RESEARCH PAPER

Comparative Pharmaceutico-Analytical, Antioxidant, and Hepatoprotective Evaluation of Rohitakadi Vati and Rohitakadi Tablet Prepared with Karvellaka Swarasa Bhavana

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ABSTRACT

Background:
Rohitakadi Vati is a traditional Ayurvedic medication for hepatic and splenic diseases. According to *Bhaishajyaratnavali*, it is administered with *Karvellaka Swarasa* as *Anupana*. However, the routine administration of fresh *Karvellaka Swarasa* is frequently inconvenient due to issues with availability, preparation, and patient adherence. As a result, a modified dosage form incorporating *Karvellaka Swarasa* via *Bhavana* was produced in the current study.

Objective:
To create and assess a modified dosage form called Rohitakadi Tablet and compare its hepatoprotective potential, antioxidant activity, and pharmaceutico-analytical properties with those of traditional Rohitakadi Vati.

Materials and Methods:

The original text was followed in the production of the Rohitakadi Vati, and the *Karvellaka Swarasa Bhavana* technique was used to produce the Rohitakadi Tablet, which was then compressed. Following that, organoleptic, physicochemical, and HPTLC analyses were performed on the two formulations. DPPH scavenging was used to measure the antioxidant effect, while the MTT test was used for examining the hepatoprotective activity against CCl_4-induced toxicity in HepG2 cells.

Results:
The pharmaceutical qualities of both formulations were sufficient. Compared to Rohitakadi Vati, Rohitakadi Tablet had greater quantities of alcohol-soluble (14.98%) and water-soluble (31.41%) extractives. The tablet formulation had a broader phytochemical fingerprint, according to HPTLC analysis that revealed variations in chromatographic profiles. Rohitakadi Tablet demonstrated somewhat higher antioxidant activity (61.20% inhibition at 1000 µg/mL) in the DPPH experiment than Rohitakadi Vati (57.78%). Both formulations demonstrated protective activity against CCl_4-induced toxicity in the hepatoprotective testing. At 101.39 µg/mL, Rohitakadi Vati had somewhat better activity than Rohitakadi Tablet (115.96 µg/mL).

Conclusion:
The features of both analysis and biology have been preserved thanks to the pharmacological changes made to the traditional formulation of Rohitakadi Vati in order to turn it into tablets using *Karvellaka Swarasa Bhavana*. These tablets maintained comparable hepatoprotective qualities while having superior pharmacological and antioxidant qualities.

Keywords: Bhavana; Hepatoprotective Activity; HPTLC; Karvellaka Swarasa; Rohitakadi Tablet; Rohitakadi Vati; Yakrit Vikara.

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Introduction

Liver illnesses are a significant global health concern and one of the main causes of morbidity and mortality worldwide. The liver is responsible for a wide range of physiological functions including metabolism, detoxification, synthesis of plasma proteins, bile secretion, and maintenance of biochemical homeostasis. Chronic exposure to alcohol, environmental pollutants, infectious agents, xenobiotics, and irrational drug use predisposes hepatic tissue to oxidative stress and hepatocellular injury.[1] Even though various modern hepatoprotective agents are available, their long-term use is not offer much benefit due to the associated side-effects and cost factors. Therefore, there is growing interest in herbal and traditional medicines for safer and effective hepatoprotective therapies.[2]

Ayurveda describes Yakrit Vikara and Pliha Vikara as disease conditions associated with disturbance of Agni, Dosha, and metabolic functions. For their therapy, a number of herbal preparations with Deepana, Pachana, Lekhana, and Rasayana qualities have been suggested. In Yakrit-Pliha Vikara, Gulma, Pandu, Udara Roga, and Shotha, rohitaka (Tecomella undulata Seem.) is a significant medicinal plant.[3] Tecomella undulata's hepatoprotective, antioxidant, anti-inflammatory, and immunomodulatory properties have been shown in experiments, validating its traditional medicinal use. [4–6]

Rohitakadi Vati, described in *Bhaishajyaratnavali*, is a classical polyherbal formulation indicated in hepatosplenic disorders. The formulation contains Rohitaka along with Karanja, Karvellaka, Ajwain, Talmakhana, Chitrakamoola Twak, Narsala, and Saindhava Lavana.[3] In the original classical reference, Karvellaka Swarasa is specifically mentioned as Anupana for administration of Rohitakadi Vati. Karvellaka (*Momordica charantia* Linn.) is known to have properties like Tikta Rasa, Deepana-Pachana properties, antioxidant activity, and documented hepatoprotective potential.[7] Previous studies have reported significant free radical scavenging activity and hepatoprotective activity of *Momordica charantia* due to the presence of flavonoids, phenolic compounds, charantin, and other bioactive phytoconstituents.[8–10]

However, routine administration of Karvellaka Swarasa along with Rohitakadi Vati is practically difficult because of issues related to fresh availability, poor taste, problem with preparation, and reduced patient compliance. Therefore, in the present study, an attempt was made to develop a modified tablet dosage form using Bhavana of Karvellaka Swarasa during pharmaceutical processing. Bhavana is one opharmaceutical process in Ayurveda that enhances drug potentiation, homogenization, bioavailability, and therapeutic efficacy through repeated impregnation of liquid media into powdered drugs.[11] Incorporation of Karvellaka Bhavana into tablet formulation was intended to preserve the therapeutic significance of the original Anupana while simultaneously improving convenience, shelf life, stability, and therapeutic potency.

In recent years, transformation of classical Ayurvedic formulations in the forms of modern pharmaceutical preparations has gained considerable importance for improving dose uniformity, physicochemical stability, portability, patient compliance, and large-scale manufacturing feasibility.[12] Tablets are superior to traditional Vati formulations in terms of better standardization and shelf stability. Additionally, pharmaceutical processing methods like Bhavana can improve active phytoconstituent extraction and absorption, increasing therapeutic efficacy.[11]

To guarantee quality, repeatability, and therapeutic dependability, Ayurvedic compositions must be

standardized and scientifically validated. Phytochemical fingerprinting and comparative analytical profiling of herbal preparations are two common uses for High Performance Thin Layer Chromatography (HPTLC). [13] Furthermore, antioxidant assays and in vitro hepatoprotective studies using HepG2 cell lines provide important scientific evidence for evaluating hepatoprotective potential, particularly because oxidative stress plays a major role in the pathogenesis of hepatocellular injury. [14,15]

Although Rohitakadi Vati possesses classical importance in the management of liver diseases, limited scientific literature is available regarding its pharmaceutico-analytical standardization and comparative evaluation with a modified tablet dosage form prepared using Karvellaka Bhavana. Therefore, the present study was undertaken to prepare Rohitakadi Tablet incorporating Karvellaka Swarasa Bhavana and to comparatively evaluate Rohitakadi Vati and Rohitakadi Tablet through pharmaceutico-analytical parameters, HPTLC profiling, antioxidant activity, and in vitro hepatoprotective assessment.

Aim

To prepare and standardize a modified tablet dosage form of Rohitakadi Vati using Karvellaka Swarasa Bhavana and to comparatively evaluate the pharmaceutico-analytical, antioxidant, and hepatoprotective activities of Rohitakadi Vati and Rohitakadi Tablet.

Objectives

1. To prepare Rohitakadi Vati as per the classical reference mentioned in *Bhaishajyaratnavali*.
2. To prepare Rohitakadi Tablet by incorporating Karvellaka Swarasa Bhavana considering its classical role as Anupana.
3. To carry out pharmaceutico-analytical evaluation of Rohitakadi Vati and Rohitakadi Tablet.
4. To perform comparative HPTLC fingerprint profiling of both formulations at 254 nm and 366 nm.
5. To evaluate the in vitro antioxidant activity of Rohitakadi Vati and Rohitakadi Tablet using DPPH assay.
6. To assess the in vitro hepatoprotective activity of both formulations against CCl4-induced toxicity using HepG2 cell line.

Materials and methods

Raw drugs required for preparation of Rohitakadi Vati and Rohitakadi Tablet were procured from authenticated sources and identified prior to pharmaceutical processing. The formulation was prepared according to the reference mentioned in *Bhaishajyaratnavali*.[16] Rohitakadi Vati was prepared by cleaning, shade drying, powdering, and sieving all ingredients separately through mesh no. 80 followed by uniform mixing and preparation of Vati. Rohitakadi Tablet was prepared using the same ingredients; however, considering the classical use of Karvellaka Swarasa as Anupana, Bhavana of freshly prepared Karvellaka Swarasa was administered during pharmaceutical processing. The triturated material was dried, granulated, and compressed into tablet form using standard pharmaceutical procedures. Both formulations were subjected to organoleptic and physicochemical evaluation including color, odor, taste, loss on drying, total ash, acid insoluble ash, extractive values, and pH according to standard Ayurvedic pharmacopeial methods.[17] Tablet-specific parameters including hardness, friability, weight variation, and disintegration time were also evaluated.[18]

Comparative HPTLC fingerprint profiling of Rohitakadi Vati and Rohitakadi Tablet was performed using CAMAG HPTLC system. Methanolic extracts of individual ingredients and finished formulations were applied on silica gel 60 F254 precoated plates and chromatographic development was carried out using Toluene: Ethyl acetate (7:3) as mobile phase. Densitometric scanning was performed at 254 nm and 366 nm.[19] Antioxidant activity of both formulations was evaluated by DPPH free radical scavenging assay using 96-well plate method.[20] In vitro hepatoprotective activity was assessed against CCl4-induced toxicity using HepG2 human liver cell line by MTT assay method.[21] HepG2 cells were treated with different concentrations of Rohitakadi Vati, Rohitakadi Tablet, and standard Silymarin, and cell viability was measured spectrophotometrically at 540 nm. The obtained data were expressed as mean ± standard deviation (SD) and analyzed using appropriate statistical methods.[22]

Result

A) Pharmaceutical Evaluation of Rohitakadi Vati and Rohitakadi Tablet

Rohitakadi Vati and Rohitakadi Tablet were successfully prepared using the prescribed ingredients according to the classical formulation. Karvellaka Swarasa Bhavana was added to the tablet formulation

during pharmaceutical processing. It was discovered that both formulations had acceptable organoleptic properties and were appropriate for additional biological and analytical testing.

Table 1. Organoleptic Characteristics of Rohitakadi Vati and Rohitakadi Tablet

Parameter	Rohitakadi Vati	Rohitakadi Tablet
Color	Greenish	Greenish
Odor	Characteristic	Characteristic
Taste	Bitter	Bitter

The greenish appearance, distinctive smell, and bitter taste of Rohitakadi Vati and Rohitakadi Tablet were similar organoleptic traits.

Physicochemical Evaluation

Table 2. Physicochemical Parameters of Rohitakadi Vati and Rohitakadi Tablet

Parameter	Vati	Tablet
Loss on drying at 105° c	0.33%	0.49%
Total ash	2.89%	2.1%
Water Soluble Ash	0.9%	1.1%
Acid Insoluble Ash	0.5%	0.5%
Water Extractive value	26.45%	31.41%
Alcohol Extractive value	13.23%	14.98%
pH	6.8	6.6

Physicochemical evaluation revealed low moisture content and comparable ash values in both formulations, while the tablet showed relatively higher water-soluble and alcohol-soluble extractive values.

Table 3. Tablet Evaluation Parameters

Parameter	Vati	Tablet
Hardness Test	3.5 kg/cm^2	3.5 kg/cm^2
Friability Test	0.5%	0.5 %
Disintegration time	4 min	4 min

The tablet formulation also demonstrated satisfactory post-compression characteristics, with acceptable hardness, friability, and disintegration time, indicating its pharmaceutical suitability.

B) HPTLC Fingerprint Analysis

1) HPTLC Profile at 254 nm

Comparative HPTLC fingerprint profiling of Rohitakadi Vati and Rohitakadi Tablet was carried out at 254 nm using silica gel 60 F254 as the stationary phase and Toluene: Ethyl acetate (7:3) as the mobile phase. Distinct chromatographic peaks corresponding to various phytoconstituents were observed in both formulations. The chromatographic profiles demonstrated the presence of multiple constituents and revealed variations in peak number and distribution pattern between the two formulations.

Table 4. Comparative HPTLC Peak Profile of Rohitakadi Vati and Rohitakadi Tablet at 254 nm

Peak No.	Rohitakadi Vati (Rf)	Area %	Rohitakadi Tablet (Rf)	Area %
1	0.03	38.38	0.03	20.64
2	0.48	24.17	0.14	2.74
3	0.67	22.43	0.38	21.09
4	0.84	15.01	0.49	8.99

Peak No.	Rohitakadi Vati (Rf)	Area %	Rohitakadi Tablet (Rf)	Area %
5	—	—	0.72	11.03
6	—	—	0.96	24.43
7	—	—	1.01	11.09

The HPTLC chromatogram of Rohitakadi Vati exhibited four major peaks at Rf values of 0.03, 0.48, 0.67, and 0.84. In contrast, Rohitakadi Tablet showed seven peaks at Rf values of 0.03, 0.14, 0.38, 0.49, 0.72, 0.96, and 1.01. A common peak was observed at Rf 0.03 in both formulations, indicating the presence of shared phytochemical constituents. The tablet formulation exhibited a greater number of resolved peaks compared to the classical Vati, suggesting a comparatively broader phytochemical fingerprint. The chromatographic profiles confirmed the presence of multiple phytoconstituents in both formulations while demonstrating variations in peak distribution following pharmaceutical modification.

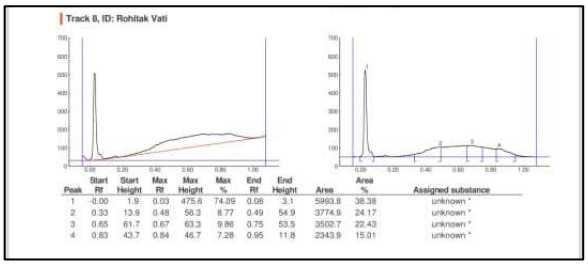


Figure No. 1 – HPTLC chromatogram of Rohitakadi Vati at 254 nm

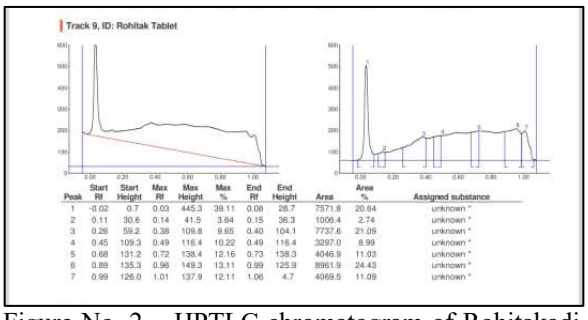


Figure No. 2 – HPTLC chromatogram of Rohitakadi Tablet at 254 nm

The HPTLC chromatograms revealed distinct phytochemical fingerprints for both formulations. Rohitakadi Tablet exhibited a higher number of resolved peaks compared to Rohitakadi Vati, indicating variations in phytochemical composition following pharmaceutical modification.

2. HPTLC Profile at 366 nm

Comparative HPTLC fingerprint profiling of Rohitakadi Vati and Rohitakadi Tablet was performed at 366 nm to evaluate the fluorescent phytochemical constituents present in both formulations. Distinct chromatographic peaks were observed in both formulations, indicating the presence of multiple phytoconstituents with varying fluorescence characteristics. The chromatographic profiles demonstrated similarities as well as differences in peak distribution pattern and relative peak areas between the two formulations.

Table 5. Comparative HPTLC Peak Profile of Rohitakadi Vati and Rohitakadi Tablet at 366 nm

Peak No.	Rohitakadi Vati (Rf)	Area %	Rohitakadi Tablet (Rf)	Area %
1	0.03	68.18	0.03	75.51
2	0.07	7.29	0.13	11.16
3	0.15	14.74	0.96	8.08
4	0.28	2.88	1.01	5.25
5	0.86	6.91	—	—

Rf = Retardation factor

The HPTLC chromatogram of Rohitakadi Vati exhibited five major peaks at Rf values of 0.03, 0.07, 0.15, 0.28, and 0.86, whereas Rohitakadi Tablet exhibited four peaks at Rf values of 0.03, 0.13, 0.96, and 1.01. A prominent common peak was observed at Rf 0.03 in both formulations, representing the major phytochemical constituent. Rohitakadi Vati showed five resolved peaks while Rohitakadi Tablet exhibited four peaks with comparatively higher area contribution of the principal peak. The chromatographic fingerprints obtained at 366 nm confirmed the presence of fluorescent

phytoconstituents in both formulations and demonstrated variations in phytochemical distribution following pharmaceutical modification.

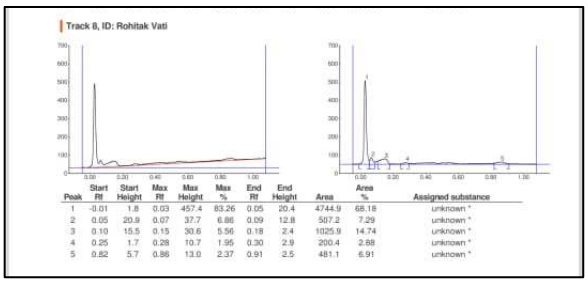


Figure No. 3 – HPTLC chromatogram of Rohitakadi Vati at 366 nm

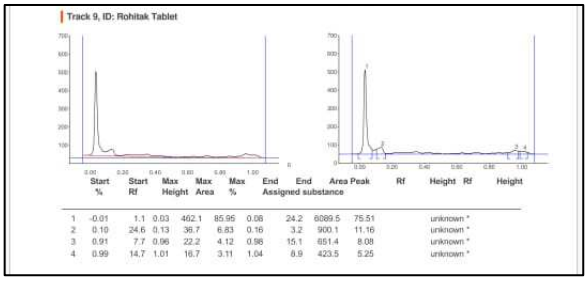


Figure No.43 – HPTLC chromatogram of Rohitakadi Tablet at 366 nm

Figure 3 and Figure 4 depict the HPTLC chromatographic fingerprints of Rohitakadi Vati and Rohitakadi Tablet at 366 nm, respectively. The fluorescent peak pattern observed at this wavelength further confirmed the presence of diverse phytochemical constituents in both formulations.

C. In Vitro Antioxidant Activity

The antioxidant activity of Rohitakadi Vati and Rohitakadi Tablet was evaluated using the DPPH free radical scavenging assay at concentrations ranging from 200–1000 µg/mL. Both formulations demonstrated concentration-dependent antioxidant activity, as evidenced by the progressive increase in percentage inhibition with increasing concentration. The standard antioxidant, ascorbic acid, exhibited the highest radical scavenging activity at all tested concentrations.

Table 6. DPPH Radical Scavenging Activity of Rohitakadi Vati and Rohitakadi Tablet

Concentration (µg/mL)	Ascorbic Acid (%)	Rohitakadi Vati (%)	Rohitakadi Tablet (%)
200	76.27	47.88	46.97
400	77.31	54.96	55.23
600	77.56	56.65	58.31
800	83.22	57.29	59.56
1000	91.88	57.78	61.20

At 1000 µg/mL, Rohitakadi Tablet exhibited 61.20% inhibition, whereas Rohitakadi Vati showed 57.78% inhibition. Both formulations demonstrated appreciable free radical scavenging activity; however, the tablet formulation showed comparatively higher antioxidant activity at concentrations of 400–1000 µg/mL. The antioxidant activity of the tested samples followed the order: Ascorbic Acid > Rohitakadi Tablet > Rohitakadi Vati.

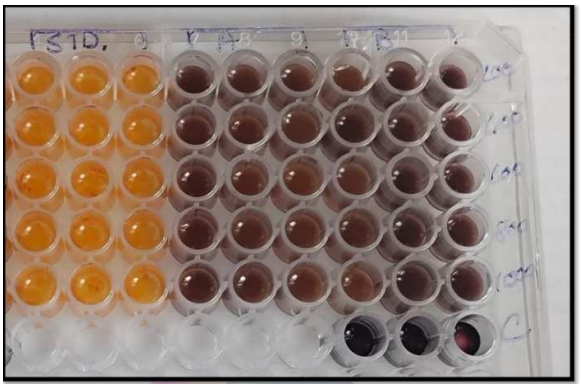


Figure 5. DPPH radical scavenging assay of Rohitakadi Vati, Rohitakadi Tablet, and Ascorbic Acid using 96-well plate method.

D. In Vitro Hepatoprotective Activity

The hepatoprotective activity of Rohitakadi Vati and Rohitakadi Tablet was evaluated against CCl_4-induced toxicity in HepG2 cells using the MTT assay. Both formulations exhibited protective activity against CCl_4-induced cellular damage and demonstrated concentration-dependent responses. Silymarin was used as the standard hepatoprotective drug.

Table 7. Hepatoprotective Activity of Rohitakadi Vati and Rohitakadi Tablet Against CCl_4-Induced Toxicity in HepG2 Cells

Sample	Concentration (µg/mL)	Cell Viability (%)
CCl_4-induced HepG2 cells	—	33.64
Silymarin	50	53.16
	100	65.47
	200	82.70
Rohitakadi Vati	50	58.62
	100	46.93
	200	38.76
Rohitakadi Tablet	50	59.02
	100	47.73
	200	43.09

Table 8. Comparative IC_{50} Values

Sample	IC_{50} (µg/mL)
Silymarin	28.17
Rohitakadi Vati	101.39
Rohitakadi Tablet	115.96

The CCl_4-treated HepG2 cells exhibited a cell viability of 33.64%, indicating significant cellular damage. Treatment with Silymarin resulted in a concentration-dependent increase in cell viability, reaching 82.70% at 200 µg/mL. Both Rohitakadi Vati and Rohitakadi Tablet demonstrated hepatoprotective activity against CCl_4-induced toxicity. Based on IC_{50} values, Rohitakadi Vati (101.39 µg/mL) exhibited slightly greater hepatoprotective activity than Rohitakadi Tablet (115.96 µg/mL), while both formulations showed lower activity compared to the standard drug Silymarin (28.17 µg/mL).

Discussion

Rohitakadi Vati is a classic formula of Ayurveda used in cases where there is malfunctioning of the organs, namely, Yakrit and Pliha. As per Bhaishajyaratnavali, Karvellaka Swarasa is recommended as Anupana for this preparation, indicating its significance in enhancing the pharmacological value of the preparation.[3] However, taking this preparation with fresh Karvellaka Swarasa is not feasible owing to several practical difficulties such as availability, preparation, palatability, and compliance. Hence, in the current research work, an innovative dosage form named Rohitakadi Tablet has been designed by incorporating Karvellaka Swarasa using Bhavana method.[11]

Bhavana is one of the important processes in pharmaceutical technology which is mentioned in Ayurveda and is involved in the intimate mixing of the drug material with the liquid medium.[11] In this particular study, Karvellaka Swarasa was chosen as Bhavana Dravya owing to its traditional use in Rohitakadi Vati and its antioxidant and liver protective actions.[7,8] Moreover, formulation of this formulation into tablets was considered to improve dose uniformity, portability, compliance, and shelf life of the product without compromising on its therapeutic value.[18]

Organoleptic assessment found the similarities between the two preparations concerning their green colour, typical odour, and bitterness. This is an indication that the sensory properties of the original formulation were conserved. Physicochemical evaluation of the formulations showed the presence of low moisture contents within them, thus reducing the risk of microbial spoilage and hence increased stability of the formulations. Importantly, the water and alcohol soluble extractives of Rohitakadi Tablet formulation were more compared to those of Rohitakadi Vati formulation. This could be explained by the fact that the Bhavana process using Karvellaka Swarasa was responsible for the addition of the phytoconstituents to the formulations.[11]

The comparative HPTLC analysis provided important insights into the phytochemical composition of both formulations. HPTLC fingerprinting technique is extensively used for assessing the quality of herbal

formulations as it helps generate a unique profile which represents the chemical constituents in them.[13] In the current case, four major peaks were seen in the case of Rohitakadi Vati while there were seven peaks in the Rohitakadi Tablets when observed under 254 nm wavelength light. Similarly, changes in the pattern of peaks were observed in the case of 366 nm wavelength light. Presence of extra peaks in the tablet formulation suggests that there have been changes in the phytochemical profile post-processing and Bhavana with Karvellaka Swarasa.

The presence of a shared peak between the two formulations suggests that the raw materials used to make Rohitakadi Vati contain similar phytochemicals. Conversely, the presence of more peaks in the chromatogram of the Rohitakadi Tablet formula may indicate that the Karvellaka Swarasa utilized in the Bhavana process contains more phytochemicals.[11] Other Ayurvedic medicinal research also show this observation about chromatogram variations, which point to both chemical and physical changes in the preparation process.[23]

The physicochemical results, which showed that Rohitakadi Tablet had higher water-soluble and alcohol-soluble extractive values than the traditional Vati, are likewise consistent with the HPTLC findings. The biological activity seen in later antioxidant and hepatoprotective assessments may be attributed to increased extractive values, which may indicate increased availability of phytoconstituents.[24] Thus, the analytical results indicate that Karvellaka Swarasa Bhavana's pharmaceutical alteration successfully maintained the classical formulation's phytochemical complexity while adding quantifiable changes to its chromatographic profile.

The antioxidant activity of herbal combinations is deemed a vital pharmacological effect owing to the fact that oxidative stress has been implicated in the development of several liver diseases. The overproduction of reactive oxygen species may cause peroxidation of lipids, denaturation of proteins, and cell damage, finally resulting in the malfunctioning of hepatocytes.[15] Hence, substances that exhibit free radical scavenger activity may help protect the liver through their antioxidative effects.[25]
In the current study, both Rohitakadi Vati and Rohitakadi Tablet showed concentration-dependent antioxidant activity in the DPPH assay. Rohitakadi Tablet has somewhat stronger free radical scavenging activity than Rohitakadi Vati at doses from 400 to 1000 µg/mL. This increased activity could be attributed to the inclusion of additional phytoconstituents via Karvellaka Swarasa Bhavana, as seen by the higher extractive values and altered HPTLC fingerprint profile seen in the tablet formulation. The presence of bioactive substances with antioxidant properties may have contributed to the modified formulation's enhanced radical scavenging ability.[7,8]
It has been reported that the Karvellaka plant (Momordica charantia) contains a number of bioactive substances like phenolic, flavonoid, triterpenoid, and other antioxidants, which are known to have significant free radical scavenging ability.[7,8] Likewise, Rohitaka (Tecomella undulata) and Karanja (Pongamia pinnata), important constituents of Rohitakadi Vati, have also shown to possess antioxidative abilities.[26,27] Hence, the demonstrated antioxidant effects seen in both formulations could be due to the collective effect of various phytoconstituents present in the formulation.
Even though the antioxidant activity of both drugs was found to be less compared to the standard drug ascorbic acid, the data indicated a considerable amount of free radical scavenging activity. As the activity in case of Rohitakadi Tablet was significantly high, this indicated that Bhavana with Karvellaka Swarasa improved the availability of the antioxidants without reducing the efficacy of the preparation. Considering the importance of oxidative stress in inducing liver damage, the above observations on antioxidant activity can contribute towards explaining the hepatoprotective activity seen in the next experiment.[9,10]

Rohitakadi Vati and Rohitakadi Tablet's hepatoprotective efficacy was assessed utilizing the CCl_4-induced HepG2 cell model, a well-established in vitro technique for testing the protective effects of medicinal medicines against chemically induced liver injury.[28] The metabolic activation of carbon tetrachloride (CCl_4) produces highly reactive free radicals that cause lipid peroxidation, oxidative stress, and membrane damage, leading to hepatocyte injury.[29] Protection against CCl_4-induced cytotoxicity is a key sign of hepatoprotective potential.

Protective activity of both formulations was seen in CCl_4-induced toxicity, indicating their potential as hepatoprotectors. However, in contrast to the antioxidant assay, where the efficacy of both formulations was comparable, the hepatoprotective assay showed marginally higher efficacy of Rohitakadi Vati, based on its IC_{50} being relatively lower compared to that of Rohitakadi Tablet. The finding implies that while Bhavana with Karvellaka Swarasa resulted in enhanced antioxidant activity, it

does not lead to corresponding improved hepatoprotective efficacy under experimental conditions in the current study. Hepatoprotection involves several processes other than antioxidant/free radical scavenging activity, such as membrane stabilization, control of inflammatory mediators, stimulation of cellular repair processes, and regulation of antioxidant activity within the cell.

The disparity between antioxidant and hepatoprotective results could further mean that the conventional preparation has an optimized phytochemical profile that renders its biological action. Despite the diminution in the protective effect seen from the tablet form of the preparation, this should not be assumed as having any adverse impact on the effectiveness of the preparation since both forms have shown a considerable level of protection against the CCl_4-induced oxidative stress. Additionally, the hepatoprotective effects exhibited by the two preparations were equal and significantly lesser compared to the reference hepatoprotective drug Silymarin.[30]

The hepatoprotective activity noticed in both preparations could be due to the synergistic effect of the combination of the drugs present in them. Rohitaka (Tecomella undulata) has been known for its hepatoprotective, antioxidant, and anti-inflammatory properties as well as being used for treating ailments related to liver and spleen.[26] In a similar fashion, Karvellaka (Momordica charantia) has been found to have hepatoprotective activity in laboratory experiments by virtue of its antioxidant and cytoprotective activities.[8] Karanja (Pongamia pinnata) has also shown hepatoprotective properties by reducing oxidative stress and by normalizing the hepatic enzyme system.[27]

Taken together, the hepatoprotective data indicate that pharmaceutical modification of Rohitakadi Vati into tablet form successfully maintained the original formulation's biological efficacy. Although Rohitakadi Vati revealed somewhat superior hepatoprotective action in the current experimental paradigm, Rohitakadi Tablet demonstrated comparable efficacy while providing advantages in terms of standardization, convenience, dose uniformity, and patient acceptance. These findings lend credence to the feasibility of establishing a reduced dosage form based on classical Ayurvedic principles while retaining significant therapeutic potential.

The results of the current study indicate that the pharmaceutical transformation of the classical Rohitakadi Vati into Rohitakadi Tablet by the process of Karvellaka Swarasa Bhavana showed modifications in terms of analytical and biological characteristics of the formulation. As seen from the high extractive values and modifications in HPTLC fingerprint profile, phytoconstituents have been successfully included in the tablet formulation through the process of Bhavana. These results have been validated through the antioxidant activity test, wherein the Rohitakadi Tablet showed higher DPPH scavenging activity when compared to the classical formulation. This finding conforms to the Samskara principle of Ayurveda, wherein pharmaceutical treatment is known to modify the formulation while keeping its medicinal nature unchanged.[11]

In the HepG2 cell model, Rohitakadi Vati showed significantly greater hepatoprotective action than Rohitakadi Tablet. However, both formulations provided significant protection against CCl_4-induced toxicity. Overall, the results show that the pharmacological alteration had no negative effect on the formulation's biological activity and that its hepatoprotective potential was successfully maintained. From a practical standpoint, the tablet dosage form provides benefits such as improved patient compliance, dose homogeneity, portability, ease of administration, and increased stability, making it a viable alternative to the traditional formulation. Thus, the current work provides early scientific data justifying the conversion of a traditional Ayurvedic formulation into a modern dosage form while retaining its therapeutic relevance and analytical integrity.

Conclusion

The Rohitakadi Tablet was successfully developed as an innovation to the conventional Rohitakadi Vati using Karvellaka Swarasa using the Bhavana method. HPTLC fingerprint analysis revealed variations in phytochemistry as a result of pharmacological intervention, although comparative pharmaceutico-analytical study demonstrated that quality parameters were good in both preparations. Rohitakadi Tablet's HPTLC chromatogram and extractive value were found to be superior to those of the conventional preparation.

Both formulations demonstrated concentration-dependent antioxidant activity, however the Rohitakadi Tablet's capacity to scavenge free radicals was marginally superior. Both formulations demonstrated protective effect in the hepatoprotective

experiment against CCl_4-induced toxicity in HepG2 cells, with Rohitakadi Vati exhibiting somewhat greater efficacy (IC_{50} values). All things considered, the new tablet formulation effectively maintained the essential analytical and biological characteristics of the traditional preparation while offering advantages such improved patient compliance, dosage uniformity, convenience, and stability. To verify its therapeutic efficacy in hepatic disorders, more in vivo and clinical research is required..

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