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A Review On: Natural Food Toxins as Anti-Nutritional Factors in Plants and Their Reduction Approaches.

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ABSTRACT

Generally, food is one of all living being's basic needs, and it is composed of diverse nutrients that can be consumed by animals, including humans, for nourishment. Almost all foods are made from plants or animals, and many plants or plant components are used as food. Therefore, it is of importance to provide reliable, widespread and up-to-date information about food content including both nutritional and antinutritional essentials. Nutrients are accompanying with positive effects on human health. Antinutrients, on the other hand, are far less popular for the current population. They are highly bioactive, proficient of harmful effects as well as some beneficial health effects in human beings, and much available in plant-based foods. Legumes and cereals contain high amounts of macronutrients and micronutrients but also anti-nutritional factors. Major anti-nutritional factors, which are found in edible crops include tannins, saponins, phytic acid, protease inhibitors, lectins, amylase inhibitor. Anti-nutritional factors combine with nutrients and act as the major concern because of reduced nutrient bioavailability. Various other factors like trypsin inhibitors and phytates, which are present mainly in legumes and cereals, reduce the digestibility of proteins and mineral absorption. These compounds are of natural or synthetic origin, affect with the absorption of nutrients, and can be responsible for some mischievous effects related to the nutrient absorption. Some of the common symptoms revealed by a large amount of antinutrients in the body can be bloating, headaches, nausea, rashes, nutritional deficiencies, *etc*. Phytates, oxalates, and lectins are few of the well-known antinutrients. Science has approved several ways in order to modify the negative influence antinutrients exhibiting on human health. Biochemical, mechanical and thermal approaches act synergistically to provide food with lower antinutritional levels. By using various methods alone or in blends, it is possible to reduce the level of anti-nutrients in foods. There are various traditional methods and technologies, which can be used to reduce the levels of these anti-nutrient factors. Several processing techniques and methods such as germination, fermentation, and autoclaving, soaking etc. are used to reduce the anti-nutrient contents in foods. This review is focused on different types of anti-nutrients, and possible processing methods that can be used to reduce the level of these factors in food products.

Keywords: Anti-nutrients Cereals, Legumes, Phytic acid, Micronutrients, Fermentation, Lactic acid bacteria.

1.INTRODUCTION

Food is one of the most important basic requirements, for all living entity's and it is composed of different nutrients that can be consumed by animals, including humans, for nourishment [2]. Almost all foods are made from plants or animals, and many plants or plant components are used as food. According to the Royal Botanic Gardens, Kew, more than 7000 vascular plants species are showed that edible, used for human consumption, and cultivated for food [3]. Plants especially food crops yield an extensive range of non-nutrient secondary metabolites in addition to nutrients. The secondary metabolites usually having complex chemical structures to simple organic compotosticated molecules like proteins [4, 5]. Among the plant metabolites, inherent plant toxicants are believed to play an ecological role in plant physiology, proliferation. Also, some of the secondary metabolites prevent killers and are thus toxic to humans [5, 6], while others have different purposes, including plant physiological defence against insects, viruses' bacteria, fungi, [4, 5, 7, 8]. Characteristic plant toxins are not harmful to the organism itself, but they are hazardous to other species, including humans, when consumed. The structures of these chemicals differ, as do their biological functions and toxicity. Plants' secondary metabolites can have a negative influence on consumers' health, extending from acute to chronic toxicity [9]. Acute toxicity includes, vomiting, nausea, stomach discomfort, dizziness, and skin allergies, whereas chronic health implications can cause irreparable harm to important organ systems such as the immune system, reproductive system, kidneys, and in severe cases, they can be carcinogenic and fatal. The presence of natural toxins in food is a significant food protection problem for both scientists and guiding bodies. Significantly, it is believed that dietary exposure to these naturally occurring nonnutrient compounds might far balance exposure to any sort of man-made chemical found in food. Taking consumer health into account, WHO cooperated with the FAO of the United Nations to develop the Joint Expert Committee on Food Additives, responsible for evaluating health risks modelled by foods containing natural toxins. The EU Council Directive on flavorings regulates intrinsic toxicants from many plant source materials, including plant foods, spices and herbs, such as coumarin, hydrocyanic acid and thujone, safrole. Based on JECFA evaluations, Codex Aliment Arius established international rules and guidelines to limit the amount of natural poisons in food [14]. Food safety is recognized as an essential component of food security, thus guaranteeing food safety is vital [15]. Food safety laws in developing countries are weak, which allows individuals to be regularly exposed to considerable amounts of intrinsic food toxicants. In Asian countries, cereals and legumes are considered as major staple foods. Cereal grains such as rice, maize and wheat belong to the grass family Graminae and hold appreciated place within the staple food crops, because they are consumed throughout the world. Cereal grains afford sufficient amounts of carbohydrates, vitamins, proteins, and most significantly dietary fibres, which are necessary for our daily diet as well as growth and maintenance of the human body [11]. Wheat is one of the key edible food crops, which is consumed by almost one third of the world's population. Wheat is the most diverse crop, which is grown throughout the world with approximately 750 million tons produced annually [13]. Wheat is mainly considered a high nutritive value cereal crop because of its composition, and contents of macronutrients like carbohydrates, proteins, and fats, in addition to minerals such as iron, calcium, zinc, phosphorus, magnesium [16]. Recently, Maize is the crucial cereal crop, which is cultivated throughout the world and deliberated as a vital source of food for humans as well as feed for animals. According to the literature, various traditional and developing food processing techniques such as fermentation, germination, drying, boiling/cooking, microwave heating, and high-pressure processing are described as effective mitigation strategies to detoxify toxicants. As a result, this review article summarizes natural food toxicants of plant sources and the role of traditional and novel food processing techniques in their detoxification.

2 ANTI-NUTRIENT FACTORS

Numerous types of anti-nutritional factors with toxic prospective have been measured in foods and shown to be heat-labile. These factors include tannin, lectins, phytic acid, saponins, and protease inhibitors, antivitamin factors, amylase inhibitors, etc. Nutrition-related problems and harmful effects to human health are raised by these factors, which are present in the seeds of cereals and legumes.

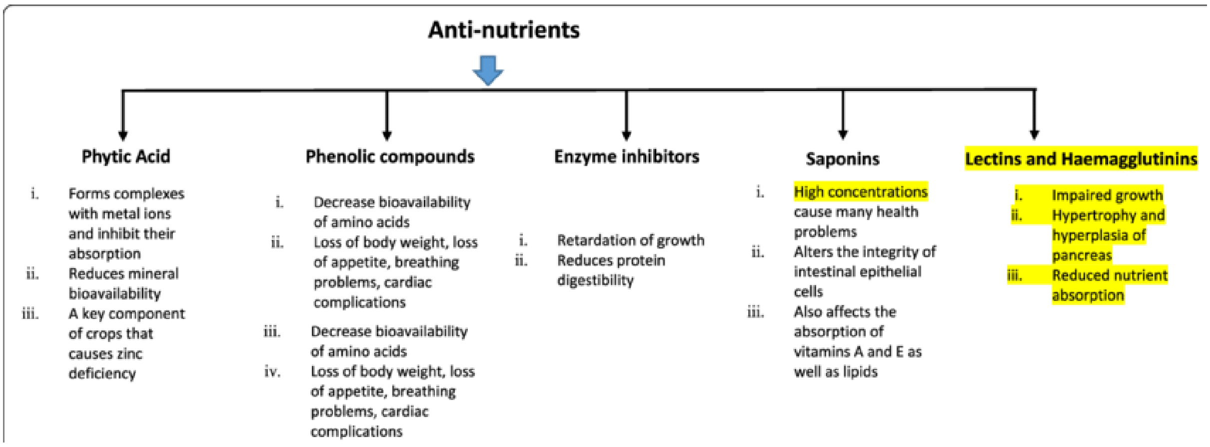

Figure 1. A brief overview of the adverse effects of key anti-nutrients that are present in foods.

2.1 Phytic Acids

Phytic acids occur naturally in the plant kingdom. Phytate is generally known as myo-inositol-1,2,3,4,5,6-hexakis dihydrogen phosphate, which is existing in foods at various levels extending from 0.1 to 6.0% [16]. Phytic acid is a secondary metabolite, which focuses naturally in plant seeds, mainly in legumes, oilseeds and peanuts, cereals, and commonly found in all plant-based foods. In numerous cases, phytates contain about 50 to 80% of the total phosphorous in seeds. Because plant-based foods contain more quantity of phytic acids than animal-based foods, the vegetarian diets culture in developing countries contribute to high assimilation levels [18,20]. According to a previous report, phytic acid delays the activity of enzymes, which are necessary for protein degradation in the small intestine and stomach. Normally, phytic acids affect the bioavailability of minerals and has a strong effect on pregnant lactating women and infants when large percentages of cereal-based foods are consumed [17,19]. Throughout germination of seeds, some native enzymes are activated, which degrade the phytic acid. In rice and wheat, which are generally recognized as monocotyledon crops, phytates are present in the bran layer and can be easily separated during milling. On the other hand, in di cotyledons such as legumes, nuts and oilseeds phytates are found in close relationship with proteins, which decreases ease of separation by a simple processing method like milling. Phytic acid is generally a negatively-charged structure, which generally binds with positively-charged metal ions such as magnesium zinc, calcium and iron to make complexes and decrease the bioavailability of these ions through lower absorption rates. Mainly due to this chelating property, phytic acid is considered as a most effective anti-nutrient in foods, and a cause of mineral ions deficiencies in animal and human nutrition.

2.2 Enzyme Inhibitors

Proteinases are enzymes, which have different roles in nurturing nutritional and functional properties of various protein molecules. Various proteolytic actions are proficient by proteases inhibitors such as cellular apoptosis, signal initiation, transmission blood coagulation inflammatory response, and several pathways of hormone processing [19]. Cereal seeds mainly contain plant serpins, one of the largest protease inhibitor family, which are also known as “suicide inhibitors” having molecular weight of 39 to 43 KDa and also found in numerous other species in the plant kingdom. Serpins are one of the most important active inhibitors, which normally inhibit the trypsin and chymotrypsin activities by temporary upon the corresponding reactive sites of the enzymes. Another one of the obviously occurring plant inhibitors are the protease inhibitors which have improved an important research area due to their effective way of protective enzyme activity by forming protein–protein interactions. They inhibit the enzyme action through the catalytic approach by delaying the active site of the enzymes. The N- or C-terminus and the showing loop of protease inhibitors are frequently considered important structural features for the inhibition of enzyme activity [14,16]. Ragi comprises bifunctional inhibitor, which deactivates the protein and starch-degrading enzymes by making trimetric complex collaborations with trypsin and α-amylase, respectively. usually legumes have high quantities of α-amylase inhibitors, protease inhibitors and lectins, which might lead to less minerals bioavailability as well as decreases the nutrients absorption and digestibility. Associated to legumes, cereals contain much lesser amounts of these digestion inhibitors, particularly those that act against amylases and proteases. Within the gastrointestinal tract of animals, proteolytic enzyme activity might be severely inhibited by protease inhibitors existing in diets [20].

2.3 Saponins

Saponins are generally deliberated as non-volatile, surface active secondary metabolites, which are broadly distributed in nature but found mainly in plants. Saponins are triterpenes or steroids and contain a sugar moiety in their structure. They are naturally produced as foam-producing glycosides by many plant species, including groundnut, oil seeds etc. Triterpenoid saponins are usually found in most sophisticated crops such as legumes tea leaves, quinoa seeds, sunflower seeds, spinach leaves, sugar beet and allium species. In distinction, steroid saponins are generally present in food plants such as oats, yucca, tomato seeds, fenugreek seeds, asparagus, aubergine, and yam [15]. Saponins are plant-derived secondary complexes, which are found in more than 100 families of wild and cultured plants that belong to the Magnoliophyta division. Magnoliophyta can be divided into two key classes: Liliopsida and Magnoliopsida, which contain majority of species that produce saponins. Saponins have a property of being able to interact with the cholesterol group of erythrocyte membranes, which leads to hemolysis [19]. Previous studies have reported that saponins also showed inhibitory activities of digestive enzymes such as amylase, glucosidase, trypsin, chymotrypsin and lipase, which can cause indigestion-related health disorders. Glucosidases are carbohydrate-hydrolyzing enzymes, which are mainly involved in the breakdown of glycosidic bonds in complex sugars. α-Glucosidase is one of the important glucosidases, which is present in the brush border of the small intestine. α-Glucosidase facilitates glucose absorption by breaking the glycosidic bonds in disaccharides and starch to produce the simpler and more absorbable monosaccharides. Saponins are not readily hydrolysed by the human digestive enzymes, therefore gastrointestinal digestion can be severely impaired. Previous studies have demonstrated that animal metabolism and health could be affected by saponins in different ways. The effects include bloating in ruminants, reduced nutrient absorption, decreased liver cholesterol and overall growth rate, and reduced intestinal absorption of many nutrients through binding of saponins to the small intestine cells [22].

2.4 Lectins And Haemagglutinins

Lectins and hemagglutinins are a form of sugar-binding proteins, which absolutely attach to red blood cells to cause cohesion. These anti-nutrients are mainly establishing in foods, which are intake in raw forms [13]. Cereals and legumes generally contain lectins, which are glycoproteins. In addition, transport and hydrolytic functions of the enterocyte would be impaired by intake of foods that contain lectins [18]. Phytohemagglutinin is a tetrameric glycoprotein with a molecular mass of 120 kDa, which is found in kidney beans and also comprises of two various subunits. Purified lectins from beans or soybeans impaired rat growth, induced expansion of the small intestine, caused damage to the epithelium of the small intestine, and stimulated hypertrophy and hyperplasia of the pancreas. Lectins impair nutrient immersion by binding to intestinal epithelial cells, and also cause damages in the intestinal tract, which allow bacterial population to come into contact with the blood stream [17].

3. NATURALLY OCCURRING PLANT FOOD TOXICANTS

Many plant species are grown for food preps a large amount of phytotoxins that are altered from the primary metabolic intermediates and products [4]. Some of the characteristic toxicants with adverse health consequences produced as secondary metabolites by different plant foods are summarized below.

3.1. Cyanogenic Glycosides

Cyanogenic glycosides are one of the major amino acid-derived plant ingredients produced as secondary metabolites and used as a defence mechanism against a variety of predators [19, 20]. They yield hydrogen cyanide (HCN) and are found is in the family of the Leguminosae, Linaceae, and Compositae, Fabaceae, Rosaceae families [17]. Particularly they occur in cassava, flaxseed. Nearly 25 cyanogenic glycosides are mainly found in the edible section of plants. Cyanogenic glycosides are derived from the amino acids phenylalanine, leucine, isoleucine, tyrosine, and valine and the non-proteinogenic amino acid, cyclopentenylglycine.

The major function of cyanogenic glycosides is to release hydrogen cyanide standardizes their toxicity [19, 20]. Dietary cyanide exposure can cause severe poisoning and has been associated in the etiology of different chronic disorders. The interaction of cyanogenic glycosides with the hydrolytic glucosidase enzyme is necessary for toxicity. Critical cyanide intoxication primarily affects the central nervous system, as well as the cardiovascular, endocrine and respiratory systems. Some time, it can ca fast breathing, use a reduction in blood pressure, fast breathing, headache, stomach-aches, vomiting, dizziness, diarrhoea, cyanosis with twitching and convulsions, mental confusion, and mortality [13]. The fatal doses described in the literature significantly vary. However, the mean lethal dose of cyanide by mouth in human adults is estimated to be in the range of 50 to 200 mg, and death is rarely deferred for more than 1 hour if untreated. Chronic cyanide exposure is known to cause symptoms that differ from those observed in severe doses. It has been linked to a numerous health problem, predominantly among cassava-eating people. Chronic cyanide toxicity has been linked to health issues such as malnutrition, congenital abnormalities, neurological problems, and myelopathy. Goiter or thyroid gland swelling has also been reported in populations where cyanogenic glycoside levels in cassava diets exceed 10–50 mg/kg [20].

3.2. Glycoalkaloids

Glycoalkaloids are one of the naturally occurring toxic substance in the Solanaceae family plants that are related with insect resistance [14, 16]. These toxins are normally produced in the flowers, roots, leaves, and edible parts of plants, including sprouts and skin. Glycoalkaloids are act as an amphiphilic due to the existence of two structural components. The hydrophobic cholestane skeleton are formed aglycone unit in with nitrogen inserted into the F-ring. The second unit is a 3-OH attached hydrophilic carbohydrate side chain [17]. The primary Solanum alkaloids of both toxicological and pharmacological significance are steroidal alkamines, all are haveing the cholestane C27 steroidal structure. The major glycoalkaloids in potato types are α-chaconine and α-solanine which also contain similar alkaloidal aglycone bases, solanidine. Both compounds are heat-stable, as they only decompose between 230 and 280° C. α-Chaconine, in particular, is the most poisonous of potato alkaloids in terms of total toxicity. It inhibits acetyl-cholinesterase, which makes the cell organ damage and disruption [15]. The concentration of α-solanine in potatoes is typically greater than the 140 mg/kg fresh weight and has been originate to cause a bitter taste and a burning feeling in the throat and mouth [14]. Moreover, in humans, the toxic dose of total glycoalkaloid is 2 to 5 mg/kg body weight, and the lethal dose is 3 to 6 mg/kg body weight.

3.3. Glucosinolates

Glucosinolates are a branch of chemicals found in plants such as cauliflower, broccoli, and cabbage that belong to the goitrogen family [20–21]. Generally, they have been noticed in 16 different angiosperm plant species, mainly in the Brassicaceae family, which includes Arabidopsis thaliana. Brassica vegetables, such as broccoli, turnip, horseradish, cauliflower, cabbage, mustard and rapeseed [18]. Glucosinolates have a principal structure that includes a β-D-thioglucose group coupled to a sulfonated aldoxime moiety and a variable chain made up of amino acids. After hydrolysis, glucosinolates. generate a definite family of anionic natural yields with the ability to form isothiocyanates with the common structure R-N=C=S [18]. Even though the fact that glucosinolates have a variety of health benefits, consuming vegetables and seeds from the Brassicaceae family entirely has been linked to harmful effects. High levels of Glucosinolates have been linked to a variety of harmful significances, including an enlarged organ abnormalities especially liver and kidney, thyroid, decreased plasma thyroid hormone levels, impaired growth, reduced reproductive routine, and even death. The enzyme myrosinase converts glucosinolates into a number of derivatives such as thiocyanates, isothiocyanates, and epithionitriles during the mastication process. However, detailed recommendations for increasing or decreasing glucosinolate-containing food consumption, as well as setting the maximum tolerated level are yet to be developed [14].

3.4. Pyrrolizidine Alkaloids

Pyrrolizidine alkaloids are the specialized heterocyclic chemical compounds produced by plants that are hypothesized to function as herbivore protection agents [13–11]. Pyrrolizidine alkaloids producing plants are mostly found in the Asteraceae and Fabaceae family plant species. Pyrrolizidine alkaloids are mainly composed of two main parts, a basic amino alcohol moiety known as a necine and one or more acids (necic acids) that esterify the necines' alcohol groups. Combining known necines and necic acids can theoretically yield a wide range of pyrrolizidine alkaloids. Necines with only one hydroxyl group at C-9 have a single ester linkage with a monocarboxylic acid. Monocarboxylic acids can esterify necines with two hydroxyl groups, such as at C-9 and C-7 (7,9-necinediols), on either hydroxyl. There is no double bond in the base of platynecine type pyrrolizidine alkaloids, and retronecine and heliotridine are enantiomers. The liver is the primary target of Pyrrolizidine alkaloids toxicity, due to the fact that bioactivation occurs mostly in this organ. Veno-occlusive disease, also referred to as hepatic sinusoidal obstruction syndrome, is the most common clinical sign, and it is thought to be a sign of Pyrrolizidine alkaloids poisoning. The symptoms associated with Pyrrolizidine alkaloids toxicity include diarrhea, vomiting, bloody and liver enlargement. Chronic Pyrrolizidine alkaloids exposure results in necrosis, fibrosis, cirrhosis, and bile duct epithelial growth; the greatest level of toxicity is liver failure and death.

4.SOME PLANS USED TO REDUCE FOOD LEVELS OF ANTNUTRIENTS

Earlier studies have been shown that especially anti-nutrients are the source for many adverse effects on diet assessment by reducing nutritional significance of foods. Prasad et al. (1963) reported that Egyptian boys were found deficient with zinc minerals, especially those that consumed bread and beans consistently. It is now very well accepted that phytate present in foods is one of the key concerns for the zinc deficiency. Jenkins and Atwal (1994) reported that dietary saponins reduced the growth and feed proficiency in chicks, while the absorption of vitamins A and E as well as lipids was also negatively impacted. A previous study by Lee et al. (1993) concluded that the metabolism of calcium, zinc and phosphorous was adversely affected when phytate was given to female rats. Besides their property of reduction of various minerals and nutrients, these anti-nutrients could cause toxicity when present in higher amounts in the diet. Due to these reasons, reduction in the anti-nutritional content of foods is of great interest. Different traditional methods and technological processing ways such as milling, soaking, roasting, cooking, debranning, germination and fermentation have been used for reducing these anti-nutritional components in foods. Here we describe various processing methods, which are used to decrease the concentration of phytate, tannin, saponins, etc. in foods.

4.1 Milling

Milling is the most important traditional methodology used to separate the bran coating from the grains. It is a process by which grains are ground into flour. The milling technique removes anti-nutrients take for example lectins, phytic acid tannins, which are found in the bran of grains, the major disadvantage of this technique is that it also removes important minerals [15]. For example, research on millet milling reported that the chemical composition of pearl millets was changed due to milling process. On the other hand, no much change was observed in pearl millet flour when processed through baking. However, milling and heating process during making of chapatti reduced the phytic acid and polyphenol contents in addition to major improvements in starch and protein digestion [17].

4.2 Soaking

Another one of the most effective method used for removing antinutrient content present in the foods is soaking because it is mainly reducing the cooking time. Soaking also helps to release of enzymes that is endogenous phytases, which are present in plant foods like almonds and other nuts and grains. Usually soaking affords the essential moist conditions in nuts, grains and other edible seeds, which are essential for their germination and associated reductions in level of enzyme inhibitors as well as other anti-nutrients to enhance digestibility and nutritional value [18]. Soaking is also commonly required for fermentation, which can also be needed for reducing the percentage of various anti-nutrients present in the foods. Most of the water soluble anti-nutrients are present in the nature, which increase their removal from foods through leaching. Soaking generally increases the hydration level of legumes and cereals, which make them soft and also activate an endogenous enzyme like phytase to enhance ease of further processing such as cooking. The previous study stated that usually 6 hours soaking reduced 27.9% and 24 hours of soaking reduced 36.0% of phytic acid at room temperature in Mucana flagellipes [18]. Still, soaking normally decreases the level of anti-nutrient phytochemicals present in the phytate, tannins, etc. Hence, due to these benefits, it was highly recommended that barley and wheat should be consumed after soaking for a period of time, specifically 12 to 24 h. The earlier research studies were conducted by Greiner and Konietzny (2006) showed that soaking reduced phytate content significantly at 45 °C and 65 °C. Soaking of grains and beans was found much effective to enhance the minerals concentration and protein availability, convoyed by reductions in phytic acid level. One more study reported that phytic acid concentration in chickpea was deceased by 47.45 to 55.71% when the soaking time was increased from 2 to 12 hours [14].

4.3 Autoclave and cooking

Autoclave is an application, which is generally used for heat treatments. When this application is used on cereals and other plant-based foods, it activates the phytase enzyme as well as increases acidity [20]. Most of the foods showed health benefits when consumed after autoclaving. For example, boiling of food grains reduced anti-nutrients content, which improved their nutritional value. Soaking and cooking also greatly decreased the phytic content in legume grains [12]. Food legumes are generally cooked by boiling or by using a pressure cooker prior to consumption. Previous studies also reported that boiling or cooking highly improved the nutritional value of foods by reducing their antinutritional (e.g. tannins and trypsin inhibitors) contents [17]. Another study by Vadivel and Biesalski (2012) reported that phytic acid concentration drastically decreased in legume grains when they were treated with cooking and soaking. In another study, it was reported that anti-nutrients of black grams and mung beans were reduced by pressure-cooking when compared to normal cooking treatment. A study by Shah (2001) observed that pressure-cooking reduced the tannins content, which led to improved black gram protein digestibility. Savage and Mårtensson (2010) also reported that oxalate content of taro leaves was reduced by 47% when boiled in water for 40 min, even though there was no significant reduction observed in oxalate content after baking for 40 min at 180 °C. Most of the previous studies concluded that autoclaving is the best method to reduce levels of several anti-nutritional compounds when compared to other processing methods [11].

4.4 Germination

Germination is also one of the most important highly suitable methodology used for reducing the anti-nutrient constituents of plant-based foods. Germination of seeds normally activates the enzyme like phytase, which degrades the phytate it will reduce the phytic acid concentration in the samples. Usually Germination modified the nutritional level of the food, it may be biochemical property and physical features of the seed. Germination is the most regularly used method for reduction of cereals anti-nutritional property [13]. Germinated cereals showed enhanced activity of phytase-degrading enzyme while in non-germinated cereals the endogenous activity of phytase enzyme was observed in reduced amounts [17]. After malting of millet samples for 72 h and 96 h, it was found that phytic acid content was reduced 23.95 and 45.3%, respectively [11]. In a previous work by Azeke et al. (2011), it was observed that phytate content of cereal grains samples was reduced significantly when estimated after 10 days of germination. Latest studies reported that germination also changes the isoflavone profile of soybean due to activation of β-glucosidases; this is important in enhancing nutritional value because isoflavones exhibit chelating properties. A study by Samia et al. (2005) reported that fermentation and germination could enhance the nutritional level of cereals and legumes by altering the chemical composition and reduce the level of anti-nutritional factors.

CONCLUSIONS

This review provides essential information on the antinutritional components of cereal and legume seeds. Plants serve as a major source of food for most living organisms. Some plants evolve defence mechanisms to protect themselves from predators by producing inherent chemicals known as secondary metabolites. These secondary metabolites such as glycosides, glucosinolates, glycoalkaloids, lectins, and pyrrolizidine alkaloids are widely found in the most important plant foods, which include cassava, flaxseed, potato, broccoli, rapeseed, chickpea. The most common anti-nutrients present in plant are in consist of saponins, tannins, phytate, and protease inhibitors. If there is an increased value of these components affect with the nutritional factors of foods by decreases the protein digestibility, mineral absorption and causing toxicity and health disorders when present in high concentrations. Nowadays, several strategies are used to overcome the effects of these food anti-nutrients, which include processing treatments such as milling, soaking, germination, autoclave and microwave treatment and fermentation. Various previous studies confirmed that fermentation is one of the best methods to reduce the anti-nutritional factors in foods when compared to all other methods. However, germination followed by fermentation also showed good results for reducing the level of anti-nutrients in foods. Microbial fermentation activates many endogenous enzymes like phytase, which generally degrades phytate in the food; phytate is one of the largest anti-nutrients, which is present in food crops. Previous works have established that anti-nutrients have close negative relationship with the micronutrient bioavailability because higher contents of anti-nutrients reduce availability or absorption of minerals and could lead to nutrients deficiency or malnutrition. As a consequence, much more work should be done on the implementation of emerging technologies, with additional scientific work recommended on food processing methods that are effective against these naturally occurring plant food toxicants, particularly pyrrolizidine alkaloids, with minimal processing.

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