



A Review on Medical Properties on Spirulina and Their Futuristic Applications

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MM and ND designed the study. Author ND collected and managed the literature. Author PM wrote the protocol. All authors read and approved the manuscript.

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ABSTRACT

Spirulina is a type of blue-green microalgae also is a type of cyanobacteria. This was established in 1967 as a "wonderful future food source". It is a rich source of minerals, vitamins, nutrients, protein, carotenoids, and essential amount of amino acids. Spirulina also a good source of antioxidants. It can protect against oxidative damage. It activates cellular antioxidants enzymes. Inhibits lipids peroxidation and also DNA damages, scavenges, free radicals, and increase the activity of superoxide dismutase and also catalyze. The Spirulina supplements seem to be affected more effectively the innate immunity and promoting the activity of natural killer cells. Also it has a high potential capacity to increase immunity power to suppress viral infections, and it is well known to be a healthy addition to one's diet. It is most commonly used as a natural dietary supplement. There is a main active compound called phycocyanin. It is a pigment-protein complex. This pigment used mainly as natural colouring in food industry. Spirulina is well tolerated when grown at under controlled conditions. Also it can be grown as a pure culture alkaline water. Spirulina products have bioactive protein with the ability to stimulate the intestinal immune system. This is available in many forms such as spirulina powder, capsules, etc and this products has many mediational uses.

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1. INTRODUCTION

Spirulina is a microscopic and filamentous cyanobacterium. The name spirulina derives from the spiral or coiled nature of its filaments. Spirulina refers to the dried biomass of cell *Spirulina platensis* and an oxygenic chemical action bacteria found worldwide in recent and marine waters. This algae represents a vital staple diet in humans and has been used as a supply of macromolecule and aliment supplements in humans with none important side-effects. Excluding the high (up to 70%) content of macromolecule, it additionally contains vitamins, particularly B12 and carotene (β -carotenes), and minerals, particularly iron. Spirulina currently belongs to the substances that square measure listed by the North American nation Food and Drug Administration below the class typically Generally Recognized as Safe (GRAS). Spirulina is comparatively straight forward to cultivate however thrives solely in alkalic lakes with a very high pH scale and in massive outside ponds below controlled conditions [1]. The dried product of spirulina is a valuable supplement and it has some therapeutic effects, such as enhancement of the immune system and reduction in blood cholesterol, production against cancers and increase of intestinal lactobacilli, reduction of nephrotoxicity [2]. The typical morphology of Spirulina which is characterized by its regularly coiled trichome, and the morphological features such as the degree of spiralization and the arrangement of spirals, are the main taxonomic criteria for spirulina. However, spirulina can occur with abnormal morphologies, such as irregularly curved and even liner shapes, in laboratory and industry cultures [3]. The blue alga naturally found in alkaline water of volcanic lakes, and its sixty two organic compound content and it's the globe richest supply of aliment and contains an entire spectrum of natural mixed Carotene and xanthophyll phytopigments [4]. C-phycoyanin is a high light- harvesting pigment. Naturally found in cyanobacteria and certain red algae. This is antioxidant substance. This antioxidant substance give a unique blue – green color. Phycocyanin can fight against free radicals and inhibit production of inflammatory signaling molecules, providing impressive antioxidant and anti-inflammatory effects [5]. Spirulina supplementation can improve antioxidant as well as immune function in volunteers. 50 years of age with a diagnosis of anemia who were supplemented with Spirulina for 12 weeks.

Endpoints included red blood cell (RBC) indices within complete blood count (CBC) and indole amine 2, 3-dioxygenase (IDO) enzyme activity as a sign of immune function at baseline and weeks 6 and 12 [6]. Cyanobacteria are ancient photosynthetic organisms that are found in various aquatic environments. Their photosynthetic pigments confer different colors on them, but they are generally regarded as blue-green [7]. Cyanobacteria additionally embrace animate thing organisms and every one of them aren't spiral-shaped. They grow naturally within the water of heat climates and area unit primarily cultivated in ponds and little lakes. In distinction to different living organisms, microalgae or Spirulina is one among the microalgae and isn't the sole microalgae that doesn't need organic, inorganic, nutrient, and different carbon sources for growth and may survive in higher alkalinescent PHS water and larger hydrogen and carbonate concentrations. Starting within the sixteenth century, blue-green algae are used as a conventional food supply for African and Mexican individuals. Among the microalgae, *Spirulina maxima*, *Spirulina platensis*, and *Spirulina fusiformis* area unit the foremost wide cultivated species around the world. Each year, quite 3 thousand heaps of Spirulina is cultivated just for human nutrition and also the production of different fine trade goods chemicals. In recent years, individuals are curious about intense Spirulina in pill and powder forms. It comparatively contains a high quantity of super molecule, carbohydrates, fat, dietary fibers, sugars, vitamins, and phytochemicals. Spirulina additionally contains moderate amounts of vitamins like axerophthol, vitamin C, vitamin E, B complex, thiamine, nicotinamide, pyridoxine, riboflavin, and B complex and useful pigments, like chlorophyll-a, zeaxanthin, diatoxanthin, 3-hydroxyechinenone, echinenone, carotin, carotenoid, canthaxanthin, c-phycoyanin, beta-cryptoxanthin, myxoxanthophyll, oscillaxanthin, phycobiliproteins, and allophycocyanin. The biological process parts and different phytochemicals in Spirulina primarily exhibit anti-inflammatory drug, inhibitor, medication, neuroprotective, hepatoprotective, and antitumor activities [8]. The biochemical composition of spirulina indicates that it has high nutritional and nutraceutical value due to its content of a wide range of essential nutrients [9]. The regular consumption of Spirulina ameliorates the symptoms of expelling cycles in girls and also the symptoms of amyotrophic lateral pathology. Spirulina prevents hypersensitive reactions and

aids within the removal of metals from the body. A recent study recommended that Spirulina helps to bind hot parts and is helpful for shielding the shape from exposure to radiotherapy. The synthetic resin compounds gift within the Spirulina area unit primarily concerned within the oxidation-reduction mechanism and act as H donors, reducing agents, metal chelator singlets, and atomic number 8 quenchers. Therefore, synthetic resin compounds will forestall the formation of ROS and reactive atomic number 7 species, that embrace free radicals, like chemical group and superoxide anions and gas, and non-free radical species, like peroxide and acid. The event of synthetic resin compounds as antioxidants for the treatment of assorted human diseases accumulated. Therefore, there's associate imperative ought to establish novel inhibitor molecules with fewer facet effects and vital hepatoprotective effects. To beat disorders, the regular consumption of natural health-promoting foods, like Spirulina tablets or powders, is advised [8] Also Spirulina platensis parathas are rich in phycocyanin and this pigment has been widely used as a natural blue colorant for the cosmetic additive [10].

2. ROLE OF SPIRULINA IN IMMUNE SYSTEM

The immune system could be a crucial biological process invention to battle invaders in young and recent organisms. Roaring aging in humans WHO accomplish nonagenarian standing and on the far side depends on however the system changes over time. Whether or not sure immune parameters vary with multiplied age is influenced by the genotype and manner of the individual [11]. Not only the consumption of spirulina be healthy by supplying proteins and other nutrients, but a number of reports have suggested spirulina to be an effective immune modulator. It has been well documented that spirulina ex-hibited anti-inflammatory properties, in particular, by inhabiting the release of histamine from mast cell-mediated allergic reaction. The active ingredient found in spirulina responsible for its anti-inflammatory activities is C- phycocyanin, a pigment commonly found in blue –green alga [12].

The Academy of Chinese Military Medical Sciences showed that Spirulina can be effectively improve the survival rate of mice after exposure to a dose of radiation, prolong their survival time, and improve their immunity and activity of superoxide dismutase (SOD). Some hospitals in Kunming city, Yunan Province, have

adopted spirulina as an auxiliary medicine, which proved to be effective in lowering blood lipid, combating fatigue and increasing the level of immunoglobulin A (IgA) and immunoglobulin M (IgM). Phycocyanin of Spirulina platensis inhibits the expansion of human leukemia K562 cells when supplemented with a diet [13]. *In-vitro* research conducted by Alam et al ., 2014 shows that spirulina plantesis boosted human macrophages and also helps fight viral infections autoimmune disease and cancers [14]. Spirulina has been alleged to be related to modulation of host system. A water extract of Spirulina has been administrated orally to patience as an anticancer and anti-viral agent although the molecular mechanism by which spirulina acts as on system remains largely undefined [15]. Spirulina showed specific positive effects on innate immune functions and might have an effect on the nonspecific immunity in many ways in which Novel sulfated polysaccharides isolated from the water extract of Spirulina, which is named as Ca spirulina showed immunomodulatory and anti-viral activities, Polysaccharides and pigment from Spirulina exaggerated immunity in mice by enhancing bone marrow replica, thymus growth, and spleen. It absolutely was rumored that Spirulina up-regulates key cells and organs of the system rising their ability to operate despite stress from environmental toxins and infectious agents. Studies on animal models documented that pigment of Spirulina stimulates organic process, particularly by inducement glycoprotein internal secretion (EPO). That c-phycocyanin and polysaccharides of Spirulina enhance white vegetative cell production. The proportion of somatic cell macrophages exaggerated once cats were administered a soluble extract of *S. platensis*. Exaggerated somatic cell activity was additionally discovered in alternative animals like mice and chicken. The soluble extract of *S. platensis* induces secretion of interleukins like IL-1 from serous membrane macrophages. The activity of NK cells was additionally increased considerably. Studies on the chicken model showed exaggerated tumoricidal activity of NK cells. Any studies are required to ascertain the precise organic chemistry mechanisms concerned.

Important components of the system, the Bone Marrow Stem Cells, Macrophages, T-cells and Natural Killer cells, exhibit increased activity. The Spleen and Thymus glands show increased operate. Additionally Scientists observe will Spirulina inflicting macrophages to extend in range, become "activated" and simpler at killing

germs. Feeding studies show that even little amounts of Spirulina build up each the body substance and cellular arms of the system. Spirulina accelerates the assembly of the body substance system, (antibodies and cytokines), permitting it to higher to safeguard against incursive germs. The cellular system includes T-cells, Macrophages, B-cells and therefore the anti-cancer Natural Killer cells. These cells flow into within the blood and these are particularly made in body organs just like the liver, spleen, thymus, humour nodes, adenoids, and bone marrow. Spirulina up-regulates these key cells and organs, rising their ability to operate in spite of stresses from environmental toxins and infectious Agents. Spirulina is also a robust tonic for the system. In scientific studies of mice, hamsters, chickens, turkeys, cats and fish, Spirulina systematically improves system operate. Medical scientists realize Spirulina not solely stimulates the system, it additionally enhances the body's ability to come up with new blood cells [16].

3. ANTIOXIDANT EFFECT OF SPIRULINA

Antioxidant are helps to product our body against free radicals. Antioxidants are the substances that neutralize free radicals in the body. Antioxidant includes flavonoids, α -lipoic acid and carotenoids etc [10]. In recent research studies demonstrated that Spirulina possess significant antioxidant activity in both *vitro* and *vivo* [17]. Antioxidant activity of spirulina is due to the presence of two phycobiliproteins they are phycocyanin and allophycocyanin. As an antioxidant effect oxygen stress level was inhibited by phycocyanon and phycocyanobilin. In research experiments the free radicals scavenging activity of C-phycocyanin isolate from spirulina was found to reduce the peroxide values of ccl_4 induced lipid oxidation of rat liver microsomes [7]. In recent research shows that Spirulina helps to find bind radioactive elements and is useful to product body against free radicals phenolic compounds which are present in the Spirulina are involved in the redox mechanism and act as hydrogen donors, reducing agent and oxygen quenchers. The phenolic compounds can prevent reactive nitrogen which include free radicals like hydroxyl and superoxide anions and non-free radical's such as hydrogen peroxide and nitrous acid [8]. Spirulina is a complete food source of chlorophyll, phycocyanin, and carotenoids. These are good antioxidant activities and induction of apoptotic events in cancer cell lines. Carotenoids and various carotenoids are present

in spirulina extracts. Carotenoids are one of the vitally important antioxidants. Carotenoids possess antioxidant activity in the presence of light. Carotenoids also have the important metabolic function in human, and protection against disease such as cancer by the way of scavenging the free radicals [10]. In spirulina major carotenoids is β -carotene potential antioxidants having radio – protective effects. Also have important metabolic functions in the conversion of vitamin-A in the human body. Carotenes in spirulina have immune response and production against disease, it knowing the free radicals which are responsible for cancer cells.

A wide spectrum of carotenoids present in the spirulina is Beta-carotene, Za xanthine, Cryptoxanthine, Phycocyanin, Lutein. Beta carotene is an antioxidant that converts to vitamin A and this beta carotene plays an important role in health. This is the richest illustrious natural supply in spirulina. These area unit born-again to the vitamin-Ain material body and offers varied health advantages. This is often a decent supply of anti-oxidants and therefore the potential production of cells. This beta carotene plays a crucial role in body which can fight against free radicals [7].C-phycocyanin is the major Bili proteins present in spirulina with antioxidant property and radical scavenging properties phycocyanin are scavenge the free radicals, including alkoxyl, hydroxyl and peroxy radicals. There is a main active component is called phycocyanin. This antioxidant substance gives unique blue color spirulina. Spirulina activates cellular antioxidant enzymes. Although in fewer study showed that spirulina have been effectively performed antioxidant activity in humans. Spirulina contains chlorophyll, phycocyanin, and carotenoids. The above components have antioxidants activity, anti-mutagenic activity, and induction of apoptotic events in cancer cell lines [10]. Much attention has been paid to the antioxidant potential for spirulina spices. In some recent studies suggest that spirulina has potent antioxidant activity in *vitro*. Many in *vivo* studies show that treatment with spirulina can be significantly reduces oxidative stress and also these study showed in *vitro* studies too. Among several alga genera, Spirulina and Chlorella deserve special attention due to their importance as human food and their in *vitro* antioxidant potential. There are some several dietary antioxidants have been identified and which could be product against free radicals production and induction of antioxidant signaling pathways, attenuation of oxidative stress and

consequently, prevention of related disorder [18]. Water soluble spirulina fraction has a potential to reduce serum glucose while at fasting and on the other hand water insoluble fraction of spirulina can suppress glucose levels and able to reduce cholesterol in blood and thus act as a anti hyperlipidemic agent and can be used in treatment of atherosclerosis. Ota, Miyakawa & Shimamatsu [14]. Antioxidants facilitate to safeguard the body against free radicals; these are substances that neutralize free radicals or their actions. Antioxidants embody carotenoids, flavonoids, and connected polyphenols, α -lipoic acid, glutathione, etc. the most supply of antioxidants for the body is vegetables and fruits. Unobtainable of fruit and vegetables in several arias of the planet, scientists rethought to produce antioxidants from alternative sources. Beginning within the middle Eighties, nice efforts and in depth investigations are turned to the event of nutraceuticals or practical food for preventing or managing varied diseases. The primary reports on antioxidants utilized for food lipids were concerning exploitation natural sources; in 1852, Wright rumored that elm bark was effective in protective animal fat and lard. Spirulina was at first classified at intervals the plant kingdom thanks to its richness in plant pigments additionally as its ability of chemical process. It absolutely was later placed within the microorganism kingdom supported a replacement understanding of its biological science, physiology, and organic chemistry properties. Spirulina naturally grows in high-salt base-forming water reservoirs in semitropical and tropical areas together with America, Mexico, Asian, and therefore the Central African Republic. Recent studies counsel that Spirulina, an animate thing blue-green algae might have a range of health edges associate degreed therapeutic properties and is additionally capable of acting as an inhibitor and anti-inflammatory agent. Spirulina is additionally used for food, feed, and organic chemistry merchandise since the Eighties. Spirulina is that the foremost targeted and nourishing whole food acknowledged to science, what is more Spirulina possesses no facet effects and is non-toxic [10]. Spirulina has profound anti-oxidant potential, its true health-protective merit has only recently been discovered. Phycocyanobilin, the chromophore bound to chief protein, phycocyanin can function as a potent inhibitor of NADPH oxidase, the enzyme complex that is the chief source of pathological oxidant stress in a wide range of health disorders [19].

4. ANTICANCER ACTIVITIES

Numerous studies have demonstrated that dietary supplementation of *S. platensis* is helpful in the prevention and treatment of atherosclerosis, diabetes, and cancers [20]. Chemotherapy is one of the main treatments used against cancer. Besides that, a group of drugs is used to kill or inhibit the growth of cancer cells. Also, these drugs are associated with toxicity, which at best is unpleasant and at worst may threaten life. There are many side effects of chemotherapeutic drugs include hair loss, nausea, etc, spirulina preparations increase phagocytic activity of macrophages and stimulate antibodies and also cytokines production [21].

Several studies show Spirulina extracts will stop or inhibit cancers during a human's body. There square measure some common types of cancer thought to be a results of harm in cell DNA running amok, inflicting uncontrolled cell growth. Cellular biologists have outlined a system of special enzymes. That's referred to as nuclease that repair broken DNA to stay cells alive and healthy. Once these enzymes square measure deactivated by radiation or toxins, errors in DNA go unrepaired and, cancer might develop. In some vitro studies recommend the distinctive polysaccharides of Spirulina enhance karyon protein activity and DNA repair synthesis. This could be why many scientific studies, observant human tobacco users and experimental cancers in animals, report high levels of suppression of many vital varieties of cancer. The themes were fed either whole Spirulina or else treated with its water extracts [16]. The understanding of mechanisms of carcinogenesis and numerous different aspects of tumor biology is kind of advanced and is of nice importance with immediate and future implications. Separate however extensively reticular pathways resulting in cellular caspase-mediated cell death are characterized because the accidental and also the intrinsic pathways. The accidental pathway is initiated by ligature of transmembrane receptors to activate membrane-proximal "activator" caspases that in turn cleave and activate downstream "effector" caspases. The intrinsic pathway needs disruption of the mitochondrial membrane and also the unleash of mitochondrial proteins, events that square measure regulated by the opposing actions of pro- and anti-apoptotic Bcl-2 members of the family. The multifunctional transcription issue p53 is believed to be a part of a "fast track" affiliation between nuclear deoxyribonucleic acid harm and also the

intrinsic pathway machinery. p 53 regulates multiple responses to genotoxic stress by transcriptional activation or repression of many genes secret writing proteins concerned in cell cycle management (p21WAF1/Cip1), deoxyribonucleic acid repair and caspase-mediated cell death. p21 (WAF1) may be a CKI that directly inhibits the activity of cyclin D/CDC a pair of and cyclin D/CDK four complexes. p21 functions as a regulator of cell cycle progression at S part. The expression of p21 is controlled by the tumor suppressor super molecule p53. Sometimes, it's expressed while not being evoked by P53. This type of induction plays an enormous role in p53 freelance differentiation that is promoted by p21. Active ingredients in spirulina, either alone or together with sure different compounds square measure studied for antineoplastic activities and their role and mechanisms of actions well described; through numerous pathways made public on top of. Selenium-enriched *Spirulina platensis* extract (Se-SE) restrained the expansion of MCF-7 human carcinoma cells through the induction of G1 cell cycle arrest and mitochondria-mediated caspase-mediated cell death. This was additionally related to a decrease in expressions of cyclin D1, cyclin D3, CDK4 and CKD6, and a rise in super molecule levels of p15 INK4B, p21 Waf1/Cip1, and p53. The synergistic effects embrace deoxyribonucleic acid fragmentation and nuclear condensation in the course of the activation of caspase-8 and caspase-9 as well as PARP cleavage. The metastatic tumor effects were evoked by mitochondrial pathology through upregulation of Bax and dangerous expression and downregulation of Bcl-xl expression. C-phycocyanin (C-PC) showed downregulation of the ant apoptotic super molecule Bcl-2 and upregulation of the proapoptotic Bax supermolecule within the R-HepG2 cells. Ca spirulina (Ca-SP) may be a sulfated polyose chelating Ca and is principally composed of rhamnose. Ca-SP may cut back the respiratory organ metastasis of B16-BL6 malignant melanoma cells, by inhibiting the tumour invasion of the basement membrane. This activity was attributed to the preventive impact of adhesion and migration of tumour cells to laminin substrate and of the heparanase activity. C-PC showed metastatic tumor effects on human chronic myelocytic leukemia cell line (K562). The consequences embrace a big decrease (49%) within the proliferation of K562 cells treated with fifty micro M C-PC up to forty eight hours. Studies additionally disclosed characteristic molecular and morphological options and fragmentation patterns typical for apoptotic cells.

Downregulation of antiapoptotic Bcl-2 with no alterations in pro-apoptotic Bax thereby tilting the Bcl-2/ Bax quantitative relation towards caspase-mediated cell death was discovered. Oral administration of spirulina at a dose of 800 mg/kg b.w. was shown to induce associate adjuvant impact alongside BCG-cell wall skeleton to enhance antineoplastic natural killer (NK) cell activation in mice. Also, in similar studies, a big reduction within the internal organ hemoprotein P-450 content and enhancing internal organ glutathione S-transferase activity was discovered within the cluster treated with spirulina compared with the management cluster. 10 mg/day of *Spirulina platensis* extract, thrice every week for thirty two weeks was shown to abate cancer progression in male golden Syrian hamsters exposed to a zero.5% answer of seven, 12-dimethylbenz [a] anthracene (DMBA) in buccal pouches. Selenium-containing pigment (Se-PC) showed potent antiproliferative properties in human malignant melanoma A375 cells and human breast glandular carcinoma MCF-7 cells. Induction of caspase-mediated cell death, accumulation of sub-G1 cell populations, deoxyribonucleic acid fragmentation, and nuclear condensation was noticed. A positive impact on inhibitor enzymes viz., SOD, catalase, glutathione enzyme, and antioxidant was incontestible alongside diminished skin and abdomen tumour burden. In an exceedingly 1st of its kind report, the potential use of *Spirulina* in chemoprevention of cancer has been incontestible in dibutyl nitrosamine (DBN) evoked rat liver toxicity and carcinogenesis. *Spirulina* supplementation prevented DMN evoked severe liver injury and histopathological abnormalities. Also, spirulina supplementation reduced the incidence of liver tumors from eightieth to twenty. The reduction of each PCNA and p53 was vital alongside inhibition of cell proliferation, enlarged p21, and diminished metallic element expression levels at forty eight hrs. Post-treatment. Also, SP enlarged Bax and diminished Bcl-2 expression, indicating induction of caspase-mediated cell death by forty eight hrs. Regression of rodent buccal pouch tumors has additionally been incontestible following the native injection of alpha-tocopherol, canthaxanthin associated an extract of *Spirulina-Dunaliella* protoctist.

The study incontestable that cancer regression was amid a giant induction of neoplasm death have faith in macrophages among the neoplasm space, suggesting a potential mechanism of neoplasm destruction. A giant increase in TNF- α positive macrophages was found in animals with tumor-bearing pouches. Animals fed

canthaxanthin conferred a notably and statistically important reduction in neoplasm variety and size compared with controls. Animals fed provitamin an incontestable a smaller however statistically important reduction in neoplasm variety and size. Animals supplemented with spirulina conferred a complete absence of gross tumors. However, microscopic sections of the buccal pouch among the alga cluster showed localized areas of abnormality and early carcinoma-in-situ undergoing destruction. Regression of experimental rodent cancer was additionally incontestable by supplementations with beta carotene and alga extracts.²⁹A cross-sectional study in Malaysian capital, Malaya (where medicine [CAM] is in practice), was performed particularly for pediatric cancers. thirty third of CAM practitioners used spirulina to reinforce medical care (which plays a vital role among the socio-cultural dimension of patients' health beliefs towards eminent treatment).³⁰ In one of the first human studies, the chemo preventive activity of *Spirulina fusiformis* (SF) (1 g/day for twelve months) in reversing oral leukoplakia in pan tobacco chewers in Kerala, Bharat has been according. Complete regression of lesions was discovered in forty fifth evaluable subjects supplemented with SF, as against seven-membered among the placebo cluster. Among one year of discontinuing supplements, nine of twenty (45%) complete responders with SF developed repeated lesions. Supplementation with SF did not finish in increased humor concentration of vitamin A or provitamin A, nor was it associated with toxicity. The diminished expression of the protein metallic element, concerned in control progression through the cell cycle and a concomitant increase in p21 expression indicate that these proteins aboard p53 area unit necessary for spirulina driven inhibition of cell proliferation. Spirulina is also a protecting Phytol-antioxidant against liver toxicity and an antitumor agent. though the in vitro and animal model studies indicate a potential application of spirulina supplementation, any diagnosing and clinical trials area unit needed to characterize the efficaciousness of spirulina along with existing medicine for chemoprevention and therapy.it had been additionally according to possess prevented heart harm caused by antibiotic drug while not moving its antitumor properties [22]. Effects of spirulina focusing on its in recent research, scientists are that specialize in utilizing natural products in conventional cancer treatment. Recent advances in research help within the development of varied novel anticancer agents. Several natural products and

their synthetic derivatives of marine organisms are identified as anticancer drugs. The anticancer properties of varied sorts of algae and their anti-inflammatory, antinociceptive, and antioxidant effects were reviewed by [23]. An inhibitory effect of *Spirulina* algae on oral carcinogenesis evaluated that the chemo preventive effect of *Spirulina fusiformis* in reversing oral leukoplakia in pan tobacco chewers in Kerala, India.

In Kerala, evaluation of chemoprevention of oral cancer with spirulina – fusiformis) studied the effect of spirulina supplementation on humans, who use pan tobacco chewers with oral leukoplakia, and observed that regression of lesions. Constituents of spirulina could also be liable for this. Not only in developing countries but even in developed countries also tobacco use is that the explanation for cancer and incidence of 30% of the cancer was observed. And tobacco features a significant influence on lung and carcinoma. Studies that the 1, 2-dimethylhydrazine (DMH) under aberrant crypts within the rat colon was reduced by *Spirulina*. Injection of Radachlorin obtained significant to full tumor regression. Radachlorin may be a photosensitizer, isolated from *S. platensis*.

The enhanced antitumor activity of natural killer (NK) cells in rats by the hot-water extract of *S. platensis*, *S. platensis* extract causes cancer regression of epithelial cell carcinoma progression induced by 0.5% of 7, 12- dimethyl Benz [a] anthracene (DMBA) of male golden Syrian hamsters. The ultrasonic extraction of *Spirulina maxima* products, phycobiliproteins including c-phycoyanin (C-PC), phycocyanobilin, allophycocyanin (APC exhibited potential anticancer activity. The extract is effective against different types of human neoplastic cell lines like lung, liver, stomach and breast cell lines that the *Spirulina platensis* has anticancer properties are could also be thanks to two important activities and that they are antioxidant and immune-modulation activities. *Spirulina* (*Arthrospira*) shows antitumor, anticancer and antimicrobial (antibacterial, antifungal, and antiviral) activities assembly of valuable) [24]. The p⁵⁷ gene is located on the human chromosome 11 p15.5a region predicted to contain a tumor suppressor gene(s) involved in the development of several human cancers, including those of breast, bladder, lung, ovary kidney and testicle. More direct evidence for the involvement of the p57 gene in human cancer was obtained by finding four of 24 [25]. Starting from the only chlorophyll a containing of

cyanobacteria of spirulina species, the first chlorine e6- based water soluble preparations for the medical purpose have been developed in 1994-2001 [26]. Spirulina have many health benefits. So, by using spirulina many food product can be produced. Such as the selection of ingredients was carried out based on the Nutritional, for the development of formulations, preliminary tests were performed with varying proportions of ingredients. The ingredients were weighed using an analytical scale and mixed in a Y type mixer. The components used in the formulation were maltodextrin, concentrated soybean protein, isolated whey protein (WPI), oatmeal, collagen, inulin, guar and xanthan gums, aroma identical to natural chocolate, cocoa, tricalcium phosphate, acesulfame potassium, sucralose, a mix of minerals (iron, zinc, copper, iodine, selenium, manganese, fluoride, molybdenum, chromium, magnesium, potassium, and sodium), and vitamins (A, D, B1, B2, PP, B5, B6, B12, C, E, H, K, and folic acid). The product that was developed with Spirulina received an additional 750 mg/100 g of microalga biomass (the concentration was set so as not to alter the homogenization of the product). Spirulina sp. LEB 18 biomass was produced in the pilot plant of the Biochemical Engineering Laboratory, on the shores Mangueira Lagoon (33°30' 13"S and 53°08' 59" W) in the city of Santa Vitória do Palmar, Brazil. The biomass was ground in a ball mill (Model Q298, Quimis, Brazil) and sieved to improve its solubility done by [27]. Usually the fortified food products have a higher nutritional value compared to control samples. These food products will find acceptance by people in terms of taste and appearance compared to control samples. Also spirulina have much health benefits so, by using spirulina food products have been prepared.

The spirulina fortified food products will be rich in iron, calcium and phosphorus, thus it will be beneficial for malnourished children, and lactating mothers and other deficiency diseases.

To effectively develop the spirulina fortified food products. Nutrient analysis study should be carried out. Nutritional analysis of all nutrients present in the biscuits, pasta and noodles. Comparison of the controlled sample with the spirulina fortified sample.

This study was carried out by different phase:

Procurement of Spirulina: Pure Spirulina powder was procured purchased from market. Development of value added food products: Most acceptable value added addition level of

Spirulina powder i.e. 10 percent was incorporated in biscuits and 5 percent was incorporated in pasta and noodles with other ingredients.(A) To effectively develop the controlled sample of biscuits, pasta and noodles.(B)To effectively develop the spirulina incorporated biscuits, pasta and noodles. Organoleptic Evaluation: The develop value added biscuits, pasta and noodles was standardized using composite scoring evaluation with the help of experts. The develop value added products along with their control samples served to the experts for organoleptic evaluation. Nutritional Evaluation: - Prepared products were analyzed for moisture, protein, fat, fiber, ash, phosphorus, calcium, iron, alcoholic acidity, pH, peroxide content done by [28]. Also spirulina have been fortified with some fruits and these types of fortifies food products have much health benefits. Spirulina was obtained from Aquaculture Research Center at Arab Academy for Science, Technology & Maritime Transport, Arab League, and Alexandria, Egypt. Papaya was obtained from the farm of Horticulture department, Fac. of Agric. Moshtohor. Banana, Potato, carrot (*Daucus carota* L.), Anna apple, guava and mango, were purchased from certain farmers at Kaha city area, Qaliuobia Governorate, Egypt and immediately transported to the laboratory. Sugar was purchased from local market in Qaliuobia Governorate, Egypt. Wheat flour (72% ext.) was obtained from El-Mokhtar Mill, Cairo governorate, Egypt. Rice, Barley lentil, chickpea, peas, Spinach and cauliflower were purchased from local market in Qaliuobia Governorate, Egypt. Banana, papaya, apple, mango, guava and potato, carrot, was washed with tap water. Then papaya and banana fruits were hand peeled, papaya seeds was carefully removed and the fruits were cut into small parts. While, carrot was peeled using stainless steel peeler, the stones of mango were removed after cutting the fruits to two half's. After that, all fruits and vegetables were blanched by using a pressure cooker where the blanching time was adjusted to be proper for each material. Potato was peeled by hand after blanching. The blanched materials were transferred to Moulinex blender equipped with cutters and stirrer which crushed and homogenized each of above mentioned materials into a mixture of pulp, then the mixture was passed through fine strainer to separate the pulp from any skin or seeds and then it was packed in plastic bags, sealed and frozen. Dry cereals and legumes were cleaned from impurities and then washed thoroughly with tap water, then separately soaked in tap water overnight, except rice was soaked for 30

minutes, The peeled chickpea, lentil, dry pea, rice and wheat were cooked separately in a pressure cooker for 5 to 10 minutes, dried in solar dryer at 45-60°C, milled in an electrical mill and then sieved through a silk sieve (60 mesh)) Spinach and cauliflower were sorted and prepared (green leaves of cauliflower were removed then edible part was cut), washed and blanched for appropriate time (4 to 5 min) using live steam blancher, cooled and dried at 60°C for 12 hrs. And ground to a particle size of 500–600 µm. All prepared materials were bottled in glass jars and stored at room temperature until using in preparation baby food formulas [29]. Pomegranate fruits were obtained from local market. Spirulina (*Spirulina platensis*) biomass was obtained from Algae Biotechnology Unit in National research center, Giza, Egypt. Echinacea purpurea leaves and flower in dried form were purchased from local market in Cairo, while sativoid crystalline, white powder, with sweetness power of 280 times as sucrose, procured from Stevia International Company for Agro-industry Product, in Cairo, Egypt (SICAP). Ethanol, Sodium carbonate, Glycerin and methanol were obtained from El-Gomhoreya Co., Cairo, Egypt. 2, 2-diphenyl-2-picrylhydrazyl radical (DPPH) and Folin-Ciocalteus phenol reagent were purchased from Sigma–Aldrich Inc. The beverages also can be produce by using this spirulina this will be more effect while comparing to solid foods.

The Formulated pomegranate beverage (FPB) prepared from pomegranate juice (PJ) mainly incorporated with Spirulina (SP): Echinacea (EP) extracts with ratio and sweetened by Stevioside (SE) according to the most appropriate concentration for each extract based on phagocytosis inhibition assay [30].

5. CONCLUSION

Due to its highly beneficial proteins and vitamins and less fat content spirulina is now widely being used in production of many food products biscuits, cakes, milk shakes and even in ice-creams. And many more food and nutraceuticals will be produced and commercialized near future. It can be easily digestible protein sources. Usage of Spirulina can be cure cancer and some viral disease. But spirulina is packed with full of vitamin A, C, E and D.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our

area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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