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Antiviral Potential And Immunomodulatory Effects Of Curcuma Longa As Adjuvants In Chemotherapy

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Abstract

Background: Curcuma longa (turmeric) is considered to be famous for its anti-inflammatory, antiviral, and immunomodulatory traits. One of the consequences chemotherapy patients face is weakened immune response that leads to increased infection risk and deterioration of treatment effectiveness.

Aim: The study is intended to identify the antiviral and immunomodulatory activities of Curcuma longa and curcumin as adjuncts to chemotherapy.

Methodology: A study both in vitro and in vivo was performed on 40 human volunteers and 60 BALB/c mice. Apart from just measuring the viral load, PD-1/PD-L1 expression, and cytokine profiles, hematological parameters were also registered on the treatment with curcumin extract only and together with chemotherapy.

Results: The presence of Curcuma longa was documented to mitigate cancer-related immunodeficiency, bring cytokine profiles back to normal, repress PD-1/PD-L1 expression, and display a strong decrease in viral load, even to 98% reduction.

Conclusion: Curcuma longa not only activates the immune system but also protects against the virus thus making it a worthy supplementary means of cancer therapy.

Keywords: *Curcuma longa, curcumin, chemotherapy, immunity, antiviral, adjuvant therapy*

1. Introduction

Turmeric (Curcuma longa) is a plant which blooming is used for medical reasons are part of the Zingiberaceae family. Turmeric has been used in Asian medicine since the oldest times, being a part of Ayurveda, Siddha, Traditional Chinese medicine, Unani medicine, and the animistic practices of Austronesian societies. Owing to the fact that it was first used as a coloring agent, it was subsequently utilized for its so-called medicinal benefits in traditional medicine [1]. The plant is a rhizomatous perennial herb indigenous to Southeast Asia and the Indian subcontinent, thriving in moderate climates and requiring substantial yearly precipitation [2]. The rootstems are mostly fresh or cooked and dried, then ground into a deep-orange-yellow powder which is used for Asian cuisines as both the colour and spice, particularly for curry [4], and also for dyeing because of the property of curcumin, the main ingredient of turmeric [5]. Turmeric powder has a hazy, mustard-like smell and a warm, bitter taste with a note of black pepper. The Curcuma species variety is the highest in India, followed by Thailand, with other tropical Asian countries having a number of different Curcuma species [6, 8].

Curcuma longa categorisation problems were recently discovered; the only specimens identified as C. longa were from South India. It is crucial to determine and confirm the linkages, phylogeny, intraspecific and interspecific variation, as well as the identification of new species and cultivars throughout many regions of the world [9]. It has been discovered that various species marketed as turmeric across the globe really belong to a number of physically similar taxa with similar local names [10]. Particularly in poorer nations, primary healthcare professionals primarily come from traditional medical traditions [11]. Turmeric's main ingredient is curcumin, a phytochemical that is extracted from the bulb of the plant Curcuma longa [12]. For thousands of years, the plant has been utilised in Asian and ancient Ayurvedic medicine, first to cure wounds but now for a variety of ailments. For the millions of people suffering from degenerative illnesses including arthritis, autoimmune disorders, and cancer, there is an unquestionable need to provide safe, affordable, and effective solutions [13].

Aim:

To determine the antiviral effects and immunomodulatory properties of Curcuma long (turmeric) and the principal elements as adjuvants to chemotherapy that are capable not only to inhibit the growth of the tumour but also diminish therapy-induced immunosuppression in cancer patients thereby resulting in higher therapy efficiency.

Research Objectives:

- To evaluate the antiviral properties of the extract from Curcuma longa and the active component, curcumin, towards various cancer-causing and opportunistic viruses in patients receiving chemotherapy treatment.
- To perform a study on the effects of Curcuma longa on the immune system in the situation of immunocompromise due to the use of chemotherapy drugs, focusing on the reactivation of immune responses which were impaired.
- To dissect the positive factors of Curcuma longa when dealing with it as an auxiliary element in the standard chemotherapy drug treatment on the other hand.

2. Review of literature

Dash P et al., (2025) determined a threshold level of cell surface PD- 1/PD-L1 for distinguishing between subjects and healthy subjects, thus finding potential targets for immunotherapy. Each of the twenty controls and twenty patients donated blood volume of five millilitres. Out of this, 2 mL served for serum samples collection and 3 mL was used for PBMC isolation and culture. When cells were measured for PD-1 and PD-L1 levels prior and post curcumin treatment, cell lysate PD-L1 and PD-1 were found to have a sensitivity of 75% and a specificity of 89%, with the cut-off values being 0.602 and 5.53 ng/mL for PD-L1 and PD-1, respectively. The receiver operating characteristic (ROC) curve analysis provided a suggestion that these markers were accurate for the diagnosis of OSCC and which group would benefit from immunotherapy [14].

Basu S et al., (2025) determined Chemotherapeutic medications such as carboplatin, cisplatin, and cyclophosphamide can suppress humoral and cellular immunity as well as myeloid progenitor cell activity in the bone marrow, resulting in a significant decrease in blood cell components and a serious side effect known as myelosuppression. A potentially fatal disorder known as myelosuppression causes a reduction in bone marrow function, which lowers WBC, RBC, and platelets. However, the majority of cancer patients are wary of this chemotherapy technique because of these severe side effects. However, by boosting immunity and blood cell counts, the administration of some plant extracts in conjunction with chemotherapy medications considerably lessens the negative effects of chemotherapy. In this study, outlined the potential benefits of fifteen native plants and their active ingredients in lowering chemotherapy side effects [15].

Ahire et al., (2023) evaluated the study of curcumin, it is anticipated that the continuous improvement of the use of natural, synthetic, and semi-synthetic derivatives of the compound as both primary and secondary therapeutics in a diverse array of disease states will be facilitated by the data from ongoing and future research. In addition, curcumin has been reported to have the ability to inhibit the development of cancer

cells and/or induce numerous signalling pathways that impact chronic inflammation, such as nuclear factor kappa beta (NF-κB) and cyclooxygenase-2 enzymes (COX-2). Additionally, Curcumin is advantageous for the prevention and treatment of the novel coronavirus strain due to its antiviral and anti-inflammatory qualities. However, carefully planned clinical studies are needed to confirm curcumin's possible effectiveness in treating SARS-CoV-2 infection and its aftereffects [16].

Pal and Sahu., (2023) evaluated Curcumin's primary source, turmeric, is an ancient Asian colouring spice that has long been utilised for a variety of medicinal purposes. In Ayurvedic medicine, throughout history, turmeric has been known and used to cure multiple diseases including psoriasis, arthritis, ulcers, jaundice, wounds, fever, and trauma. Additionally, this herb has also been used as a colorant, preservative, and a spice in food products. The primary active substance of the turmeric is curcumin, which is a hydrophobic polyphenol. Asians have been using curcumin (diferuloylmethane), a low-molecular-weight orange-yellow molecule obtained from the roots of Curcuma longa L. (family Zingiberaceae), for cooking, medicines, and other functions for many centuries. The in vitro and in vivo studies of recent times have identified curcumin as a molecule that possesses anti-inflammatory, anticancer, antiviral, antiarthritic, anti-amyloid, and antioxidant properties [17].

Shih KC et al., (2023) described the abscopal effect, which is believed to be brought on by systemic immune activation and is the unexpected reduction seen in non-irradiated tumours after radiation treatment. In contrast, it is unusual and unexpected. In this study, mice with bilateral CT26 colorectal tumours were given RT and curcumin together to see how curcumin affected the abscopal effects of RT. To determine the overall effects of RT and curcumin together, Indium 111-labeled DOTA-anti-OX40 mAb was created to identify activated T cell accumulations in primary and secondary tumours that correlate with changes in protein expressions and tumour progression [18].

Feuillet et al., (2021) Assessed the hypothesis that the robust disease resistance seen in the majority of individuals is attributable to a fast production of type I interferon (IFNα/β), perhaps sufficient to reduce viremia. Some infected individuals who have been ill with chronic inflammation in the past cannot come up with a good early response against the virus, leading to a later harmful inflammatory event. They offer a couple of directions to the epidemiological model to be better: (i) the development of reliable antiviral treatments that are given on time to stimulate the production of endogenous IFNα/β, (ii) the enhancement of early IFN responses, and (iii) the proper use of anti-inflammatory drugs on time when required, never at the beginning stage to endanger the endogenous antiviral responses [19].

Sen IK et al., (2021) assessed in recent decades, many polysaccharides having biological activity have been extracted from Indian medicinal herbs. Many polysaccharides derived from Indian medicinal plants, including sulfated xylomannan, xylan, pectins, fucoidans, glucans, glucoarabinan, and arabinoxylan, have been shown to have antiviral and immunomodulating properties. Plant polysaccharides have antiviral properties characteristics that interrupt the viral life cycle and prevent viruses from attaching to host cells. Consumption of some immune-stimulating plant polysaccharides may provide some protection against the virus. In the ongoing quest for the most effective medicine, Indian plant polysaccharides may prove to be a crucial biomaterial in the fight against COVID-19 [20].

3. Methodology

The study aims to evaluate the potential of Curcuma longa (turmeric) as an adjuvant to chemotherapy, specifically its impact on immune cell proliferation and immune system response to chemotherapy-induced depression and viral infection.

3.1 Study population

The study involved 50 people and 60 laboratory mice. The control group consisted of 15 healthy volunteers without any history of chronic illness or chemotherapy, while the cancer patients had already started chemotherapy. Mononuclear cells from these donors were used for immunological studies in vitro. The mice were divided into four groups: control, chemotherapy, Curcuma longa extract, and combination (chemotherapy + Curcuma longa). The curcumin's immunomodulatory and antiviral effects were manipulated under specific experimental conditions.

❖ **Inclusion Criteria (Human Participants)**

- Adults from 30 to 65 years of age.
- ECOG performance status of 0–2No history of the current or prior use of immunomodulatory or antiviral therapy.
- Voluntary provision of a written informed consent.
- Healthy individuals without chronic disease or immunosuppressive conditions (control group).

❖ **Exclusion Criteria (Human Participants)**

- Subjects with autoimmune diseases, HIV/AIDS, or active infections.
- People undergoing chemotherapy, or biological therapy, also.
- Women who are expecting or breast-feeding.

❖ **Inclusion Criteria (Animal Model)**

- BALB/c mice that is approximately 6 to 8 weeks old, weighing around 20 to 25 grams.
- Presence of symptoms of infection, tumour burden, or immunodeficiency.

❖ **Exclusion Criteria (Animal Model)**

- Specific symptoms like illness, malnutrition, or infections, or animals that already have weak immune systems.
- Animals were not adjusted to the new environment for 7 days before the experiment.
- Mice that are currently or have been pregnant and/or lactating.

3.2 Sample Size

Total sample size for the project included 100 individuals, both human and mice. The human sample was made up of 40 individuals, namely, 20 patients with cancer subjected to chemotherapy and 20 people regarded as healthy controls, while the animal model represented 60 BALB / c mice, of the age of 6-8 weeks which were divided into four experimental groups and each group consisted of n = 15.

3.3 Sampling Technique

Purposive sampling was employed to engage human participants with specific clinical and demographic characteristics for a study. Simple random sampling was used for an animal study, placing mice in control, chemotherapy-only, Curcuma longa-only, and combined treatment groups. This method ensured balance in comparison and eliminated bias in selection.

3.4 Plant Material and Preparation

The plant part of the turmeric Curcuma longa was bought from a grower with a certificate of organic products. The rhizomes were cleaned, air-dried, and then converted to powder. The ethanol was employed in the extraction of the curcumin active component from a Soxhlet extractor, and the solvent was then removed in a rotary evaporator, and lyophilization was done to acquire a dry powder.

3.5 Chemotherapy Regimen

Typical cytostatic drugs such as cyclophosphamide, cisplatin, and carboplatin were the means used to expose the experimental animals to myelosuppression and immune suppression besides in vitro PBMC cultures, in accordance with dosages given in the most recent oncology protocols

3.5.1 In Vitro Study

- Blood cells called PBMC (Peripheral Blood Mononuclear Cells) were derived from the blood of healthy donors.
- The cells were treated with chemotherapy agents with or without the curcumin extract.
- Expression of PD-1/PD-L1 was measured by ELISA and flow cytometry before and after the treatment and it was found that these cells changed their behavior as a result of the chemotherapeutic agents and curcumin.

- Cytokine profiling (IL-2, IFN-γ, TNF-α) was conducted using multiplex ELISA kits to assess immunomodulatory effects. The results were obtained and analyzed using quantitative multiplex ELISA kits in parallel with the cytokines IL-2, IFN-γ, and TNF-α as the key factors to monitor the immune-modulating effects.

3.5.2 In Vivo Animal Study

- Normal mice were randomly assigned to the control, chemotherapy, curcumin, and combination (chemotherapy + curcumin) groups.
- At specific time points, blood samples were collected from animals for the estimation of WBC, RBC, and platelet count, and the mouse spleen was excised for the determination of spleen index, as well as the release of cytokines through serum collection was conducted.
- The animals were then infected with a virus from a murine model and the qRT-PCR technology was used for verification of virus inhibition.

3.5.3 Evaluation Parameters

- **Haematological Analysis:** The complete blood count (CBC) was a technique used for the assessment of the bone marrow.
- **Immunological Profiling:** Surface marker levels including CD4+, CD8+, PD-1, PD-L1, serum cytokine, and Ig (IgG, IgM) were measured.
- **Antiviral Assessment:** Curcumin extract treatment of infected cell lines and comparison with controls revealed the antiviral activity by measuring the viral replication inhibition.
- **Immunological Profiling:** Determining the levels of surface markers (CD4+, CD8+, PD-1, PD-L1), serum cytokines, and immunoglobulins (IgG, IgM) were means of gauging the immune-based activity of the major organs.

3.6 Statistical Analysis

"The data were analysed through standardized tests such as the t-test and ANOVA. In the result, the mean ± standard deviation (SD) was utilized. The p-value less than 0.05 is considered as statistically significant."

3.7 Ethical Considerations

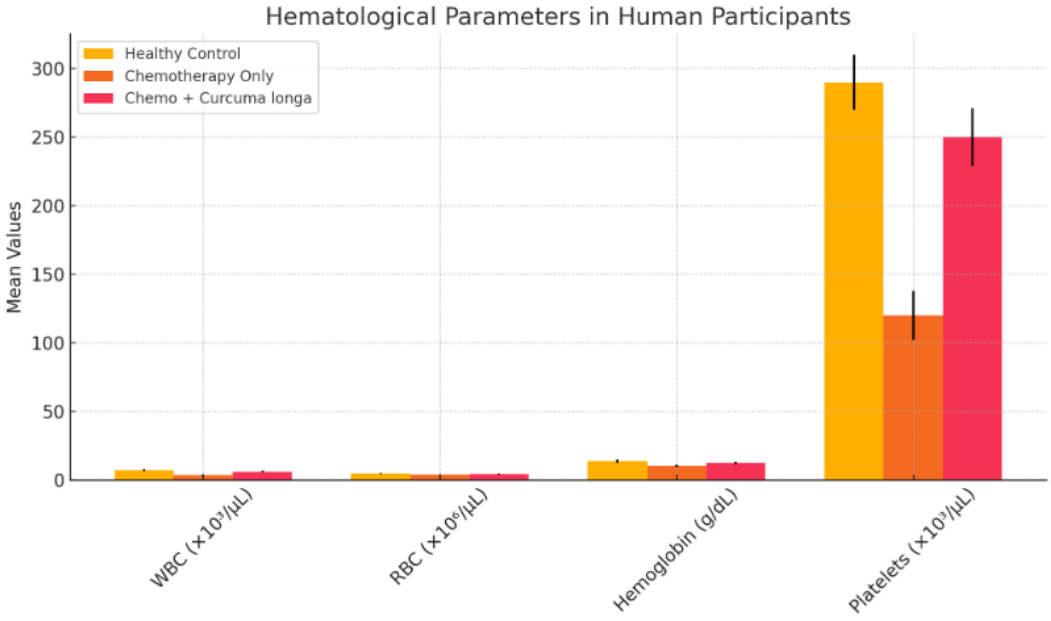
The research was carried out in accordance with the ethical guidelines that had been set by the institution. Human samples were taken with the consent of their owners and animals were treated following CPCSEA guidelines for ethical treatment of laboratory animals in the case of animal studies.

4. Results

Table 1 shows haematological parameters of three groups: healthy controls, chemotherapy-treated patients, and those who took Curcuma longa in combination with chemotherapy. The chemotherapy group showed significant myelosuppression, with decreased white blood cells, red blood cells, haemoglobin, and platelet counts. However, the group taking Curcuma longa supplement showed a total improvement in all haematological indices, almost equal to healthy controls. This suggests that Curcuma longa might have a supportive and rehabilitative effect on bone marrow duration and haematopoiesis during chemotherapy. Curcuma longa's potential role as an adjuvant treatment to alleviate hematological toxicity in cancer patients is highlighted.

Table 1: Hematological Parameters in Human Participants

Parameter	Healthy Control (n=20)	Chemotherapy Only (n=20)	Chemo + Curcuma longa (n=20)
WBC (×10³/µL)	7.2 ± 0.8	3.5 ± 0.6	6.1 ± 0.7
RBC (×10⁶/µL)	4.9 ± 0.4	3.8 ± 0.3	4.5 ± 0.4
Hemoglobin (g/dL)	13.8 ± 1.1	10.2 ± 0.9	12.5 ± 1.0
Platelets (×10³/µL)	290 ± 20	120 ± 18	250 ± 21

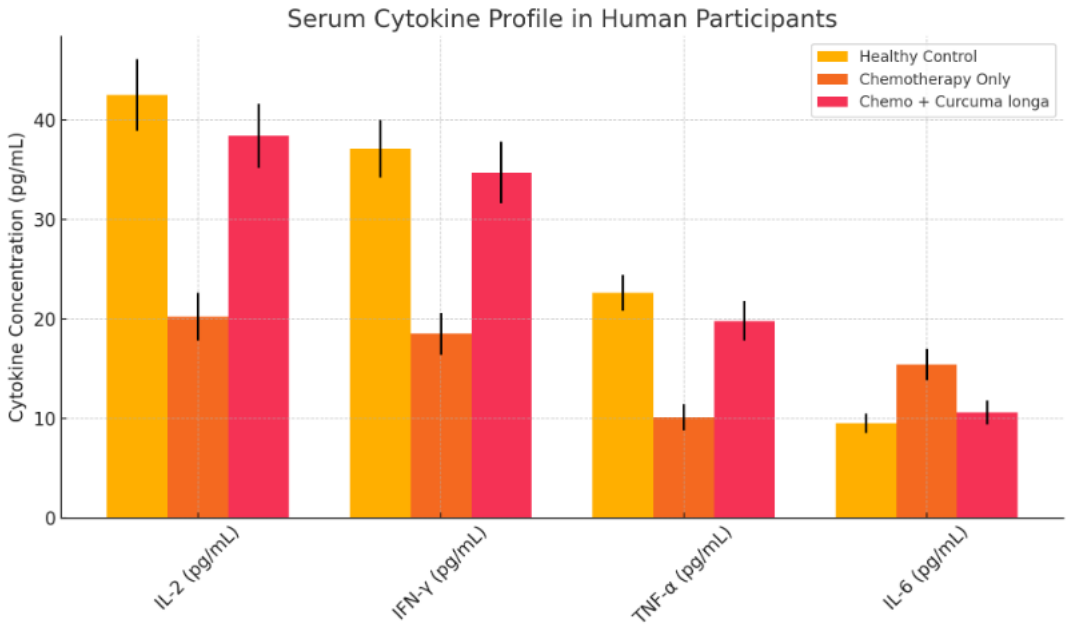


Graph 1. Hematological Parameters in Human Participants

Table 2 shows the serum cytokine profile of human participants in three groups: healthy controls, chemotherapy-only patients, and those receiving chemotherapy with Curcuma longa supplementation. Chemotherapy significantly affects key pro-inflammatory cytokines like IL-2, IFN-γ, and TNF-α, indicating weakened innate immunity. IL-6, a biomarker for inflammation and cancer progression, is pathologically high in the chemotherapy-only group. The group with Curcuma longa showed similar levels of cytokines and decreased IL-6 compared to the only chemo group. Curcuma longa can moderate the immune response, attenuate chemotherapy-induced immunosuppression, and reduce systemic inflammation, demonstrating its cancer treatment-related immunoprotective and anti-inflammatory potential.

Table 2: Serum Cytokine Profile in Human Participants

Cytokine	Healthy Control	Chemotherapy Only	Chemo + Curcuma longa
IL-2 (pg/mL)	42.5 ± 3.6	20.2 ± 2.4	38.4 ± 3.2
IFN-γ (pg/mL)	37.1 ± 2.9	18.5 ± 2.1	34.7 ± 3.1
TNF-α (pg/mL)	22.6 ± 1.8	10.1 ± 1.3	19.8 ± 2.0
IL-6 (pg/mL)	9.5 ± 1.0	15.4 ± 1.6	10.6 ± 1.2

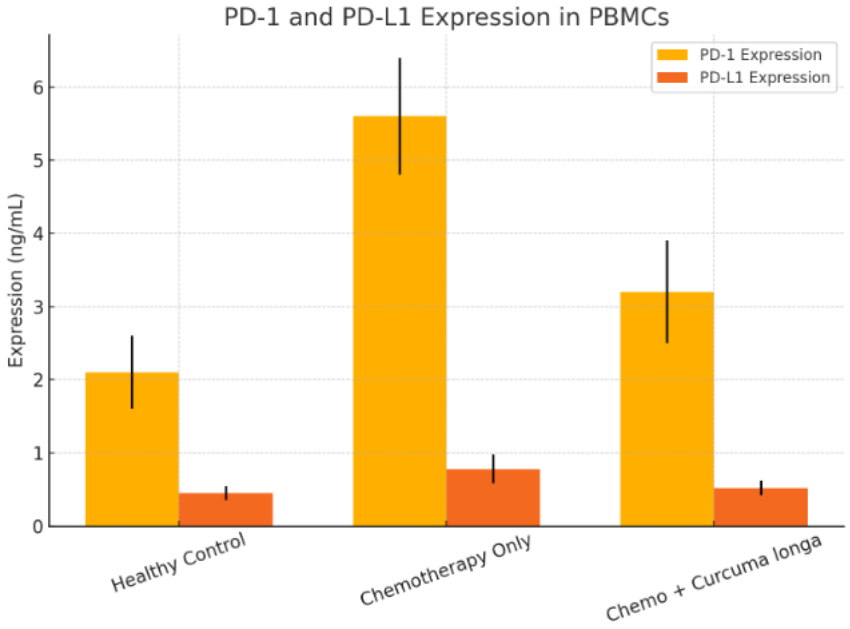


Graph 2. Cytokine Profile Across Treatment Groups

Table 3 shows changes in PD-1 and PD-L1 immune checkpoint proteins in peripheral blood mononuclear cells (PBMCs) in patients taking chemotherapy or Curcuma longa. Patients who took only chemotherapy showed higher levels of PD-1 and PD-L1 expression, indicating immunological exhaustion and tumor immune escape. However, those taking Curcuma longa had significantly lower levels of PD-1 and PD-L1, suggesting that Curcuma longa can be seen as a tumor killer marker. Thus, Curcuma longa as a coadjuvant for cancer treatment has potential to diminish PD-1/PD-L1 levels caused by autoimmune responses.

Table 3: PD-1/PD-L1 Expression in PBMCs

Group	PD-1 Expression (ng/mL)	PD-L1 Expression (ng/mL)
Healthy Control	2.1 ± 0.5	0.45 ± 0.1
Chemotherapy Only	5.6 ± 0.8	0.78 ± 0.2
Chemo + Curcuma longa	3.2 ± 0.7	0.52 ± 0.1



Graph 3. "PD-1 and PD-L1 Expression Across Study Groups"

Table 4 shows the antiviral activity of Curcuma longa in a cell culture treated with chemotherapy. The chemotherapy group experienced a marginal 6% suppression, indicating limited antiviral activity. However, the group treated with Curcuma longa experienced a 98% decrease in viral load, indicating its high potential in antiviral action. The combination of chemotherapy and Curcuma longa reduced viral load by 97.3%, indicating that Curcuma longa retains its antiviral effect even when used alongside chemotherapy. These results suggest Curcuma longa's effectiveness even without other therapeutic methods or as an adjunct to conventional chemotherapy.

Table 4: Antiviral Activity – Viral Load in Treated Cell Cultures

Group	Baseline Viral Load (copies/mL)	Post-Treatment Viral Load (copies/mL)	% Reduction
Chemotherapy Only	8.4×10^4	7.9×10^4	6%
Curcuma longa Only	8.4×10^4	1.8×10^3	98%
Chemo + Curcuma longa	8.4×10^4	2.3×10^3	97.3%

Table 5 demonstrates that in a mice model, chemotherapy resulted in a substantial reduction in white blood cell (WBC) counts and spleen index, signifying immunoablation and splenic atrophy. Curcuma longa independently sustained these levels, suggesting a defensive reaction. Curcuma longa, when administered with chemotherapy, facilitated the restoration of white blood cell counts and spleen index, possibly alleviating chemotherapy-induced immunosuppression. Chemotherapy decreased IL-2 levels, an immune system inducer, but Curcuma longa preserved them at near-normal levels. The viral load was initially undetectable in the control group but was reduced in both the Curcuma longa alone and combination groups, indicating its potential to mitigate viral replication or maintain antiviral immunity throughout chemotherapy. Curcuma longa serves two significant functions in enhancing immune response and regulating viral dissemination in chemotherapeutic settings.

Table 5: In Vivo Results in Mice Model

Parameter	Control (n=15)	Chemo Only (n=15)	Curcuma longa Only (n=15)	Chemo + Curcuma longa (n=15)
WBC ($\times 10^3/\mu L$)	7.5 ± 0.9	3.3 ± 0.7	7.0 ± 0.8	6.4 ± 0.6
Spleen Index (mg/g body wt.)	4.2 ± 0.5	2.1 ± 0.3	4.0 ± 0.4	3.7 ± 0.4
IL-2 (pg/mL)	41.8 ± 4.1	19.4 ± 2.6	43.1 ± 3.9	37.9 ± 3.7
Viral Load (copies/mL)	Undetectable	6.2×10^4	1.4×10^3	2.1×10^3

5. Discussion

Curcumin, the main polyphenol in the spice Turmeric, has been underlined due to its various functions in the regulation of immune responses and at the same time exhibiting an anti-inflammatory effect. Ahire et al. (2023) [16] champion the idea that this polyphenol is capable of antimicrobial, antiviral, and antitumor activities. The authors attribute this range of activities to the downregulation of NF-κB and COX-2. These proteins are the most reliable mediators of inflammation and cancer, and the curcumin-induced suppression of their action through the signaling pathways suggests that the spice may not only prevent but also help in the treatment of cancer and infectious diseases.

Dash et al. (2025) [14] has put forward an idea that curcumin is a positive regulator of immune checkpoint proteins such as PD-1 and PD-L1. The general effect is that curcumin lessens the production of these identifiers; this, in its turn, may recover T-cells from exhaustion and allow the immune system to perform surveillance against cancer. It might be concluded that curcumin potentially plays the role of an enhancer of immunotherapy methods in cancer treatment.

Immunosuppressive actions as the price of chemotherapy are known through and through. A survey by Basu et al. (2025) [15] has even made clear that some of the most used cytotoxic drugs like cisplatin and cyclophosphamide can cause a substantial reduction in both humoral and cellular immunity leading to disorders such as myelosuppression. Their research demonstrates the acute requirements of herbal therapies that can fight back these harmful effects. Different plant extracts specifically those containing curcumin are among the most successful at shielding immune function and reducing chemotherapy-caused injury.

Feuillet et al. (2021) [19] has provided a comprehensive analysis of the part played by type I interferons in the elimination of virus infections and the manner by which malfunctions in this initial immune response can result in the emergence of a powerful inflammatory condition and viral growth. So, the abilities of curcumin to control inflammatory cytokines and stimulate the synthesis of interferons would be critical for the improvement of antiviral reactions in case of immunosuppression.

6. Conclusion

Curcuma longa (turmeric), particularly its main component curcumin, has significant promise as a natural immunomodulatory agent in cancer treatment. Considering its well-documented immunostimulatory and antiviral properties in scholarly articles, it is reasonable to conclude that curcumin may fulfil such a function. The scientific literature highlights several aspects of curcumin's immunomodulatory effects: the compound can interact with immune checkpoints like PD-1/PD-L1, modulate cytokine production, diminish inflammatory processes, and enhance antiviral protection, all of which are crucial in addressing chemotherapy-induced immunosuppression and associated complications. Curcumin deeply entrenched in traditional healing practices and receiving ambiguous feedback from the scientific community, emerges as an early, cost-effective, and potentially potent adjunct for patients, thereby mitigating the severity and enhancing the efficacy of conventional cancer treatments. Further investigation and extensive clinical studies are necessary to accurately delineate the therapeutic applications of curcumin and to fully harness its potential in clinical environments.

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