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FORMALDEHYDE EXPOSURE INDUCED NASAL HISTOLOGICAL CHANGES AND THE THERAPEUTIC EFFECT OF *HARITAKI KWATHA* (*TERMINALIA CHEBULA*) IN WISTAR ALBINO RATS: AN EXPERIMENTAL STUDY

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ABSTRACT

Background: Formaldehyde (formalin) vapour is a volatile, highly water-soluble irritant to which dissection-hall personnel are repeatedly exposed, and the nasal mucosa is its principal site of deposition. *Haritaki* (*Terminalia chebula* Retz.) is an Ayurvedic *Rasayana* with reported antioxidant, anti-inflammatory and antiproliferative activity. **Objective:** To evaluate formaldehyde-induced nasal epithelial changes through histopathological examination and assess the preventive and curative efficacy of *Haritaki Kwatha* in Wistar albino rats. **Methods:** Twenty-four Wistar albino rats were divided into four groups of six: control, disease control, preventive and curative. The disease control and preventive groups were exposed to 37% formaldehyde vapour for 2 h/day for 30 days. The preventive group received *Haritaki kwatha* 2 ml/day concurrently, while the curative group received formaldehyde exposure for 30 days followed by *Haritaki kwatha* for 30 days. Nasal mucosa was evaluated histopathologically, along with body weight and behavioural changes. **Results**: The disease-control group showed epithelial irregularity and degeneration, reduced goblet cells, distortion of Bowman's glands, disorganisation of olfactory neurons, inflammatory infiltration, vascular congestion and oedema. The preventive group showed mild epithelial changes with largely preserved glands and neurons. The curative group showed near-normal epithelial architecture, preserved goblet

cells and Bowman's glands, and minimal inflammation. Body weight was lowest in the disease-control group and approached control values in the curative group. **Conclusion**: Repeated formaldehyde exposure produced significant structural changes in the nasal mucosa of Wistar albino rats.Simultaneous administration of *Haritaki kwatha* reduced these changes, while post-exposure administration was associated with near-normal histological features, suggesting preventive and restorative effects.

KEYWORDS: formaldehyde*;* nasal epithelium*;* olfactory mucosa*;* histopathology*; Haritaki kwatha; Terminalia chebula;* Wistar Albino rats.

1. INTRODUCTION

Formalin, a 37% aqueous solution of formaldehyde, is widely used for cadaver preservation and in dissection halls. Although cadaveric dissection remains essential for medical education, students, anatomists and technicians are regularly exposed to formaldehyde vapours. Its volatility and irritant properties make it an important indoor air pollutant. Exposure may cause watering of the eyes, sneezing, headache and irritation of the respiratory tract. Prolonged exposure has been associated with nasal mucosal inflammation and cellular proliferation, which may contribute to carcinogenesis.

The nasal cavity is the first line of defence against inhaled substances. Its ciliated epithelial cells and mucus-secreting goblet cells help filter, warm and humidify inspired air through mucociliary clearance. Damage to this protective lining may affect respiratory and olfactory functions, causing symptoms such as dyspnoea, anosmia and epistaxis.

In Ayurveda, *Haritaki* is described as a *Rasayana* and indicated in *Pranavaha Srotas* disorders. Its phytochemical constituents, including tannins, chebulinic acid, chebulagic acid, gallic acid and ellagic acid, possess reported antioxidant, anti-inflammatory and antiproliferative properties.

Considering the potential nasal toxicity of formaldehyde and the reported therapeutic properties of *Haritaki*, the present study was undertaken to evaluate formaldehyde-induced histopathological changes in the nasal epithelium of Wistar albino rats and assess the preventive and curative effects of *Haritaki kwatha*.

This study was designed to experimentally evaluate the histopathological changes induced by repeated formaldehyde exposure in the nasal mucosa and to assess the preventive and curative effects of *Haritaki Kwatha* in Wistar albino rats.

Aim

To evaluate the effect of repeated formaldehyde exposure on the nasal mucosa and the preventive and curative effects of *Haritaki Kwatha* in Wistar albino rats.

Objectives

To evaluate the histopathological changes in the nasal mucosa of Wistar albino rats following repeated formaldehyde exposure.

To assess the preventive effect of *Haritaki Kwatha* on formaldehyde-induced nasal mucosal changes.

To assess the curative effect of *Haritaki Kwatha* following formaldehyde exposure.

2. MATERIALS AND METHODS

2.1 Ethical approval and animals

Twenty-four healthy adult Wistar albino rats weighing 200–250 g were housed in the institutional animal facility under standard conditions and according to CPCSEA guidelines(AAMC/CCSEA/IAEC/2024/SAP-10). The animals were maintained in polypropylene cages with stainless-steel grill tops and paddy-husk bedding, under a 12-hour light/dark cycle, with controlled temperature and humidity. Standard pelleted feed and water were provided *ad libitum*. Such controlled housing conditions are consistent with laboratory-animal care recommendations.

2.3 Experimental groups and formaldehyde exposure

Twenty-four rats were weighed and randomly allocated to four groups of six using randomisation software (Table 1; Fig. 1). Formaldehyde exposure was produced by soaking a cotton ball in 1 ml of 37% formaldehyde solution and placing it inside wire gauze in the cage.

The cage was covered on all sides except on one side, were a hole was made to allow ventilation and kept in an isolated room; animals were exposed for 2 hours daily for 30 days. The airborne formaldehyde concentration was not measured.

Table 1: Grouping of animals and interventions.

Group	Designation	Intervention	N	Killed on
1	Control	Normal diet and water for two months	6	Day 60
2	Disease control	Normal diet and water; formaldehyde exposure for 30 days	6	Day 30
3	Preventive	Formaldehyde exposure with concurrent *Haritaki kwatha* (2 ml/day) for 30 days	6	Day 30
4	Curative	Formaldehyde exposure for 30 days, then *Haritaki kwatha* (2 ml/day) for a further 30 days	6	Day 60

2.4 Tissue collection and histological assessment

Animals were sacrificed with an overdose of diethyl ether anaesthesia on day 30 (groups 2 and 3) or day 60 (groups 1 and 4). The noses were excised, placed in sterile containers of 10% formalin and sent for histopathological processing. Sections were examined by light microscopy and documented.

Body weight was recorded weekly (baseline to week 8). Fur colour was graded 0–3 and fur shafts were examined microscopically. Food and water intake, scratching and facial rubbing, sneezing, stool consistency and urine odour were observed and graded weekly.

2.6 Statistical analysis

Between-group differences in body weight were tested by one-way ANOVA with Bonferroni post hoc comparisons, and changes within each group over time by repeated-measures ANOVA. Ordinal behavioural grades were analysed by the Kruskal–Wallis test with Dunn's post hoc test, the Friedman test, the Wilcoxon signed-rank test and the Mann–Whitney U test, as appropriate. A p value below 0.05 was considered significant. Histological findings were evaluated qualitatively.

3. RESULTS

3.1 Overview of histological findings

All animals survived to the planned end-points, and the histological pattern was uniform within each group: all six animals of a group showed the changes described below. Table 2 summarises the findings by structure, Fig. 2 compares representative fields from the four groups, and Figs. 3–6 show the photomicrographs of each group. Injury was greatest in the disease-control group reduced in the preventive group and least in the curative group, whose mucosa most closely resembled that of the controls.

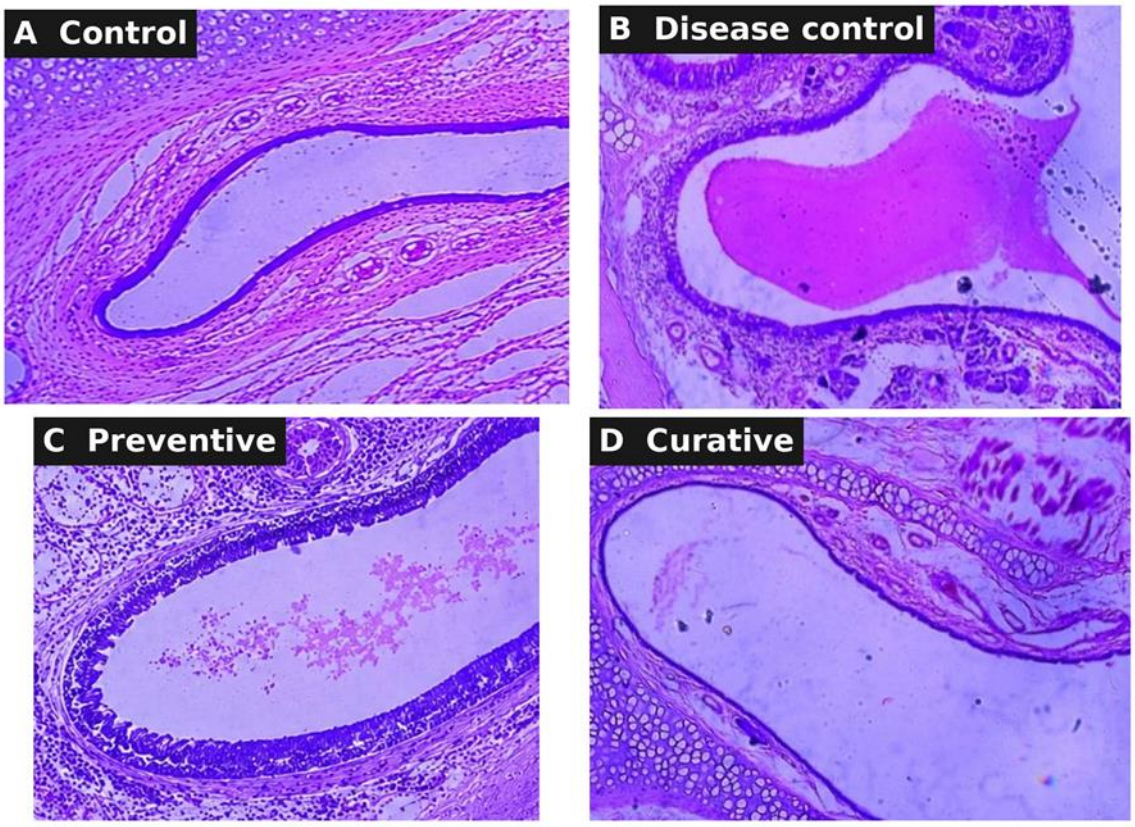


Figure 2. Representative nasal mucosal fields from each group for side-by-side comparison: (A) control, from Fig. 3A; (B) disease control, from Fig. 4A; (C) preventive, from Fig. 5A; (D) curative, from Fig. 6A. Note the clear lumen and thin epithelium in A and D, dense eosinophilic intraluminal material in B, and scanty flocculent material in C.

Table 2. Comparative histological features of the rat nasal mucosa (n = 6 per group; all animals in a group showed the pattern listed).

Feature	Control	Disease control	Preventive	Curative
Ciliated pseudostratified epithelium	Intact; normal thickness	Irregular; focal degeneration, thinning, partial desquamation	Mild irregularity; largely preserved	Normalised; intact ciliated lining, good continuity
Goblet cells	Well preserved; normal mucus secretion	Reduced density; mucosal irritation	Mostly intact; mild reduction	Preserved and functional
Bowman's glands	Normal, well organised	Mildly distorted	Near normal	Restored to near-normal appearance
Olfactory receptor neurons	Intact; regular arrangement	Disorganised; degeneration	Largely preserved	Improved integrity
Lamina propria	Normal vascularity; no infiltrate	Inflammatory infiltrate, vascular congestion, oedema	Minimal infiltrate; minimal congestion	Healthy; minimal vascular change
Intraluminal eosinophilic material†	Not seen	Abundant, dense, homogeneous	Scanty, fine, flocculent	Minimal or absent

3.6 Microscopy of the fur shaft

Fur shafts were examined by light microscopy Control fur showed a smooth, regular cuticular surface, uniform shaft thickness and uniform pigmentation. Disease-control fur showed an irregular surface with uneven deposition of yellowish pigment, mild roughening of the cuticle, loss of lustre and slight thinning in places. Preventive fur showed similar but milder alterations with relatively maintained structural integrity. Curative fur was relatively smooth with only mild residual pigment change and better-preserved cuticle. Grossly, formaldehyde-exposed animals developed yellowish fur discoloration from about day 3, reaching grade 3 by days 7–14 in the disease-control group.

3.7 Body weight and clinical/behavioural parameters

Baseline body weight did not differ among groups (p = 0.630). Thereafter, control animals gained weight steadily (227.50 g to 243.08 g), disease-control animals lost weight (228.83 g to 221.58 g by week 4), preventive animals remained essentially stable, and curative animals lost weight during exposure and then recovered from week 4 onwards (Table 3; Fig. 7). Between-group differences were significant overall (F = 42.194, p < 0.001) and at week 4, when the disease-control group weighed 13.25 g less than controls (p = 0.015). By week 8 the curative group (238.58 g) no longer differed significantly from controls (243.08 g) on post hoc testing.

Table 3. Body weight (g), mean ± SD, and within-group change over time (repeated-measures ANOVA, 9 time points).

Group	Overall mean ± SD	Baseline	Week 4	Within-group change
Control	234.88 ± 6.82	227.50	234.83 ± 5.19	Increase; $F(8,40) = 18.354$, $p < 0.001$
Disease control	222.81 ± 5.26	228.83	221.58 ± 4.65	Decrease; $F(8,40) = 13.436$, $p < 0.001$
Preventive	225.25 ± 6.74	228.83	224.17 ± 6.52	Stable; $F(8,40) = 1.411$, $p = 0.221$
Curative	232.69 ± 7.22	231.50	230.25 ± 9.25	Increase from week 4; $F(8,40) = 2.634$, $p = 0.020$

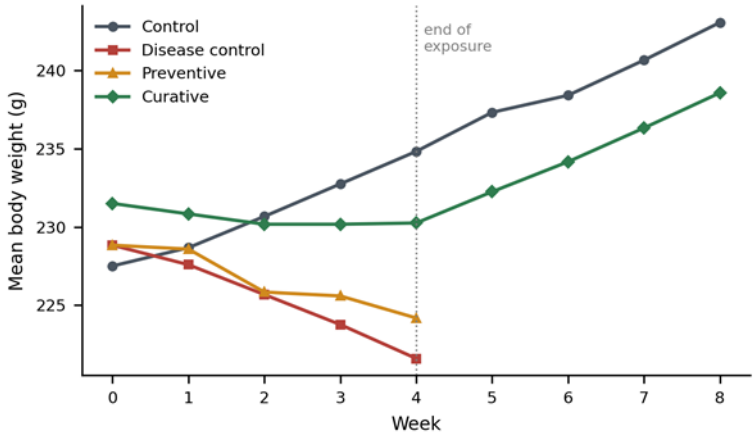


Figure 8. Mean weekly body weight by group. Disease-control and preventive animals were followed for 4 weeks; control and curative animals for 8 weeks.

Sneezing, scratching, water intake and urine odour were increased in formaldehyde-exposed animals and improved with *Haritaki kwatha* (Table 4). Preventive treatment significantly lowered scratching from week 2 and sneezing from week 3 relative to untreated disease ($p < 0.01$), while in the curative group sneezing responded first and scratching, sneezing and water intake all normalised by week 8. Food intake was normal in every group. Soft stools were seen only in Haritaki-treated groups.

Table 4. Summary of fur, behavioural and clinical parameters.

Parameter	Control	Disease control	Preventive	Curative
Fur colour	Grade 0	Yellowish from day 3; grade 3 by day 7–14	Grade 1, reaching grade 2 at most	Grade 3 during exposure; grade 1 after treatment
Sneezing	None	Frequent; grade 3.0 to 2.0 over weeks 1–4	Mild; grade 3.0 to 0.5	Grade 2.0 at week 4; 0 by week 8
Scratching	None	Persistent; grade 3.0 (weeks 2–3), 2.5 (week 4)	Grade 3.0 to 1.0	Grade 2.5 at week 4; 0 by week 8
Water intake	Normal (about 150 ml)	Increased; 150 to 190 ml	About 170 ml, stable	190 ml at week 4; 150 ml by week 8
Urine odour	Normal	Increased ammoniacal odour	Mild increase	Mild; reduced after treatment
Stool	Normal	Normal	Soft	Soft

Discussion of Histopathological Changes

The control group showed normal nasal mucosal architecture, with intact olfactory epithelium, well-preserved cellular arrangement, normal glands and vascularity, and no evidence of degeneration or inflammation.

The disease-control group showed clear pathological changes following repeated formaldehyde exposure. The olfactory epithelium showed irregularity, focal degeneration, thinning and partial desquamation, with disturbed cellular arrangement. The lamina propria showed inflammatory cell infiltration, vascular congestion and oedema, along with some glandular distortion. These findings are consistent with experimental studies showing that formaldehyde exposure can damage the nasal epithelium and produce inflammation, degeneration and proliferative changes.

The preventive group showed better preservation of mucosal architecture compared with the disease-control group. Only mild epithelial irregularity, minimal inflammation and vascular congestion were observed, while the glands and olfactory cells were largely preserved. This suggests that concurrent administration of *Haritaki kwatha* may have reduced formaldehyde-induced tissue injury. *Terminalia chebula* has demonstrated antioxidant and anti-inflammatory properties in experimental studies, which may contribute to this protective effect.

The curative group showed further improvement, with near-normal epithelial continuity, preserved cellular arrangement and glands, and minimal inflammatory changes. The improvement may be related to the antioxidant and anti-inflammatory properties of *Haritaki*. Recent experimental evidence also supports cytoprotective and antioxidant effects of *T. chebula* in oxidative epithelial injury models.

Formaldehyde vapour may be correlated with *Bashpa* and *Teekshna Gandha*, causing irritation and disturbance of the nasal mucosa. *Haritaki*, described as *Tridoshahara, Anulomana and Rasayana*, may help restore physiological balance. Its antioxidant and anti-inflammatory properties may further contribute to the improved epithelial architecture observed in the treated groups.

Hence formaldehyde exposure produced noticeable structural injury to the nasal mucosa, whereas *Haritaki kwatha* administration was associated with better preservation and

restoration of tissue architecture. The findings suggest protective and restorative effects of *Haritaki kwatha* against formaldehyde-induced nasal mucosal injury.

5. CONCLUSION

Repeated inhalation of formaldehyde vapour produced consistent histological changes of the rat nasal mucosa, involving the ciliated epithelium, goblet cells, Bowman's glands, olfactory receptor neurons and lamina propria, together with weight loss and irritant behaviour.Simultaneous administration of *Haritaki kwatha* attenuated these changes, and administration after exposure was accompanied by near-normal mucosal histology. These findings support a protective and restorative role for *Haritaki kwatha* in formaldehyde-induced nasal injury.

REFERENCES

1. World Health Organization. WHO Guidelines for Indoor Air Quality: Selected Pollutants. Copenhagen: WHO Regional Office for Europe; 2010.
2. International Agency for Research on Cancer. Formaldehyde, 2-Butoxyethanol and 1-tert-Butoxypropan-2-ol. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Vol. 88. Lyon: IARC; 2006.
3. IARC Working Group. Chemical Agents and Related Occupations: Formaldehyde. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Vol. 100F. Lyon: IARC; 2012.
4. Occupational Safety and Health Administration. Formaldehyde Standard, 29 CFR 1910.1048. Washington DC: US Department of Labor.
5. Akbar-Khanzadeh F, Vaquerano MU, Akbar-Khanzadeh M, Bisesi MS. Formaldehyde exposure, acute pulmonary response, and exposure control options in a gross anatomy laboratory. Am J Ind Med., 1994; 26(1): 61–75.
6. Kulle TJ. Acute odor and irritation response in healthy nonsmokers with formaldehyde exposure. Inhal Toxicol, 1993; 5(3): 323–332.
7. Standring S, editor. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 42nd ed. London: Elsevier; 2020.
8. Mescher AL. Junqueira's Basic Histology: Text and Atlas. 16th ed. New York: McGraw-Hill Education; 2021.
9. Young B, O'Dowd G, Woodford P. Wheater's Functional Histology. 6th ed. Philadelphia: Elsevier; 2014.

10. Kerns WD, Pavkov KL, Donofrio DJ, Gralla EJ, Swenberg JA. Carcinogenicity of formaldehyde in rats and mice after long-term inhalation exposure. Cancer Res., 1983; 43(9): 4382–4392.
11. Monticello TM, Swenberg JA, Gross EA, Leininger JR, Kimbell JS, Seilkop S, et al. Correlation of regional and nonlinear formaldehyde-induced nasal cancer with proliferating populations of cells. Cancer Res., 1996; 56(5): 1012–1022.