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Potential Health Benefits and Adverse Effects Associated with Phytate in Foods

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Abstruct
Phytate (myo-inositol (1,2,3,4,5,6) hexakisphosphate), a naturally compound formed during maturation of plant seeds and grains is a common constituent of plant-derived foods. This paper is aimed to review the scientific information concerning the potential health benefits and adverse effects associated with phytate in foods. The adverse health effects of phytate in the diet is its effect on mineral uptake. Minerals of concern in this regard would include Zn^{2+}, $Fe^{2+/3+}$, Ca^{2+}, Mg^{2+}, Mn^{2+}, and Cu^{2+}. Especially zinc and iron deficiencies were reported as a consequence of high phytate intakes. In addition, a the adverse effect on the nutritional value of protein by dietary phytate is discussed. Consumption of phytate, however, seems not to have only adverse health effects but also potential benefits on human health. Dietary phytate was reported to prevent kidney stone formation, protect against diabetes mellitus, caries, atherosclerosis and coronary heart disease as well as against a variety of cancers.
Keywords: Antinutrient, Phytate, Health Benefits, Health Effects, Human Nutrition

Introduction

Phytate (is also known as Inositol hexakisphosphate (InsP6)) is the salt form of phytic acid, are found in plants, animals and soil. It is primarily present as a salt of the mono- and divalent cations K^{+}, Mg^{2+}, and Ca^{2+} and accumulates in the seeds during the ripening period. Phytate is regarded as the primary storage form of both phosphate and inositol in plant seeds and grains [1]. In addition, phytate has been suggested to serve as a store of cations, of high energy phosphoryl groups, and, by chelating free iron, as a potent natural anti-oxidant [2,3].

Phytate is ubiquitous among plant seeds and grains, comprising 0.5 to 5 percent (w/w) [1]. The phosphorus bound to phytate is not typically bio-available to any animal that is non-ruminant. Ruminant animals, such as cows and sheep, chew, swallow, and then regurgitate their food. This regurgitated food is known as *cud* and is chewed a second time. Due to an enzyme located in their first stomach chamber, the rumen, these animals are able to separate, and process the phosphorus in phytates. Humans and other non-ruminant animals are unable to do so [4].

Phytate works in a broad pH-region as a highly negatively charged ion, and therefore its presence in the diet has a negative impact on the bioavailability of divalent, and trivalent mineral ions such as Zn^{2+}, $Fe^{2+/3+}$, Ca^{2+}, Mg^{2+}, Mn^{2+}, and Cu^{2+} [6]. Whether or not high levels of consumption of phytate-containing foods will result in mineral deficiency will depend on what else is being consumed. In areas of the world where cereal proteins are a major and predominant dietary factor, the associated phytate intake is a cause for concern [27].

Besides, phytate has also been reported to form complexes with proteins at both low, and high pH values. These complex formations alter the protein structure, which may result in decreased protein solubility, enzymatic activity, and proteolytic digestibility. The phytate degrading enzyme, phytase, is in vogue for degradating phytate during food processing, and in the gastrointestinal tract. The major concern about the presence of phytate in the diet is its negative effect on mineral uptake [28]. Phytate markedly decrease Ca bioavailability, and the Ca:Phy molar ratio has been proposed as an indicator of Ca bioavailability. The critical molar ratio of Ca: Phy is reported to be 6:1 [29]. In human studies, Phy:Zn molar ratios of 15:1 have been associated with reduced zinc bioavailability, and the molar ratio [Ca][Phy]/[Zn] is a better predictor of zinc availability, because calcium exacerbates phytate's effect on zinc absorption, and if the values were greater than 0.5 mol/kg, there would be interference with the availability of zinc [30].

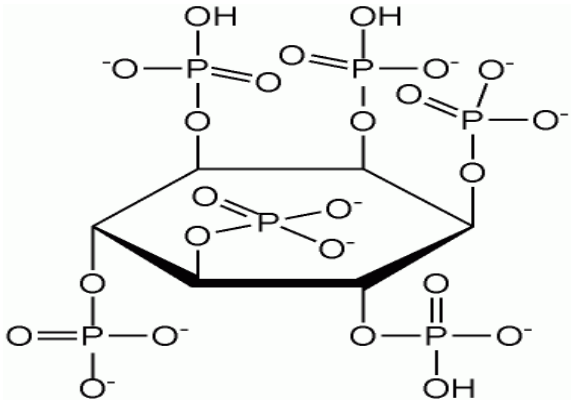

Figure 1. Structure of Phytate ($Insp_6$), empirical formula=$C_6P_6O_{24}H_{18}$

At the same time, phytate may have beneficial roles as an Antioxidant, and Anticarcinogen [31]. The outcome of surveillance of populations consuming vegetarian-type diets has shown lower incidence of Cancer, which suggests that phytate has an Anticarcinogen effect [32]. Dietary phytate may have health benefits for Diabetes patients because it lowers the blood glucose response by reducing the rate of starch digestion and slowing gastric emptying. Likewise, phytate has also been shown to regulate Insulin secretion [33]. It is believed that phytate reduces Blood clots, Cholesterol, and Triglycerides, and thus prevents Heart diseases. It is also suggested that it prevents renal stone development. It is used as a complexing agent for removal of traces of heavy metal ions [34]. Depending on the amount of plant-derived foods in the diet, and the grade of food processing, the daily intake of phytate can be as high as 4500 mg. On average, daily intake of phytate was estimated to be 2000–2600 mg for vegetarian diets as well as diets of inhabitants of rural areas in developing countries, and 150–1400 mg for mixed diets [35, 37. 38]. Among the cooking treatments boiling appeared effective to reduce the phytate level, which could reduce as high as 20% of phytate [36, 39]. However, the updated information on health benefits and adverse effects of phytate in foods is scant. Therefore, the objective of this review is to assess updated scientific information of the potential health benefits and adverse effects associated with phytate in foods.

Adverse health effects of Phytate

The major concern about the presence of phytate in the diet is its negative effect on mineral uptake. Minerals of concern in this regard would include Zn^{2+}, $Fe^{2+/3+}$, Ca^{2+}, Mg^{2+}, Mn^{2+}, and Cu^{2+} [13,14], but also a negative effect on the nutritional value of protein [5,7].

Effect on mineral uptake

Phytate forms complexes with numerous divalent and trivalent metal cations. Stability and solubility of the metal cationphytate complexes depends on the individual cation, the pH-value, the phytate:cation molar ratio, and the presence of other compounds in the solution [15]. Phytate has six reactive phosphate groups and meets the criterion of a chelating agent. In fact, a cation can bind to one or more phosphate group of a single phytate molecule or bridge two or more phytate molecules [3, 40]. Most phytates tend to be more soluble at lower compared to higher pH-values [16]. Solubility of phytates increase at pH-values lower than 5.5-6.0 with Ca^{2+}, 7.2-8.0 with Mg^{2+} and 4.3-4.5 with Zn^{2+} as the counter ion. In contrast, ferric phytate is insoluble at pH values in the range of 1.0 to 3.5 at equimolar Fe^{3+} : phytate ratios and solubility increases above pH 4 [17]. Another important fact is the synergistic effect of secondary cations, among which Ca^{2+} has been most prominently mentioned [18, 41]. Two cations may, when present simultaneously, act jointly to increase the quantity of phytate precipitation. For example, Ca^{2+} enhanced the incorporation or adsorption of Zn^{2+} into phytate by formation of a calcium-zinc phytate. The effect of Ca^{2+} on the amount of Zn^{2+} co-precipitating with phytate is dependent on the Zn^{2+} : phytate molar ratio. For high Zn^{2+} : phytate molar ratios, Ca^{2+} displaces Zn^{2+} from phytate binding sites and increases its solubility. The amount of free Zn^{2+} is directly proportional to the Ca^{2+}-concentration. For low Zn^{2+} : phytatemolar ratios, Ca^{2+} potentiate the precipitation of Zn^{2+} as phytate. Thus, higher levels of Ca^{2+} result in a more extensive precipitation of the mixed phytates. Mg^{2+} also has been shown in vitro to potentiate the precipitation of Zn^{2+} in the presence of phytate, however, Mg^{2+} has been found to exert a less pronounced effect on Zn^{2+}-solubility than Ca^{2+} [18, 42].

The knowledge about the interaction of partially phosphorylated myo-inositol phosphates with different cations is limited. Recent studies have shown that myo-inositol pentakis-, tetrakis- and trisphosphates have a lower capacity to bind cations at pH-values ranging from 5.0 to 7.0 [19]. The capacity to bind cations was found to be a function of the number of phosphate groups on the myo-inositol ring. The cation-myo-inositol phosphate complexes are more soluble as the number of phosphate groups decreases. There is also some evidence for

weaker complexes when phosphate groups are removed from phytate. In addition, the binding affinity of cations to myo-inositol phosphates has been shown to be affected by the distribution of the phosphate residues on the myo-inositol ring.

The formation of insoluble metal cation-phytate complexes at physiological pH-values is regarded as the major reason for a poor mineral availability, because these complexes are essentially non-absorbable from the gastrointestinal tract. Most studies have shown an inverse relationship between phytate content and mineral availability, although there are great differences in the behaviour of individual minerals. Zn^{2+} was reported to be the essential mineral most adversely affected by phytate [13,14]. Zn^{2+} deficiency in humans was first reported in 1963 in Egyptian boys whose diets consisted mainly of bread and beans [20, 43]. These patients, who were characterised by dwarfism and hypogonadism, showed a response to dietary Zn^{2+} supplementation. It became accepted that the presence of phytate in plant-based foods is an important factor in the reduction of Zn^{2+} absorption.

Phytate affects Zn^{2+} absorption in a dose-dependent manner. There is, however, some lack of agreement among studies, particularly with respect to specific foods and their individual components. In addition, phytate was shown not only to depress the availability of dietary Zn^{2+}, but also to affect Zn^{2+} homeostasis negatively [15]. A great deal of controversy exists regarding the effect of phytate on the availability of dietary iron [14, 21]. Much of this controversy may be due to the low absorption of iron in general, the presence of different iron-phytates with different solubility, and the existence of two types of food iron, heme and nonheme iron.

Heme iron is better absorbed and its absorption is little affected by dietary factors; nonheme iron, however, is less easily absorbed, and its absorption is affected by other dietary factors. Since many human studies indicate that phytate has a very strong inhibitory effect on iron absorption, it is well accepted today, that phytate appears to be the major but not the only contributor to the reduction in iron availability in man [22, 44]. Human studies also indicated that phytate inhibits Ca^{2+} absorption, but the effect of phytate on Ca^{2+} availability seems to be less pronounced compared to that on the availability of iron and particularly Zn^{2+} [7, 14]. This may be due to the relatively high Ca^{2+} content of plant-based foods, the capability of the bacterial flora in the colon to dephosphorylate phytate and the fact, that Ca^{2+} could be absorbed from the colon [23]. Relatively few studies have dealt with the effects of phytate on dietary Cu^{2+}, Mn^{2+} and Mg^{2+} utilisation. Phytate has been shown to decrease their bioavailability in in vivo studies, but it appears that the effect of phytate on Cu^{2+}, Mn^{2+} and Mg^{2+} availability is less marked than those for some other essential elements [13,14].

The fact that phytate-phosphorus is poorly available to single- stomached living beings including man was already demonstrated [24, 25]. Phosphorus is absorbed as ortho-phosphate and therefore the utilisation of phytate-phosphorus by single-stomached living beings will largely depend on their capability to dephosphorylate phytate. It was already shown, that the human small intestine has only a very limited capability to hydrolyse phytate [26] due to the lack of endogenous phytate-degrading enzymes (phytases) and the limited microbial population in the upper part of the digestive tract.

Effect on protein digestibility

Phytate interactions with proteins are pH-dependent [5, 7]. At pH-values below the isoelectric point of the protein, the anionic phosphate groups of phytate bind strongly to the cationic groups of the protein to form insoluble complexes that dissolve only below pH 3.5. The α-NH2 terminal group, the ε-NH2 of lysine, the imidazole group of histidine and guanidyl group of arginine have been implicated as protein binding sites for phytate at low pH-values. These low pH proteinphytate complexes are disrupted by the competitive action of multivalent cations. Above the isoelectric point of the protein, both protein and phytate have a negative charge, but in the presence of multivalent cations, however, soluble protein-cation-phytate complexes occur. The major protein binding site for the ternary complex appears to be the nonprotonated imidazole group of histidine, but the ionized carboxyl group of the protein are also suggested sites. These complexes may be disrupted by high ionic strength, high (pH> 10), and high concentrations of the chelating agents.

Phytate is known to form complexes with proteins at both acidic and alkaline pH [5]. This interaction may effect changes in protein structure that can decrease enzymatic activity, protein solubility and proteolytic digestibility. However, the significance of protein-phytate complexes in nutrition is still under scrutiny. Strong evidence exists that phytate-protein interactions negatively affect protein digestibility in vitro and the extent of this effect depends on the protein source [5]. A negative effect of phytate on the nutritive value of protein, however, was not clearly confirmed in studies with simple-stomached animals [7, 45]. While some have suggested phytate does not affect protein digestibility, others have found an improvement in amino acid availability with decreasing levels of phytate. This difference may be at least partly due to the use of different protein sources. Of nutritional significance might be also the inhibition of digestive enzymes such as α-amylase [46,47], lipase [48] or proteinases [49,51], such as pepsin, trypsin and chymotrypsin, by phytate as shown in in vitro studies. The inhibitory effect increases with the number of phosphate residues per myo-inositol molecule and the myo-inositol phosphate concentration. This inhibition may be due to the non-specific nature of phytateprotein

interactions, the chelation of calcium ions which are essential for the activity of trypsin and α-amylase, or the interaction with the substrates of these enzymes. The inhibition of proteases may be partly responsible for the reduced protein digestibility. Phytate has also been considered to inhibit α-amylase in vivo as indicated by a negative relationship between phytate intake and blood glucose response [50, 52].

Beneficial health effects of phyate

In the view of the above results, the evidence seems overwhelming that high intakes of phytate can have adverse effects on mineral uptake in humans. In the last years, however, some novel metabolic effects of phytate or some of its degradation products have been recognised. Dietary phytate was reported to prevent kidney stone formation [8], protect against diabetes mellitus [9], caries [10], atherosclerosis and coronary heart disease [11] as well as against a variety of cancers [12]. The levels of phytate and its dephosphorylation products in urine, plasma and other biological fluids are fluctuating with ingestion or deprivation of phytate in the human diet [53]. Therefore, the reduction in phytate intake in developed compared to developing countries might be one factor responsible for the increase in diseases typical for Western societies such as diabetes mellitus, renal lithiasis, cancer, atherosclerosis and coronary heart diseases. It was suggested that phytate exerts the beneficial effects in the gastrointestinal tract and other target tissues through its chelating ability, but additional mechanisms have also been discussed. Moreover, the potential beneficial effects of phytate in the prevention of severe poisoning should be considered.

One to two percent calcium phytate in the diet has been found to protect against dietary Pb^{2+} in experimental animals and in human volunteers [54]. Furthermore, calcium phytate was capable of lowering blood Pb^{2+} levels [7, 55]. Thus, phytate seems to be a helpful means to counteract acute oral Pb^{2+} toxicity. The effect of calcium phytate on acute Cd^{2+} toxicity is still discussed controversially, but the majority of studies point to an improved Cd^{2+} absorption in the presence of phytate [56,57]. This may result in a Cd^{2+} accumulation in liver and kidney.

Diabetes mellitus is one of the most common nutrition-dependent diseases in Western society. It may be caused by hyper-caloric diets with high percentage of quickly available carbohydrates. Foods that result in low blood glucose response have been shown to have great nutritional significance in the prevention and management of diabetes mellitus. In this regard phytate-rich foods are of interest, since a negative relationship between phytate intake and blood glucose response was reported [9,52]. For example, phytateenriched unleavened bread based on white flour reduced the in vitro starch digestibility besides flattening the glycemic response in five healthy volunteers in comparison with bread without phytate addition [52]. The in vitro reduction of starch digestion was positively correlated with the myo-inositol phosphate concentration and negatively with the number of phosphate groups on the myo-inositol ring. It has to be noted, that there are also studies which have not found an inhibition of α-amylase and starch digestion by phytate.

Phytate and Coronary Heart Disease

Heart disease is a leading cause of death in Western countries, yet it is low in Japan and developing countries. Elevated plasma cholesterol or more specifically, elevated Low Density Lipoprotein cholesterol concentrations have been shown to be one of the risk factors. It has been proposed that dietary fibre or more specifically phytate, as a component of fibre, may influence the aetiology of heart disease [58]. Animal studies have demonstrated that dietary phytate supplementation resulted in significantly lowered serum cholesterol and triglyceride levels [11]. This effect was accompanied by decrease in serum zinc level and in zinc-copper ratio. Thus, the hypothesis was put forward that coronary heart disease is predominantly a disease of imbalance in regard to zinc and copper metabolism [59]. The hypothesis is also based on the production of hypercholesterolemia, which is a major factor in the aetiology of coronary heart disease, in rats fed a diet with a high ratio of zinc and copper [60]. It was thought that excess zinc in the diets resulted in decreased copper uptake from the small intestine, since both minerals compete for common mucosal carrier systems. As phytate preferentially binds zinc rather than copper [61], it was presumed that phytate exerts its effect probably by decreasing zinc without affecting copper absorption. It should be pointed out that the support for the preventive role of phytate in heart disease is based only on a few animal and in vitro studies. Results from human studies are still lacking.

Phytate and Renal Lithiasis

The increase of renal stone incidence in northern Europe, North America, and Japan has been reported to be coincident with the industrial development of these countries, making dietary intake suspect. Epidemiological investigations found that there were substantial differences in renal stone incidences between white and black residents of South Africa [62]. The major dietary difference is that, compared to the white population, blacks consumed large amounts of foods containing high levels of fibre and phytate. Furthermore, a high phytate diet has been used effectively to treat hypercalciuria and renal stone formation in humans [7,63]. In recent years, research on phytate as a potent inhibitor of renal stone formation has been intensified [8,64,65]. By comparing a group of active calcium oxalate stone formers with healthy people it was demonstrated that urinary phytate was

significantly lower for stone formers [8]. Therefore, in vitro and in vivo experiments as well as clinical studies clearly demonstrate that phytate plays an important role in preventing the formation of calcium oxalate and calcium phosphate crystals, which function as nuclei for kidney stone development. Because excretion of low phytate amounts in the urine was shown to be an important risk factor in the development of renal calculi and urinary excretion of phytate decreased significantly after intake of a phytate-free diet [64], the importance of dietary phytate in maintaining adequate urinary levels to permit effective crystallization inhibition of calcium salts and consequently preventing renal stone development was demonstrated.

Phytate and Cancer

The frequency of colonic cancer varies widely among human populations. It is a major cause of morbidity and mortality in Western society. The incidence of cancer, especially large intestinal cancer has been associated principally with dietary fat intake and is inversely related to the intake of dietary fibre. It was further suggested that the apparent relationship between fibre intake and rate of colonic cancer might arise from the fact that many fibre-rich foods contain large amounts of phytate and that this latter might be the critical protective element, since an inverse correlation between colon cancer and the intake of phytate-rich fibre foods, but not phytatepoor fibre foods has been shown [66]. A high phytate intake may also be an important factor in reducing the breast and prostate cancer mortality in man [12]. Both in vivo and in vitro experiments have shown striking anticancer effects of phytate. It was demonstrated that phytate is a broad-spectrum antineoplastic agent, affecting different cells and tissue systems [12]. Phytate inhibited the growth of human cell lines such as leukaemic haematopoietic K-562 cell line [67,68], colon cancer HT-29 cell line [69], breast cancer cell lines [70], cervical cancer cell lines [71], prostate cancer cell lines [72,74], HepG2 haepatoma cell line [75], mesenchymal tumour cells [76], murine fibrosarcoma tumour cells [76], and rhabdomyosarcoma cells [77] in a dose- and time-dependent manner. However, cells from different origin have different sensitivity to phytate, suggesting that phytate may affect different cell types through different mechanisms of action. It was also demonstrated, that phytate has the portential to induce differentiation and maturation of malignant cells, which often results in reversion to the normal phenotype [68]. Phytate was further shown to increase differentiation of human colon carcinoma HT-29 cells [69,78], prostate cancer cells [72, 73], breast cancer cells [70], and rhabdomyosarcoma cells [77]. The effectiveness of phytate as a cancer preventive agent was also shown in colon cancer induced in rats and mice. Phytate was effective in a dose-dependent manner given either before or after carcinogen administration.

The phytate-treated animals demonstrated a significantly lower tumour number and size. Studies using other experimental models showed that the antineoplastic properties of phytate were not restricted to the colon. Phytate significantly reduced experimental mammary carcinoma [79,80, 83], skin papillomas [84], tumour size of metastatic fibrosarcoma and experimental lung metastases [76], growth of rhabdomyosarcoma cells [77], and regression of pre-existing liver cancers [75,85]. In addition synergistic cancer inhibition by phytate when combined with inositol was demonstrated in several cancers in experimental animals [76,81,82,86]. The in vivo experiments were performed either by adding phytate to the diet or by giving phytate via drinking water. Comparable of even stronger tumour inhibition was obtained with much lower concentrations of phytate when it was given in drinking water.

Mechanism of action

The mechanisms involved in the anticancer activity of phytate are not fully understood. It was suggested that phytate exerts the beneficial effects through its chelating ability, but additional mechanisms have also been discussed. Because several myo-inositol phosphates, including phytate, are present as intracellular molecules and because the second messenger D-myo-inositol (1,4,5) trisphosphate is bringing about a range of cellular functions including cell proliferation via mobilising intracellular Ca^{2+} [87], phytate was proposed to exert its anticancer effect by affecting cell signalling mechanisms in mammalian cells [68]. About 35 of the 63 possible myo-inositol phosphate isomers were identified in different types of cells [87]. Depending on cell type, that is different receptors, phosphatases, and kinases, myo-inositol phosphates were linked with different physiological effects, such as basic cell functions like secretion and contraction as well as functions like cell division, cell differentiation and cell death. Therefore, practically every myo-inositol phosphate isomer extracellularly present and may have a metabolic effect by activating receptors, by being metabolised by phosphatases and kinases or by acting as inhibitors of these intracellular proteins after being internalised by cells. An effect of extracellular phytate on the concentration of several in- tracellular myo-inositol phosphate esters has already been demonstrated in human erythroleukemia cells [68]. Furthermore, it has been recently reported that highly negatively charged myo-inositol polyphosphates can cross the plasma membrane and be internalised by cells. Myo-inositol hexakisphosphate was shown to enter HeLa cells followed by an intracellular dephosphorylation to partially phosphorylated myo-inositol phosphates [71], whereas myo-inositol (1,3,4,5,6) pentakisphosphate showed a quite slow turnover after internalisation by SKOV-3 cells [88]. It was suggested that the anticancer activity of phytate is actually due to its dephosphorylation to lower forms. Myo-inositol (1,3,4,5, 6)

pentakisphosphate inhibits specifically phosphatidylinositol 3-kinase, the enzyme catalysing the phosphorylation of inositol phospholipids at the D3 position to generate 3'-phosphorylated phosphoinositides [89], which act by recruiting specific signalling proteins to the plasma membrane [90]. Activation of phosphatidylinositol 3-kinase is a crucial step in some events leading to angiogenesis, the formation of a mature vasculature from a primitive vascular network [90, 91]. Angiogenesis is involved in pathologies such as arteriosclerosis and tumour growth.
The observed anticancer effects of phytate could be mediated through several other mechanisms. Besides affecting tumour cells, phytate can act on a host by restoring its immune system. Phytate augments natural killer cell activity in vitro and normalises the carcinogen-induced depression of natural killer cell activity in vivo [7, 92]. The anti-oxidant role of phytate is known and widely accepted. The 1,2,3-trisphosphate grouping in phytate has a conformation that uniquely provides a specific interaction with iron to completely inhibit its capability to catalyse hydroxyl radical formation from the Fenton reaction [93]. Chelation of iron to the 1, 2, 3-trisphosphate grouping may also reduce the likelihood for ironcatalysed lipid peroxidation [94]. It is as yet uncertain whether physiological intakes of phytate can significantly improve the anti-oxidant status in man. The anticancer action of phytate may be further related to mineral binding ability or other positively charged compounds. By complexing Zn^{2+} and /or Mg^{2+}, phytate can affect activity of enzymes essential for DNA synthesis. Due to inhibition of starch digestion in the small intestine, undigested and unabsorbed starch will reach the colon where it may either contribute to faecal bulk and increase the dilution of potential carcinogens, or it may be fermented to short-chain fatty acids, which may subsequently decrease the colonic pH. The increased production of shortchain fatty acid, particularly butyrate, may play a protective role in colon carcinogenesis, because butyrate has been shown in several in vitro studies to slow down the growth rate of human colorectal cancer cell lines [95,96]. Decreased pH has been suggested to be protective of colon carcinogenesis [97] by possibly causing alterations in the metabolic activity of colonic flora, altering bile acid metabolism and inhibiting ammonia production and absorption [98, 99].

Conclusion

Phytate is a principal chelating agent in cereal-based foods and is capable of impairing divalent mineral bioavailability through binding. Phytate has been recognized as an antinutrient due to its adverse effects. It reduced the bioavailability of minerals and caused growth inhibition. Many studies reported that phytate in plant foods binds essential dietary minerals in the digestive tract, making them unavailable for absorption. It forms insoluble complexes with Cu^{2+}, Zn^{2+}, Fe^{3+} and Ca^{2+} and as a result reduces the bioavailability of these essential minerals. Many animal feedings of plant food trials reveal that lower bioavailability of zinc, calcium, magnesium, phosphorus and iron are due to the presence of phytate. This is the main reason why phytate has been considered as an antinutrient.
Recent studies on phytate have shown its beneficial effects such as decrease in blood lipids, decrease in blood glucose response and cancer risk. In addition, a high phytate diet is used in the inhibition of dental caries and platelet aggregation, for the treatment of hypercalciuria and kidney stones in humans, and as antidote activity against acute lead poisoning. The beneficial health effects of phytate are more significant for populations in developed countries because of the higher incidence of cancer especially colon cancer which is associated with higher fat and lower fibre rich food intakes. Such populations generally do not suffer from mineral deficiencies. On the one hand, the chelating ability of phytate is considered to be a detriment to one's health whilst, on the other hand, many researchers consider this ability to bind with minerals as its most powerful asset. Such a variant topic signifies that more intensive studies are needed to obtain better insight into the mechanism responsible for the ''friend or foe" challenge of phytate. Moreover, regardless of a series of researches on the positive and negative features of phytate, the information on the dosage for humans eliciting positive or negative effects is limited and the optimal dosage for clinical therapies is yet to be determined.

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