reporting. All authors revised the manuscript and approved the final version.

11. Ethics Statement

This is a review of published literature. No animals were used and no ethical approval was required.

12. Data Availability

No new data were generated. All sources are cited in the reference list.

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