## POSITION STATEMENT

It is the position of the Indian Dietetic Association that people should consume at least 30g of dietary fibre from a variety of plant sources in order to attain various physiological benefits. The CODEX Alimentarius Commission has described dietary fibre as 'carbohydrate polymers derived from a plant origin which are not hydrolyzed by the endogenous enzymes in the small intestine of humans'. Dietary fibre is beneficial to health and, if consumed in adequate amounts, reduces the risk of several chronic diseases, such as cardiovascular disorders, type II diabetes, obesity, certain types of cancer, while supporting digestive health. Sources of dietary fibre have the added benefit of naturally occurring micronutrients and phytochemicals that may improve human health. In addition, a higher fibre intake provided by foods is likely to be less calorically dense and lower in fat and added sugar. Dietary fibre intake in India varies among different socioeconomic groups from 15 to 41 g/day, depending upon the type of food consumed. Dietary fibre intakes in wheat- or millet-based diets are generally higher than in a rice-based diet. Healthy adults and children can achieve adequate dietary fibre intakes by increasing their consumption of dietary fibre from variety of fruits, vegetables, legumes, and whole-grain products. Health benefits from consuming dietary fibre through these foods must be actively communicated to the public.

Over the years, the definition of dietary fibre (DF) has been a subject of discussion globally. Recently, The CODEX Alimentarius Commission has described dietary fibre as 'carbohydrate polymers derived from a plant origin which may include fractions of lignin and/or other compounds associated with polysaccharides in the plant cell walls with ten or more monomeric units, which are not hydrolyzed by the endogenous enzymes in the small intestine (SI) of humans and belong to the following categories:

- Edible carbohydrate polymers naturally occurring in the food as consumed
- Carbohydrate polymers, which have been obtained from food raw material by physical, enzymatic or chemical means and which have been shown to have a physiological effect of benefit to health as demonstrated by generally accepted scientific evidence to competent authorities
- Synthetic carbohydrate polymers which have been shown to have a physiological effect of benefit to health as demonstrated by generally accepted scientific evidence to competent authorities.

However, such compounds are not included in the definition of dietary fibre if extracted and re-introduced into a food'. The definition has left the decision on whether to include carbohydrates of 3 to 9 monomeric units up to the national authorities (1).

**Benefits of adequate fibre intake**

There is considerable epidemiological evidence that higher dietary fibre intakes provide various physiological benefits. Data from the National Institute of Health AARP Diet and Health Study, a large prospective cohort, showed that dietary fibre intake, specifically from grains are inversely associated with total mortality rates, particularly cardiovascular, infectious, and respiratory deaths in both men and women, and in men it was also found to be associated with reduced cancer deaths (2). According to Anderson et al, (2009) individuals with high intakes of dietary fibre are significantly at lower risk for developing cardiovascular diseases (CVD), stroke, hypertension, diabetes, obesity, and some specific gastrointestinal diseases (3).

## Digestive Health

### Improved Bowel Function

It is well believed that one of the main benefits of dietary fibre relates to its improved bowel function. Various studies have associated the intake of Soluble Dietary Fibre (SDF) with improved bowel movement and chronic idiopathic constipation. In a systematic review by Suares and Ford (2011), it was found that, soluble fibre led to improvements in 'straining, pain on defecation and stool consistency, an increase in the mean number of stools per week and a reduction in the number of days between stools' (4). This effect can be attributed to the ability of the soluble fibre to ferment. It has been suggested that fermentable fibre can increase fecal output by stimulating microbial growth, with the production of short-chain fatty acids (SCFA) and other products (5). In a review by Slavin et al, it was observed that consumption of the soluble fibres inulin or oligo fructose result in an increase in faecal weight, while inulin helped relieve constipation and poly-dextrose increased faecal mass and at times stool frequency (6). Apart from soluble fibre, insoluble fibre is also believed to play a major role in improving the bowel function. Insoluble fibres are better known for their beneficial impacts on the health of the digestive system by providing bulk to the diet, accelerating colonic transit via mechanical stimulation of the colonic mucosa (7,8,9). Studies of digestion have shown that resistant starch exerts mild laxative properties, predominantly through stimulation of biomass excretion, but also through some decrease in non-starch protein breakdown (10). The benefits of wheat bran for faecal bulking and transit time are definitive, and have been confirmed by EFSA health claim opinions as well (11,12).

Diarrhea is another extreme of abnormal bowel function. Soluble fibre may absorb water in the gut, reducing the gut transit time. By forming a gel-like consistency and delaying emptying of the intestine, DF can help reduce diarrhoea (13).

### Gastrointestinal Disorders

Burkitt pointed out a protective effect of dietary fibre on intestinal disorders when he observed a low incidence of colon cancer and other non-infectious intestinal diseases among people consuming a fibre-rich diet in African countries (14). A low fibre diet has been commonly observed in patients with IBD, irrespective of disease activity (15,16). Several studies have been performed to evaluate the association between dietary fibre intake and Inflammatory Bowel Disease (IBD), but the results have been inconsistent. The chronic idiopathic Inflammatory Bowel Diseases have been seen to be stemmed from release of several pro-inflammatory mediators. Many studies have associated the IBD with the impairment in production of short-chain fatty acids (SCFAs) (17).

Among the multiple groups of metabolites which are resulted on the fermentation of dietary fibre, short-chain fatty acid is a major group (18,19) which may be beneficial in IBD. However, decreased risk of Crohn's disease but not Ulcerative Colitis was associated with high intake of dietary fibre and fruits (20). Another large prospective cohort study found no association between dietary fibre and etiology of Ulcerative Colitis. A negative association has been found in various studies in the incidence of diverticular disease and fibre intake as well. Diverticulosis is characterized by the formation of sac-like structures, also known as diverticula, which are formed within the colon. Diverticulosis occurs as a consequence of pressure induced damage to the colon. Low fibre diets reduce the stool volume, causing constipation which increases intracolonic pressure (21). On the basis of epidemiological data, Burkitt et al. (1973), suggested a high incidence of colon cancer, diverticulosis, irritable bowel syndrome and hemorrhoids to persistent fibre deprivation. It was found that with increasing intake of dietary fibre, risk of diverticular disease reduced significantly. However, considerable reduction in risk was only found with intakes of fruit and cereal fibre (14).

### Cardiovascular Disorders

Higher intake of dietary fibre may improve serum lipid levels, lower blood pressure, and reduce inflammatory marker levels, explaining fibre's protective properties in improving cardiovascular health (22). A systematic review of cohort studies done on dietary fibre confirmed that total dietary fibre intake was inversely associated with the risk of developing CVD and CHD. Insoluble fibre and fibre from cereal and vegetable and fruit sources were inversely associated with risk of coronary heart disease and CVD. A risk reduction of 9% was found for each 7g/day increase in the dietary fibre intake (23).

#### Hypertension

A systematic review and meta-analysis demonstrated a small but significant improvement in both Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) when a median dose of 8.7g fibre/day was given for over 7 weeks to 1430 participants. Additionally, it was observed in the study that hypertensive patients were more responsive than normotensive individuals (24). Soluble fibre intake causes significant decrease in SBP and DBP (25). However, in another systematic review, fibres from β-glucans caused significant reductions in blood pressure but no such effects were observed from other soluble fibres (26).

#### Lipid Profile

High-fibre diets are also associated with improved lipid profiles (27). Total dietary fibre intake has been inversely associated with blood lipid fractions like total cholesterol, low-density lipoprotein (LDL) cholesterol, and triglycerides, and is positively associated with high-density lipoprotein cholesterol (28). After performing clinical trials in Asian populations, it was suggested by Zhou et al. that dietary fibre intake may help people maintain or increase the plasma HDL-C levels (29). The findings of a cross-sectional study also suggested that increased DF intake was significantly associated with an increased plasma HDL-C levels (30). Dietary fibre has been seen to be associated with increased HDL-C through a mechanism that increases excretion of bile and cholesterol, which then stimulates the hepatic uptake to lower plasma LDL-C concentration (32,33). Viswanathan and Mohan showed significant reduction in serum cholesterol among diabetic patients with a high fibre diet and it was seen that these effects were sustained for a long-time period (31). Water-soluble fibres (specifically, beta-glucan, psyllium, pectin, and guar gum) were found to be most effective in reducing serum LDL-C concentrations, without really affecting high density lipoprotein (HDL) concentrations (34).

#### C-Reactive Protein

Dietary fibre intake has also been associated with protective effects against C-reactive protein (CRP), a sensitive marker of acute inflammation documented as an independent predictor of risk of developing cardiovascular disease. Several epidemiological studies have also demonstrated an inverse relationship between DF intake and CRP (35,36,37). With regard to the source of fibre, positive associations were found in epidemiological studies between increased cereal consumption, a source of both insoluble and soluble fibres, and reduced risk of metabolic syndrome, cardiovascular diseases, and markers of systemic inflammation (38,39,40).

### Weight control

Several studies have shown that there is a positive association between low dietary fibre intake and a high BMI and increasing the intake of dietary fibre significantly reduces the risk of gaining weight and fat in women (41,42,43,44,45). This effect may be attributed to the ability of providing satiation. Viscous soluble fibres prolong the intestinal phase of digestion and absorption, and increase the time-course of post-absorptive signals (46). The viscous nature and water holding capacity of the fibre slow down the rate of digestion and absorption of macronutrients (47). This can intensify hormone release during the alimentary period, impacting metabolic pathways of food intake regulation. Average bite size, eating rate and overall ad-libitum energy consumed have been shown to get influenced when the viscosity is increased (48). The mechanism by which insoluble fibres that survive transit through gut, which may alter satiety and hunger cues, can be different from soluble fibres. Rather than modifying the rate of gastric emptying, insoluble fibres may affect satiety through changes in gut hormones or intestinal transit rate (46).

### Diabetes

A diet rich in dietary fibre has been suggested to be beneficial in people with type II diabetes by American Diabetes Association (49). Dietary Fibre delays digestion and absorption of carbohydrates, ameliorating postprandial hyperglycaemia (87). Yao and colleagues conducted a meta-analysis and found that in 19,033 cases out of 488,293 participants, the risk of type 2 diabetes decreased with total dietary fibre, cereal fibre, fruit fibre and insoluble fibre intake (50). Fujii et al (2013), assessed 4,399 patients and found that increased dietary fibre intake was associated with better glycemic control (51). In another study, Threapleton et al reported that with each 7 g/d dietary fibre consumed, the diabetes risk was reduced by 6% (52). Dietary fibre may enhance peripheral insulin sensitivity in insulin-resistant subjects via the production of short-chain fatty acids due to the intestinal fermentation of fibre (53,54). Soluble dietary fibre has also been associated with lower postprandial glucose levels and increased insulin sensitivity in diabetic and healthy subjects. The effects were attributed to the viscous properties of soluble fibre (55,56). SDF exerts physiological effects on the stomach and small intestine which modulate postprandial glycaemic responses, including delayed gastric emptying (57). A beneficial effect of insoluble dietary fibre has also been discussed in large prospective cohort studies,where a consistent association has been found between consumption of insoluble dietary fibre derived from cereals and whole grains and reduced risk of type II diabetes (58,59).

### Cancer

#### Colorectal cancer

An inverse association has been found in various studies between dietary fibre intake and risk of colon cancer. Epidemiological studies that have compared colorectal cancer incidence among countries with estimates of dietary fibre consumption suggests a protective role of dietary fibre on the incidence of colon cancer (60). In a recent meta-analysis, it was found that for every 10g total dietary fibre consumed daily, the risk of cancer was reduced by 9% (61). With relation to the specific type of fibre, Dagfinn et al. conducted a systematic review and meta-analysis of 25 prospective observational studies, and it was concluded that a high intake of dietary fibre, in particular cereal fibre and whole grains, was associated with a reduced risk of colorectal cancer (62). On relation of the source of fibre to risk of colorectal cancer, it was suggested in the WCRF report that for whole grains, there was a 21% decreased risk per three servings per day for colorectal cancer and 16% decreased risk for colon cancer (63). It was observed that dietary fibre from cereals was particularly significant in reducing the risk of colorectal cancer by increasing stool bulk, diluting faecal carcinogens, and slowing down transit time, thus helping reduce the contact of carcinogens with the colorectal lining (62).

### Gastric cancer

Dietary fibre intake has also been suggested to be associated with reduced gastric cancer risk. In a meta-analysis conducted by Zhang et al (2013) which included 580,064 subjects, a dose-response analysis associated a 10g/day increment in fibre intake with a significant (44%) reduction in gastric cancer risk (64). Bravi et al (2009) also found an inverse relationship between stomach cancer risk and various types of fibre however, an inverse association was found for fibre from vegetables, and to a lesser extent from fruit but not from grains (65).

### Breast cancer

Dietary fibre has also been hypothesized to reduce breast cancer risk based on observations that dietary fibre may inhibit intestinal reabsorption of estrogens and may increase fecal excretion of estrogens (66). In a systematic review and meta-analysis of epidemiological studies which included a total of 3,662,421 participants, it was suggested that dietary fibre consumption is significantly associated with a reduced risk of breast cancer, particularly in post-menopausal women. It showed a 12% decrease in breast cancer risk with dietary fibre intake. Dose-response analysis showed that for every 10-g/day increment in dietary fibre consumption, the risk of breast cancer reduced around 4% (67). With relation to the type of fibre, a meta-analysis suggested that soluble fibre had a strong inverse association with breast cancer risk (9% risk reduction), however, no such association was found with regard to insoluble fibre intake (68). High intake of fibre during adolescence was also associated with 16% lower risk of overall breast cancer and 24% reduced risk of breast cancer before menopause. However, many prospective studies have reported no statistically significant association between fibre intake and breast cancer risk (69,70,71,72). The role of dietary fibre in preventing other types of cancers is still unclear.

## Potential Negative Effects of consuming dietary fibre

It is implausible that healthy adults consuming dietary fibre within the recommended ranges will be affected by any potential negative effect. However, excessive consumption may cause decreased mineral bioavailability and gastro-intestinal discomfort. Dietary fibre intake influences the mechanisms by which nutrients are absorbed in the diet. It may influence the bioavailability of nutrients, microbial composition and gastrointestinal functions (73). Diets rich in fibre, specifically those food items rich in anti-nutrients e.g. phytate, seem to decrease the absorption of several minerals in the small intestine especially iron, calcium, magnesium and zinc (74). In the large intestine, fermentation of dietary fibre and other nondigested carbohydrates by anaerobic bacteria's produce gas, including hydrogen, methane, and carbon dioxide, which may cause flatulence. Flatulence and abdominal fullness has been observed when consumption reaches high levels (75-80g/day), which is fairly unlikely to be consumed in most people's diets (74). Thus, dietary fibre can cause GI discomfort, but mainly when consumed at high levels (75). Another concern can be that diets that contain large amounts of dietary fibre tend to be bulky and have low energy density. Therefore, in individuals with a low appetite, high fibre diet may satisfy appetite too promptly, making it difficult to meet energy and nutrient requirements (74).Thus, it is suggested that consumption of naturally fibre rich food including whole grains, fruits and vegetables should be encouraged instead of relying upon functional fibre supplements. This increases the nutritional value of the diet by providing other micronutrients as well and also reduces the likelihoods of experiencing any potential negative effect.

**Recommendations**

The RDA is the average daily dietary intake level that is estimated to meet the nutrient requirement of nearly all healthy individuals (97.5%) in a particular group but, since, there is no biochemical assay to reflect the dietary fibre nutritional status, there remains insufficient information to determine the Recommended Dietary Allowance (RDA) for fibre (60). Also, dietary fibre is not considered as a nutrient as there is no deficiency state, which is why in most countries an AI has been developed which has been observed to provide various physiological benefits. World Health Organization (WHO) suggests an intake of >25g of fibre per day (76). Various food and health related organizations encourage meeting the recommendations through a diet rich in vegetables, fruit and whole-grain cereals. Majority of countries recommend an intake of 25-35 g/day of dietary fibre for adults and the recommendation range from 18-38g/day (77). It is always suggested to meet the recommendations by consuming foods that are rich in natural dietary fibre as these foods are also a good source of other nutrients including various vitamins, minerals, phytochemicals and antioxidants.

There is a lack of data on the effects of dietary fibre in children and it is generally recommended that children under two years of age do not consume fibre-rich foods at the expense of energy dense foods (74).

The Indian Council of Medical Research recommends that the daily diet of an adult should contain at least 40g of dietary fibre (based on 2000 Kcal diet) (79). It is recommended to consume a variety of grain products, including whole grains and to choose at least four to five servings per day of fruits and vegetables. Along with dietary fibre recommendations, the significance of adequate water intake should be emphasized.

Habitual Indian diets which are predominantly based on unrefined cereals and plant foods, the suggested dietary fibre intake levels are easy to achieve (80). Dietary fibre intake in India varies among different socioeconomic groups from 15 to 41 g/day (81). The fibre intake was observed to be lower in women (15-30 g/day) and much lesser in tribal population (15-19 g/day). DF intake through wheat- or millet-based diets is generally higher than in a rice-based diet. Among the lower-socio-economic group particularly, nearly 80% of the fibre intake is attributed to the consumption of cereal based diets. A high soluble NSP content was observed in the diets of high-income groups than lower income groups as in the former case, diets include more fruits, vegetables and legumes, although the total NSP content of the diets in both the groups might be the same (82).

**Effect of cooking**

It is well recognized that mostly in India, the food goes through a lot of processing and is consumed in a well-cooked form, especially vegetables. Thus, it makes it imperative to know the effect of cooking on the dietary fibre content of various food items. One such study was done by Azizah and Zanon (1997), who studied the effect of processing on the Total Dietary Fibre (TDF), Soluble Dietary Fibre (SDF) and Insoluble Dietary Fibre (IDF) on various samples of cereals and legumes. It was found that soaking had no significant effect on TDF, IDF and SDF content of various legumes and cereals samples, however, IDF in wheat and moong beans were significantly ($p<0.05$) reduced. On boiling at 100˚C for ten minutes, it was seen that TDF content of barley decreased while of rice it was seen to be increased significantly. The IDF content of wheat, barley and nuts were found to reduce significantly ($p<0.05$) while that of soy beans were increased significantly. No change was noticed in SDF content. Roasting at 80˚C for 5 minutes significantly ($p<0.05$) increased TDF of wheat, rice, moong bean and soy bean but decreased significantly ($p<0.05$) of ground nuts. IDF content of wheat, barley and moong beans decreased while SDF content increased in soy beans. It was then concluded that both IDF and SDF increased with thermal treatments in the samples that had higher protein content e.g. soy beans (83). In another study by Vasishtha and Srivastava (2013), effect of cooking on components of dietary fibres were studied, in which it was found that cellulose, lignin and pectin increased during soaking and cooking, whereas hemicellulose increased during soaking but decreased during cooking (84). Pressure cooking showed a more pronounced effect on the reduction of these dietary fibre components than ordinary and microwave cooking (85). Lignin contents remained nearly unaffected on cooking. On cooking of vegetables, amount of hemicellulose was significantly reduced as compared to cellulose (86).

**Conclusion**

From a public point of view, increased consumption of dietary fibre from variety of fruits, vegetables, legumes, and whole-grain products will provide various physiological benefits. Dietary fibre is beneficial to health and, if consumed in adequate amounts, reduces the risk of several chronic diseases, such as CVD, type II diabetes, obesity, certain types of cancer, while supporting digestive health.

Sources of dietary fibre, as opposed to functional fibre, have the added benefit of naturally occurring micronutrients and phytochemicals that may improve human health. In addition, a higher fibre intake provided by foods is likely to be less calorically dense and lower in fat and added sugar. Health benefits from consuming dietary fibre must be actively communicated to the public.

**Table 1: Dietary fibre content of some selected fibre-rich foods (78)**

| Food | Dietary Fibre (g/100g) | Energy (KJ/100g) |
|---|---|---|
| **Cereals** | | |
| Barley | 15.64 ± 0.64 | 1321 ± 19 |
| Quinoa | 14.66 | 1374 |
| Bajra | 11.49 ± 0.62 | 1456 ± 18 |
| Wheat Flour | 11.36 ± 0.29 | 1340 ± 7 |
| Ragi | 11.18 ± 1.14 | 1342 ± 10 |
| **Pulses** | | |
| Bengal gram (Whole) | 25.22 ± 0.39 | 1201 ± 9 |
| Black gram (Whole) | 20.41 ± 0.06 | 1219 ± 5 |
| Field Bean (Black) | 23.40 | 1155 |
| Red Gram Whole | 22.84 ± 0.43 | 1146 ± 10 |
| Soya Bean (Brown) | 21.55± 0.66 | 1596± 11 |
| **Vegetables** | | |
| Agathi Leaves | 8.60 | 295 |
| Broad Beans | 8.63 ± 0.15 | 123 ± 4 |
| Drumstick Leaves | 8.21 ± 0.19 | 282 ± 27 |
| Fresh Peas | 6.32 ± 0.26 | 340 ± 19 |
| Ladies Finger | 4.08 ± 0.20 | 115 ± 5 |
| Carrot (Red) | 4.49 ± 0.19 | 160 ± 19 |
| **Fruits** | | |
| Sapota | 9.60 ± 0.57 | 307 ± 18 |
| Guava (White Flesh) | 8.59 ± 0.05 | 135 ± 5 |
| Gooseberry | 7.75 ± 0.64 | 99 ± 19 |
| Avocado | 6.69 | 604 |
| Pear | 4.48 ± 0.08 | 157 ± 3 |
| **Nuts and Seeds** | | |
| Gingelly Seeds (Black) | 17.16 ± 0.19 | 2124 ± 8 |
| Almond | 13.06 ± 0.31 | 2549 ± 4 |
| Pistachio Nuts | 10.64 ± 0.16 | 2257 ± 10 |

**Indian Dietetic Association Working Committee on Position Paper on Dietary Fibre**

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