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Effects of Curcumin Nanoparticles on Tumor Markers in Male Rats

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Abstract: Turmeric's active chemical, curcumin, has been shown to have potential as a cancer treatment. Bioavailability and solubility are obstacles however. Nanotechnology is a process that has produced nanocurcumin and this can remove these restrictions. It can potentially be used for cancer treatment.

A study was conducted to evaluate the efficacy of curcumin nanoparticles in lowering the levels of tumor markers in male rats. We compared the action of curcumin nanoparticles with the standard curcumin-treated and untreated tumor-induced groups. Rats given the nanoparticles had better treatment effects because their levels of markers for cancer (alpha-fetoprotein (AFP), carcinoembryonic antigen (CEA), and CA-19-9) were markedly lower.

Keywords: Curcumin, Nanoparticles, Tumor markers, Male rats, AFP, CEA, CA-19-9, Cancer, Drug delivery

1. Introduction:

The salient characteristic of cancer is unregulated cell proliferation that can manifest itself in the form of solid tumours or blood tumours (malignant diseases of the blood or marrow among other organs). Cancer treatment mainly consists of surgery, chemotherapy, and radiotherapy[1]. Even with significant advances in detecting and treating cancer, we still need to develop safe and effective therapies to control the disease and its growth. Radiation therapy and chemotherapy routinely cause side effects, as well as drug resistance in cancer treatment[2]. To limit damage to healthy organs, innovative treatments that specifically target cancer cells have been discovered in response to limitations. [3]. Compared to older treatment options, such as chemotherapy, radiation, and surgery, cancer immunotherapy is associated with significant gains in patient

survival and quality of life. There has been a significant increase in the use of immunotherapy for the treatment of metastatic, adjuvant, or neoadjuvant cancer [4]. People are very interested in curcumin, a bioactive molecule with cancer-fighting potential that is extracted from the root of the turmeric plant, Curcuma longa. a large number of preclinical studies have demonstrated that curcumin modifies many biological pathways that promote cancer progression [5] Cell growth, cell death, blood vessel growth, and tumor spread. Curcumin has limited medical applications because of its low bioavailability, rapid metabolic degradation and low water solubility. Nanotechnology definitely offers a great advantage over the shortcomings of more conventional drug delivery systems [6]. When they are used together, peptides and nanoparticles are effective in treating cancer. Peptide-functionalized nanoparticles can be better targeted towards tumor cells. Self-assembling nanoparticles can be made by combining peptides with drugs.

Curcumin, the active ingredient in turmeric, has anti-inflammatory and anticancer properties. Its bioavailability however limits its therapeutic usage[7]. Nanoparticle formulations of curcumin may improve absorption and help to enhance targeted delivery. The study assesses the effect of curcumin nanoparticles on the level of tumor markers of male rats[8]. It also aims to improve anticancer therapeutic strategy. Cancers like the pancreas, liver, and colon show increased levels of tumor markers like CA-19-9, CEA, and AFP. Keeping track of these markers helps diagnose cancer and assess treatment effectiveness. This study assesses the effects of regular curcumin versus curcumin nanoparticles on tumor markers in a chemically induced cancerous rat [9].

2. Materials and Methods.

2.1. Ethical Approval and Animals

From a licensed laboratory animal facility, we obtained twenty-four mature male Wistar rats, weighing between 150 and 180 grams. The rats were kept in a typical laboratory setting, with a pellet diet and constant access to water. The IACUC ensured that all experiments followed all applicable ethical guidelines for the care and use of animals in research. There were four groups of male rats studied: control, tumor-induced, tumor + curcumin, and tumor + nanoparticles. A four-week therapy plan followed the chemical induction of tumors. The ELISA technique was used to measure the concentrations of AFP, CEA, and CA-19-9 in the serum.

2.2. Grouping and Experimental Design

Each of the four groups of rats contained six rats chosen at random. Oral saline was given to Group 1 (Control) as a therapy. A carcinogen was given to Group 2 subjects in order to hasten the development of tumors. Group 3 (Tumor + Curcumin): After tumor formation, 100 mg/kg of curcumin was taken orally daily. The fourth group, called "tumor + curcumin NPs," received 100 mg/kg of curcumin nanoparticles daily following tumor induction.

2.3. Nanoparticle Preparation Using Curcumin

Using the nanoprecipitation approach, curcumin nanoparticles were synthesized. The turmeric was dissolved in ethanol and gradually added to an aqueous phase while being constantly stirred. The solvent was extracted from the mixture by sonication, which was followed by a reduction in pressure. In order to determine the zeta potential and particle size, dynamic light scattering (DLS) was employed.

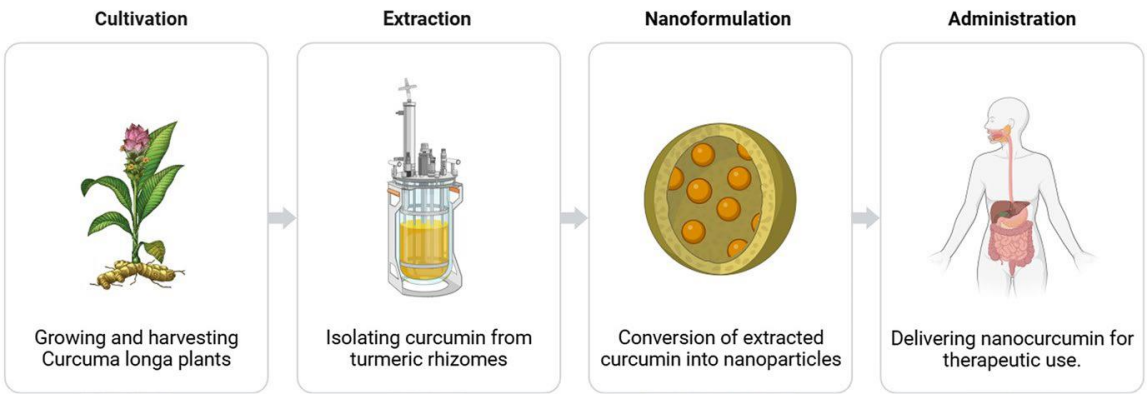

Figure: 1. Four- steps nanocurcumin synthesis process

2.4. **Tumor Induction and Monitoring**

The DN was found to induce xenograft tumors in mice models when injected subcutaneously. Tumorigenesis was initiated through intraperitoneal administration of the diethyl nitrosamine DEN. Thus, tumor progression was assessed weekly through palpation and ultrasonography. The rates of tumor growth were calculated and documented..

2.5. Biochemical Analysis

After four weeks, rats were anesthetized, and blood samples were collected through heart puncture. Before analysis, the serum was removed and kept at -20°C. We used commercial ELISA kits to determine the levels of AFP, CEA, and CA-19-9 according to the manufacturer's instructions..

2.6. Histopathological Examination

After fixation with 10% neutral-buffered formalin, the liver and colon tissues were embedded in paraffin, sectioned to 5 µm, and stained with hematoxylin and eosin (H&E). Examination of sections with a light microscope was done to evaluate the appearance of the tumor and structure of the tissue section.

2.7: Data Analyzing Statistics:

SPSS version 25.0 was utilized to analyze the data. The results are presented as the mean, with or without standard deviation (SD). The ANOVA one-way and the Tukey´s post hoc test are statistically significant, thus corroborating the findings. A p-value lower than 0.05 was regarded as statistically significant..

3. Results

3.1. effect on tumor marker:

The group with tumors had higher levels of all three markers[10]. According to the results, treatment with curcumin resulted in a significant reduction in levels. Results from the curcumin nanoparticle group have also shown far greater reductions, comparable to control[11].

Curcumin nanoparticles showed a significant decrease in the levels of tumor markers as compared to tumor-induced as well as standard curcumin ($p < 0.05$).Table 1

Table 1: Tumor Marker Levels in Different Groups (ng/mL)

Group	AFP	CEA	CA-19-9
Control	5.2	2.1	7.4
Tumor-induced	15.8	8.9	22.5
Tumor + Curcumin	10.4	5.7	13.1
Tumor + Curcumin NPs	6.3	2.8	8.1

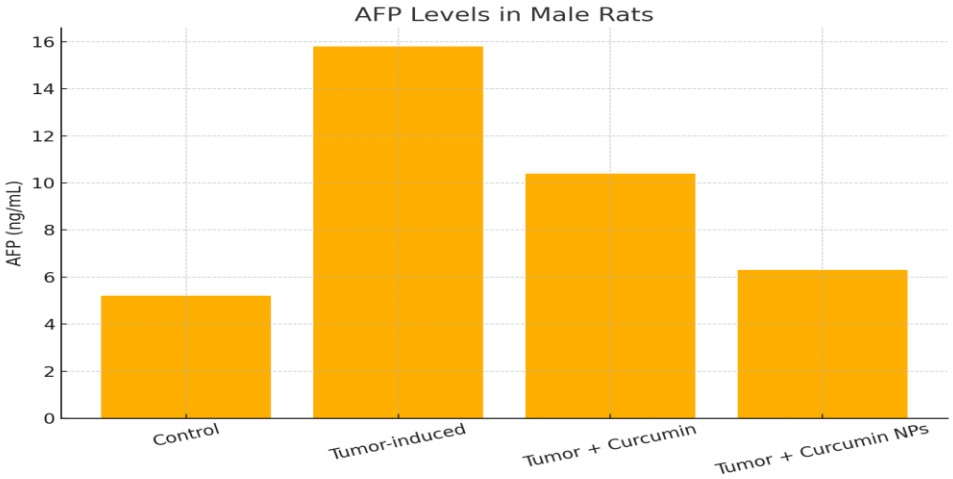

Figure 2: concentrations of AFP in various treatment groups.

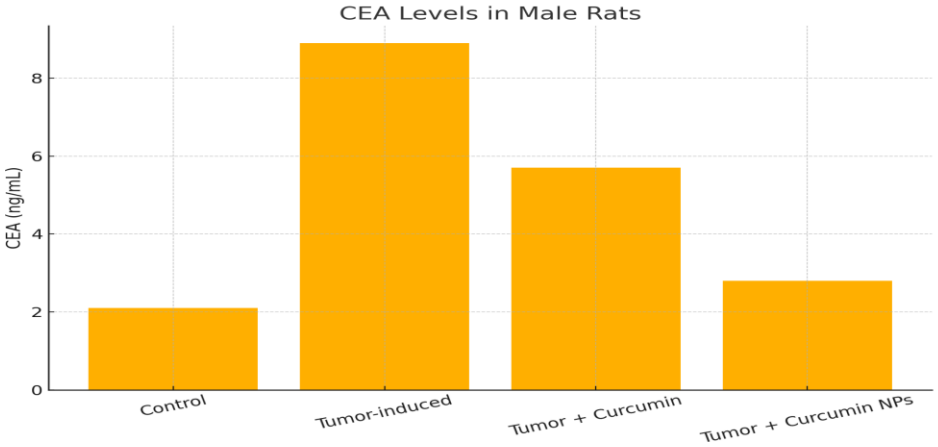

Figure 3: concentrations of CEA in various treatment groups.

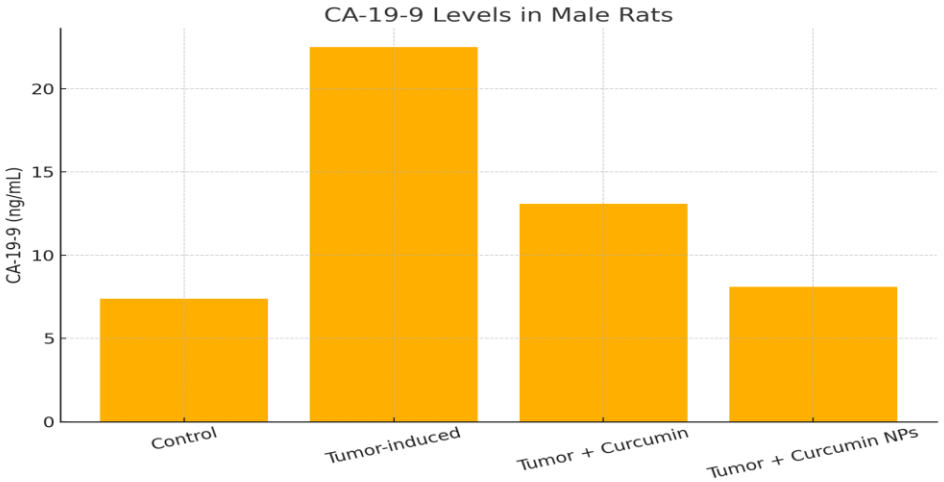

Figure 4: CA-19-9 levels across different treatment groups.

3.2. Histopathological Findings

Liver tissues of the group that was induced with a tumor showed significant cell atypia nuclear pleomorphism and necrosis[12]. On the contrary, administration of curcumin nanoparticles to rats sustained the tissue architecture with minimum evidence of dysplasia. The findings support the biochemical data..

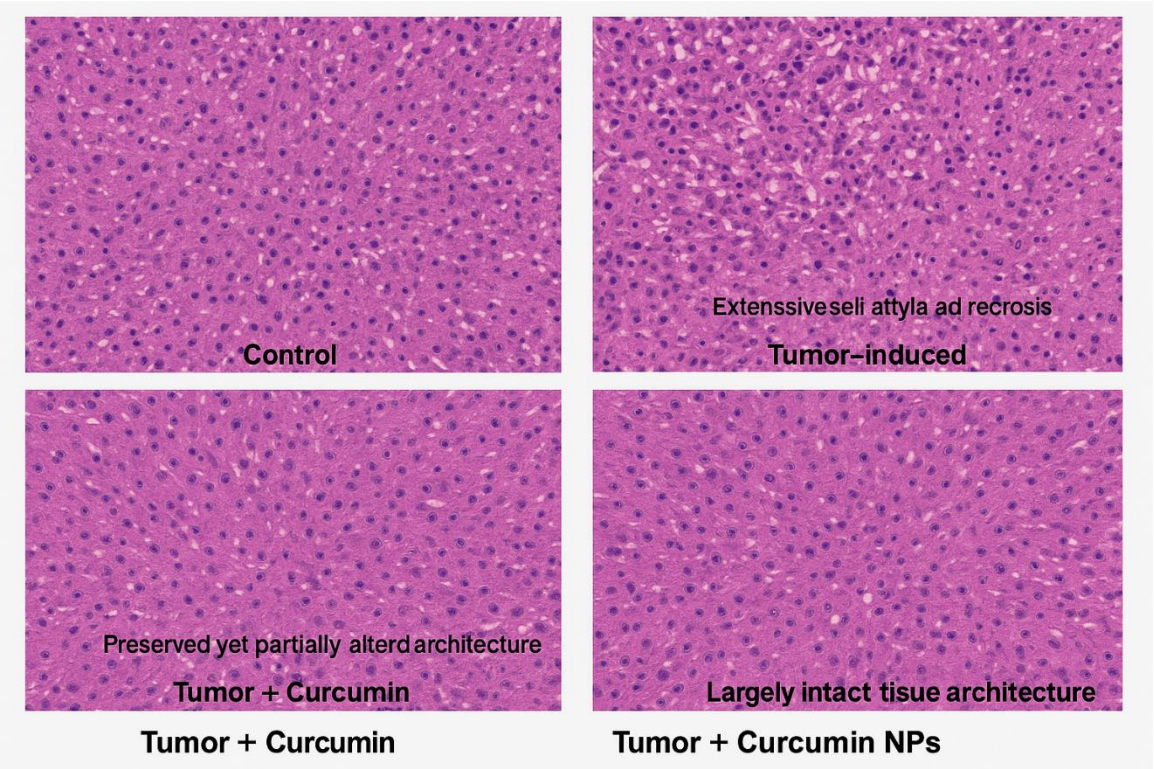

Figure 5: liver histology stained with hematoxylin and eosin (H&E). It accurately reflects typical microscopic features seen in liver tissue across different experimental groups: (A)**Control**: Normal hepatocyte arrangement and clear sinusoids[13]. (B)**Tumor-induced**: Disorganized structure, atypia, necrosis. (C) **Tumor + Curcumin**: Partial restoration with less necrosis. (D)**Tumor + Curcumin NPs**: Near-normal architecture.

4. Discussion

The significant rise in AFP, CEA, and CA-19-9 levels in tumor-induced rats supported the carcinogenic model. Curcumin was given in a normal dose that only slightly reduced the level of markers but curcumin nanoparticles reduced the level sharply and almost normalized it[14]. The findings suggest the nanoparticle formulation is more effective and has preferable bioavailability..

By making curcumin more soluble, improving cellular absorption, and shielding it from fast metabolism, nanoparticles enhance its distribution. The potential of curcumin nanoparticles to stop tumor growth is further supported by the histological changes that have been shown[15].

The benefits of drug delivery by nanoparticles in cancer treatment have also been mentioned in earlier research. Curcumin encapsulated with nanoparticles dramatically improved plasma concentrations and therapeutic results, according [16]. When compared to free curcumin, another's showed that curcumin nanoparticles were more cytotoxic to cancer cell types.

Curcumin is better distributed when encased in nanoparticles because they increase solubility, improve cellular absorption, and protect it from rapid metabolism. The observed histological alterations provide more evidence that curcumin nanoparticles may inhibit tumor growth[17].

Drug distribution using nanoparticles has also been considered in previous study as a potential benefit in cancer treatment. The study found that the therapeutic outcomes and plasma concentrations of curcumin were significantly enhanced when the compound was encased in nanoparticles. The cytotoxicity of curcumin nanoparticles to various cancer cell types was demonstrated by to be higher than that of free curcumin [18].

6. Conclusion and recommendations.

The treated rats demonstrated significant reductions in alpha-fetoprotein (AFP), carcinoembryonic antigen (CEA), and cancer antigen 19-9 (CA-19-9), indicating enhanced treatment efficacy.

It is important for future study to investigate the effects of curcumin nanoparticles over a longer period of time, as well as their biodistribution and the influence they have on additional molecular targets. Combinational therapies using nano-curcumin with other chemotherapeutic agents may offer synergistic effects. Clinical trials will be essential to translate these promising preclinical results into practical cancer treatments.

Acknowledgment: great thank forward to the lab. Staff at college of health and medical technique for their effort during experiment and histopathology examination. Despite these promising results, several aspects require further investigation. Long-term studies are essential to determine the sustained efficacy, safety, and potential cumulative effects of curcumin nanoparticles. In addition, understanding their biodistribution, metabolism, and clearance will help optimize dosing strategies and minimize possible off-target interactions. Future research should also explore the impact of nano-curcumin on a broader spectrum of molecular targets, including inflammatory mediators, apoptotic regulators, and pathways associated with tumor angiogenesis and metastasis.

Furthermore, combinational therapeutic approaches using nano-curcumin with standard chemotherapeutic agents or other natural bioactives may provide synergistic benefits, enhancing overall treatment outcomes while potentially reducing toxicity. Ultimately, well-designed clinical trials will be indispensable to translate these encouraging preclinical findings into clinically applicable cancer therapies and to validate nano-curcumin’s role in modern oncological practice.

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